A Profile of Injuries Among Participants at the 2013 CrossFit Games in Durban

By

Chantel da Silva

Dissertation submitted in partial compliance with the requirements for the

Master's Degree in Technology: Chiropractic

Durban University of Technology

I, Chantel da Silva, do declare that this dissertation is representative of my own work in both conception and execution

_____ _____

Chantel da Silva Date

Approved for Final Submission

_____ _____

Supervisor Date

Dr A. N. Gomes

M.Tech: Chiropractic, M.MedSci(Sports Medicine)

DEDICATION

I am here today because of your love and support. I dedicate this research to my best friend for fighting alongside me, my partner for his dedication to my future, my sister-in-law for her constant strength and finally to my father for always believing in me.

ABSTRACT

Background:

CrossFit is a workout program developed in 2000 which involves high intensity interval training coupled with resistance training elements of powerlifting and gymnastics. CrossFit has grown to include competitive events and there are an ever increasing number of affiliate gyms internationally. CrossFit's greatest criticism is related to safety. There is limited published data on the exercise program.

Aims:

The aims of this study were: to determine a retrospective cohort analysis of the demographic, injury and treatment profiles of participants at the 2013 United We Stand CrossFit Games who presented to the Durban University of Technology's sports treatment facility; to determine the association, if any, between demographics and injury types; and, to provide any recommendations regarding the clinical record form used.

Methods:

This study was a retrospective, quantitative, descriptive study on the chiropractic Student Sports Association's report form in order to produce a retrospective cohort analysis of the injury and treatment profiles.

Persons who made use of the chiropractic treatment facility at the 2013 United We Stand CrossFit Games were required to complete an informed consent form. A sixth year chiropractic student then filled in a Chiropractic Student Sports Association report form to record participant, complaint and treatment information. The study was not limited to competitors, but all persons who had access to the chiropractic treatment facility. These forms were then collated and data captured on the complaints which presented and were treated at the chiropractic treatment facility.

Results:

The data collected revealed that 137 participants presented to the chiropractic treatment facility in 162 visits, with 263 complaints treated. The age range of the sample was between 18 and 43 years, with a mean age of 27.49 years. The majority of participants who presented to the CTF were competing athletes and just under half of the study sample reported to not having a history of previous injury.

The study found that the lumbar region (20.9%), wrist/hand (14.4%), shin/calf (11.0%) and knee (10.2%) were the most commonly presented regions of complaint. The highest presenting mechanism of injury was that of overuse (22.4%) followed by running (19.0%). Acute injuries accounted for 72.20% of all injuries. With regards to diagnoses, myofascial trigger points made up 21.6% of all injuries, followed by muscle strains (19.7%). Facet syndromes of the spinal column accounted for 13% of diagnoses.It was shown that kinesiotape, manipulation, massage and ischemic compression were the top treatment interventions utilised. It was also shown that rest, ice and referrals were types of treatment that were not utilised. Due to statistical inconsistencies no significance tests were possible between demographic and injury characteristics. Recommendations were proposed in order to maximise the quality of data captured.

Conclusion: The results add insight into the injuries presented and the treatment they acquired at the chiropractic treatment facility at a national CrossFit event. The most common injuries require investigation in both training and competitive environments. Various recommendations have been proposed for the record form used at sporting events in order to facilitate the collection of high quality data.

Keywords: CrossFit, injuries, quantitative profile, chiropractic, musculoskeletal injuries, injury profile

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABBREVIATIONS AND DEFINITIONS

Acute injury

For the purposes of this research an acute injury is defined as an injury which occurs suddenly as a result of macro-trauma or aggravation of a chronic complaint.

Aesthetic training

Physical training with afocus on developing the ideal defined physique, which can be described as perfect symmetry, six pack abdominals, large rounded shoulders, large developed quadriceps muscles and gluteal.

AMRAP

As Many Rounds as Possible.

Ball slam

A combination of a squat and downward medicine ball throw from an overhead position.

Bear complex

Five barbell exercises performed concurrently. Each movement flows onto the next, starting by power cleaning the barbell off the ground; with the bar now at shoulder level a front squat is performed. At the bottom of the front squat a push press is performed overhead and the bar is lowered back to the posterior shoulders and a back squat is performed. The complex is completed by a push press from behind the shoulders, returning the bar anteriorly which is then lowered back to the ground (Schultz, 2014).

Box jump

Plyometrics involves a quick powerful movement consisting of a pre-stretching or countermovement that activates the stretch shortening cycle (Ebben *et al.,* 2008). A box jump starts in a squat position, facing a box. A jump is then initiated, the knees and hips flexed to bring the body vertically for the feet to land on the box, ending in a

squat position, then standing by extending at the hips and then stepping down to the ground.

Burpee

An exercise that consists of a series of movements starting and ending in a standing position (Forster, 2014). It involves a squat thrust and dropping into the plank position before returning to the standing position (UWS Manual, 2013).

CF

CrossFit.

C-facet

Cervical facet syndrome.

Chipper workout

A workout consisting of five to ten movements completed at a moderate level of exertion for time.

Chronic injuries

For the purposes of this research a chronic injury is defined as an injury as a result of repetitive micro-trauma, stress or trauma to soft tissue structures and improper healing of these structures resulting in pain for a pro-longed period.

Circuit training

A form of body conditioning using resistance training and high-intensity methods. It consist of completing the prescribed exercises in the circuit, a short rest period and then starting the exercises again.

Clean and jerk

This is a lift that consists of two weightlifting movements, the clean and the jerk. The clean involves moving the weighted barbell from the floor to the racked position across the deltoid muscles and clavicles. The jerk then involves lifting the barbell above the head until the arms are straight and the bar is stationary.

Cluster Fran

Fran is the name given to a particular workout by CrossFit Inc. Clustering is a method in which the repetitions in a workout are broken up in order to maintain a pace for the full workout without overexerting (Johnson, 2013).

Complaint

A complaint refers to the reason of visitation to the CTF facility at the 2013 UWS CF Games, whether due to an injury, prophylactic reasons or for management.

CSSA

Chiropractic Student Sports Association.

CTF

Chiropractic treatment facility.

Deadlift

The movement starts from a bent over position; knees and hips flexed; back straight; feet hip width apart with the hands in an alternating grip on the bar outside the legs. The lift is performed by extending the knees and hips, keeping the shoulder posterior to the bar, resulting in a fully erect end position, with the bar at hip level.

Delayed onset muscle soreness (DOMS)

Generalised muscle pain after unaccustomed physical activity that results in pain at rest hours later, after said activity (Mueller-Wohlfahrt *et al.*, 2012).

Double-unders

Traditional rope jumping occurs with the individual holding a rope with oneend in each hand. The handles are then swung so that the rope passes over head and anteriorly back down to the floor while the individual jumps over the rope as it arcs under the feet. The CF double under is a variation on the traditional exercise which requires greater coordination. They are accomplished by greater jump heights, faster wrist movements and rope swing to allow the rope to pass under the feet twice between the single jumps of the individual.

Extreme conditioning programs

High-intensity, high-volume, with short rest periods, multi-joint exercise program (Grier *et al.,* 2013).

Facet Syndrome

Characterised by inflammation in the joint capsule or increased joint fluid following repetitive micro-trauma and is often diagnosed by anamnesis in addition to physical examination. It is clinically characterised by back pain, pseudo-radicular pain, sensitivity on palpation of the facet joints and decreased and painful range of motion (Karkucak*et al.,* 2014).

Front squat

A squat performed using a grip on the bar that is wider than that of the shoulders; the bar should rest across the clavicles, upper chest and anterior deltoids. The arms should be parallel to the floor, chest elevated and torso rigid at the beginning of the movement. Feet should be spaced between shoulders and hip width apart. On the descending portion of the squat, the hips and pelvis move posteriorly with hip flexion, followed by knee flexion and anterior knee motion. Back and head remain neutral. The concentric phase of the lift begins by pushing through the centre of the feet, lifting out of the bottom end of the movement and ends when hips and knees have reached full extension.

Functional exercise

A classification of exercises that consists of training activities of daily living that originates from rehabilitation.

Gymnastics

An exercise that increases strength, suppleness and agility, especially when using special apparatus in the gymnasium (Adamson, 2007).

Hand release power burpee

This involves standing upright, with the arms at the sides.The knees then bend, followed by the hips, as the hands drop to the floor. The body must be flat on the floor, toes must stay in contact with the floor and the hands must leave the ground. From this position the hands return to the floor and the body is thrust back up to a

standing position. The hand release power burpee omits the jump at the end of the movement (UWS Manual, 2013).

HIT

High-intensity Interval Training.

Injury

For the purposes of this research an injury is defined by that which causes a participant pain or discomfort and leads to that participant seeking treatment at the CTF at the 2013 UWS CF Games.

ITBS

Iliotibial band syndrome.

Kettle bell

A ball shaped weight with a handle, usually made of cast iron (Brumitt *et al.,* 2010).

Kettle bell swing

The exercise is started in the squat position with a neutral spine and the kettlebell handle secure in the grip of both hands between the legs, a swing is then set off through the sagittal plane by simultaneous extension of the hips, knees and ankles. The momentum generated allows the kettlebell to be swung to chest level and returned to the starting point (Liebenson, 2011). The CF variation of this exercise involves the kettlebell being swung passed eye level (UWS Manual, 2013).

Kippling

A method whereby momentum is created by swinging the lower body to generate explosive force to complete repetitions. This method is used during exercises such as the pull-up (Hak *et al.,* 2013).

L-facet

Lumbar facet syndrome.

Manipulation

Is described as the application of a force to specific body tissues with therapeutic intent (Ernst and Canter, 2006).

Muscle-up

The muscle up consists of being suspended by the rings, which are then pulled towards the chest; the chest is anteriorly positioned over the top of the rings with elbows flexed. The arms are then pressed out from the rings by extending the elbows, bringing the body over the rings.

Myofascial trigger Point (MFTP)

A discrete, focal, hyperirritable knot located in a tight band of skeletal muscle (Chaitow and DeLany, 2002; Dommerholt *et al*., 2006; Travell and Simons, 1983).

MTSS

Medial tibial stress syndrome.

Niggle

A cause of trivial but persistent discomfort (Oxford Dictionary, 2015).

Non-traditional exercises

Can be viewed as those exercises outside of conventional strength or endurance training. Usually involves the use of objects such as the kettlebell, weighted ball or prowler sled, or entails the use of body weight functional movements such as the burpee.

Olympic weightlifting

A sporting discipline in which an athlete attempts to lift a maximum weight in a single lift of a loaded barbell. Two lifts form part of this discipline, namely, the snatch and clean and jerk (Butragueño *et al.,* 2014).

Overhead squat

Performed with the bar overhead using a wide grip, centred over the heels and elbows locked in extension (Chiu and Burkhardt, 2011). This is a variation of the standard powerlifting squat technique.

Overuse injuries

Defined as those injuries without a specific, identifiable event or cause responsible for their occurrence.

Participants

All persons who attended the chiropractic treatment facility at the UWS CF Games in 2013 including competitors, judges, medical team, sponsors etc.

Perception

Can be defined as the way in which things are seen, understood to be like, and interpreted as (Oxford Learner's Dictionary, 2015).

Pistol squat

Also known as a single-legged squat. This squat is performed balanced on a single leg with the other leg extended in front of the body.

Preventative

A term used in this study as a mechanism of injury to code for participants who presented to the 2013 UWS CF Games for prophylactic reasons. The participant could either have a pre-existing complaint or was asymptomatic and wished to prevent a complaint from occurring.

Proprioceptive neuromuscular facilitation (PNF)

Is a stretching technique used to enhance both passive and active range of motion in a clinical and athletic setting in order to optimise muscular performance and aid rehabilitation (Sharman *et al*., 2006).

Powerlifting

A sporting discipline that consists of three attempts at maximal weight on three lifts. These are the squat, bench press, and deadlift (Butragueño *et al.,* 2014).

Prowler push

The prowler is a form of sled training, which uses resistance from an apparatus called the prowler. The prowler has two sets of handles, either high or low. The prowler is equipped to carry weights according to the needs of the individual, or teams of individuals pushing it. The prowler positions the torso parallel to the ground resulting in the legs applying ground force at a 45 degree angle.This stance allows for a sprint type movement with a forward lean.

Pull-ups

The body is suspended by the arms in either a supinated or pronated grip on a bar and the body is lifted up by muscular effort.

Red flags

These are indicators of possible underlying clinical conditions which may be serious and require further medical attention.

Resistance training

A form of exercise which uses resistance from external forces to induce muscle contraction to achieve strength gains.

Rhabdomyolysis

A condition in which damaged skeletal muscle breakdown material is released into the bloodstream and results in kidney damage. Exertional rhabdomyolysis occurs when extreme exercise overload results in skeletal muscle breakdown (Ciccolella *et* al., 2014).

RM

Repetition Maximum.

RockTape

A branded kinesiology tape for athletes. Originally used by acupuncturists and chiropractors in Japan, kinesiology tape is now also used by practitioners to treat injuries and improve sports performance (RockTape, 2014).

Sumo Deadlift High Pull (SDHP)

This involves a wide stance, torso bent over with a grip inside the knees either on a barbell or kettlebell. The torso is straightened as in a traditional deadlift, but an upward pull with the arms occurs at the bottom of the movement bringing the barbell or kettlebell up to the chin (UWS Manual, 2013).

Shuttle run

Usually consists of a 20 meter sprint between marked off cones. One begins from the one end and sprints to the second cone. At the second cone, one must decelerate, turn around and accelerate back to the first cone. This is repeated 5 times at full exertion for to achieve 100 meters (100 meter shuttle run, 2014).

SI Syndrome

Sacroiliac syndrome

Snatch

Involves lifting a barbell from the floor to overhead at arm's length in a single continuous movement (Waller *et al*., 2007).

Spondylosis

Refers to degenerative osteoarthritis.

Spotting

Described as the act of physically assisting an athlete's body through space or through movement. The act of spotting is used in various sports such as gymnastics and weightlifting (Sands *et al.,* 2011).

Strongman/woman Competition

The sport of strongman/woman is a weight training exercise, which is similar to the sports of weightlifting, bodybuilding and powerlifting. It combines traditional strength training with specific implement training, such as the axle deadlift, log-press, tire flip and yoke walk (Butragueño *et al.,* 2014).

T-facet

Thoracic facet syndrome

Team splits three/three

Event configuration used at the 2013 UWS CF Games in which 3 team members perform the one workout and the other 3 team members perform another.

Toes to bar

An exercise that starts with the athlete hanging from a bar with the arms in a fully extended position, knees are then brought to the chest and toes swung towards the bar, keeping the legs fully extended. Toes must touch the bar (UWS Manual, 2013).

Trail run

A sport which involves outdoor running on hiking trails.

UWS

United We Stand.

WOD

Work Out of the Day.

Zercher hold and carry

This hold requires the barbell to be positioned in the crooks of the elbows anterior to the torso. The hold is a static exercise while the carry involves walking with a weighted barbell for a set distance (UWS Manual, 2013).

Chapter 1 : Introduction to the study

1.1 Introduction

This chapter provides a background to the study before presenting the aims, objectives and hypotheses. Finally limitations are considered prior to a summarising conclusion for this chapter.

1.2 Background

Sport and the pursuit of health have become increasingly popular, and exercise is identified as an important medium to gain continued health. People have increasingly turned to various activities to gain the benefits exercise has to offer (Lavallee and Balam, 2010). CrossFit (CF) is a workout program founded by Greg Glassman in 2000 as a trademark of CrossFit Inc (Gerhart, 2013).The sport of CF began in 2007 when the workout program became competitive with the introduction of the CF Games (Gerhart, 2013). Forbes Online has described the growth of CF as “astounding” due to rapidly increasing participation numbers and brand sponsorships (Rishe, 2013). Though few investigations have been published regarding the workout, many anecdotal reports are available via social media, blogs and magazines (Jacobson, 2013). The greatest criticism CF is faced related to safety. With CF being associated with exercise-induced rhabdomyolysis due to its high intensity, it has been labelled by some as dangerous (Bergeron *et al.,* 2011). One study found that overuse injuries which are chronic in nature and result from repetitive micro-trauma (Matava, 2008) may indeed plague the workout program (Smith *et al.,* 2013).

CrossFit aims to prepare the body for the unknown by training with “constantly varied, high intensity, functional movement” (Glassman, 2007). It is a general, broad and inclusive workout program which incorporates a lot of what is already practiced by the majority of people in various workout programs, such as powerlifting and gymnastic techniques in addition to rowing, running, swimming and cycling (Glassman, 2010). The difference between other exercise programs and CF is the

high-intensity interval training (HIT) methods utilised (Smith *et al.,* 2013). HIT is a strategy by which alternating short periods of intense exercise are coupled with less-intense recovery periods (Perry *et al.,* 2008). By means of this technique, CF includes an unsystematic selection of multiple joint exercises, which are completed at high resistance against the clock (as many rounds as possible) or to a set amount of repetitions to achieve maximum fitness (Smith *et al.,* 2013).

To date the available literature on CF is scarce. Of the known and available studies, two studies investigated CF related injuries (Hak *et al.,* 2013; Weisenthal *et al.,* 2014). The study by Hak *et al.*, (2013) concluded that the injury rates reported were similar to those seen in other sports as well as traditional fitness training; however these injury rates were lower than those reported for contact sports. The second study reported a preliminary injury rate of 20%, showing the shoulder, knee and lower back to be the most frequently injured areas of the body (Weisenthal *et al*., 2014). Weisenthal *et al.* (2014) concluded that the injury rates in CF were comparable to those found for other athletes and comparable injury profiles to gymnasts, Olympic weight lifters and power lifters.

Investigating the proposed mechanisms involved in CF injuries requires exploring the different aspects that constitute the CF system of exercise. CF utilises a random selection of multiple exercises to be completed in varied time domains (Smith *et al.,* 2013). Exercises can include functional lifts such as the squat, deadlift, snatches, and clean and jerk which are methods derived from powerlifting and weightlifting. Exercises may also incorporate gymnastic techniques such as ring work, bar efforts, handstands and rope climbs. Furthermore, short bursts of cardiovascular efforts may be included such as sprints, rowing, cycling and swimming (Glassman, 2010).

Powerlifting and weightlifting have been found to have similar if not lower injury rates compared to other sporting disciplines; common injuries include the shoulder, low back and knee (Butragueño *et al.,* 2014). Common injuries in strength training include strains and tendinitis (Calhoon and Fry, 1999). Injuries occur as a result of overuse, poor technique or excessive collisions with the bar (Hedrick and Wada, 2008).

It is important to note that CF completes weightlifting movements against time and frequently with relatively heavy weights in many repetitions and sets. Lifts should not be performed in a fatigued state as they require great technical skill and form due to the high spinal loads (Hedrick and Wada, 2008). Improper technique holds great risk for injuries to the low back ranging from a strain to a herniated disc (Lavallee and Balam, 2010).

As previously mentioned, gymnastic techniques also feature strongly in CF workouts. Gymnastics is defined as an exercise that increases strength, suppleness and agility, especially when using special apparatus in the gymnasium (Adamson, 2007). Lower limb injuries are reported more often in female gymnasts and upper extremity injuries are found predominately in male gymnasts (Meeusen and Borms, 1992; Kruse and Lemmen, 2009). Specific and gender related rates of injury have been reported with regards to gymnastics (Adamson, 2007), however these rates cannot be compared to CF as this involves a select combination of artistic, floor and other gymnastic disciplines across all genders.

There is a greater propensity for injury in multisport athletes, typically caused by overuse and inappropriate practices (Strock *et al.,* 2006). CF incorporates many movements and aspects of sports, combining them into a single stint (Moon, n.d). In a consensus paper on extreme conditioning programs by the consortium for health and military performance in the United States the following improper training methods associated with CF were put forward: inadequate amount of recovery in combination with overtraining, high repetitions with heavy weights, improper form in timed workouts, and lack of training periodisation (Bergeron *et al.,* 2011). At any level of competition, injuries are to be expected. Injury rates do not prevent participation in sports, but acknowledging the potential and risk thereof and accurately recording injuries allows the study of appropriate measures to reduce these.

Exercise provides great benefits in the promotion of health and wellbeing, yet every sport involves the real risk of injury (Miller, 2013). CF is a means to achieve all-inclusive fitness (Glassman, 2010). It is a functional strength and conditioning workout program that is constantly varied, using high intensity methods as a distinguishing feature (Glassman, 2007). The conceptualisation of CF as a

competitive sport is relatively new considering the first international games were held in 2007 (Rockwitz, 2013). Participation in competitive sports brings with it the inevitable risk of injury and the treatment of musculoskeletal injuries is a primary focus of chiropractic training and thus the chiropractor is integral in the management of musculoskeletal injuries. Given the whole body nature of sports injuries chiropractors are well-positioned to treat athletic injuries. Even so, little research has been conducted to determine the type of injury care provided by chiropractors at a sporting event such as this.

There is a lack of literature on CF training (Smith *et al.,* 2013). The benefits of injury surveillance in sport are numerous, and considering the findings by Smith *et al*. (2013) regarding injuries sustained during their ten week study, the need for further investigations to produce objective data is evident. Therefore the objectives of this study are to collect demographic information; provide an injury profile; determine the treatment profile during the 2013 United We Stand (UWS) CF Games and to analyse whether any associations exist between demographics and injury type.

1.3 Research aim and objectives

The aim of the study was to compile an injury profile of participants attending the chiropractic treatment facility at the United We Stand CF Games in Durban KZN, 2013.

The First Objective was to determine the demographic information about participants who presented to the chiropractic treatment facility during the UWS CF Games for treatment.

The Second Objective was to determine an injury profile in terms of injury type and mechanisms involved.

The Third Objective was to determine the treatment profile used in the management of participants who presented to the chiropractic treatment facility.

The Fourth Objective was to determine associations between demographic and injury profiles.

The Fifth Objective was to make recommendations, if any, to improve the clinical record form.

1.4 Rationale

Current literature on CF injuries have been limited and has focused on survey data distributed to athletes through online channels (Hak *et al*., 2013; Weisenthal *et al*., 2014). In these studies CF athletes present with self-reported training injuries. No studies to date have gathered sporting injury data during a competitive event. The rationale for this research was to focus and provide information on all participants (and their injuries) who presented to the chiropractic treatment facility at the 2013 UWS CF Games.

By considering the above mentioned data, health care professionals (e.g. sports medicine doctors, chiropractors, biokineticists, and physiotherapists) would be able to diagnose and/or treat injuries more effectively, according to each profession's scope of practice (Renstrom, 1993). Additionally, epidemiological and descriptive data on sporting injuries provides a basis for the development of accurate injury prevention strategies (Feddermann-Demont *et al.*, 2014).

There is a lack of knowledge surrounding the treatment practices of chiropractors in the sports fraternity (Kazemi and Shearer, 2008). Thus, one of the objectives of this study was to provide a profile of treatment practices of chiropractic students at a sporting event.

Injury surveillance is a key component of injury prevention strategies and is reliant on superior epidemiological data (Ekegren *et al.,* 2014). In order to make an ongoing impact on sports injury prevention, fine tuning and continuous improvement of the data collection procedure is required. Recognising the weaknesses in the procedures and report form used by the CSSA will allow for continued growth, appropriateness of data collected and usefulness of research conducted on such data. Hence one of the objectives of this study was to provide recommendations to improve the clinical record form.

1.5 Assumptions and limitations

When undertaking a retrospective study, participants at the time of the event are required to consent to the recording of their data for potential research purposes. To permit this, the participants had to understand the function of the data being captured and the possibility of it being used for research.

This research relied on trained chiropractic students for the capturing of the participants clinical information, diagnoses and treatment protocols, on the Chiropractic Students Sports Association (CSSA) form. This facilitates accuracy of results. Nevertheless, the data recorded in this study was based on clinical observations that were established in part by trainee chiropractors under the guidance of clinical supervisors; therefore the diagnoses may be limited in their scope (Allied Health Professions Act 63 of 1982).

As per the South African Health and Safety Act, emergency medical staff (paramedics) were available for use by the participants. Also available to see to the medical needs of the participants were physiotherapists and qualified chiropractors, all of whom did not contribute to the data collected for this study.

The ability of participants to seek chiropractic treatment free of charge may have resulted in over reporting of injuries. Participants are more likely to seek treatment if the services are offered free of charge (Konczak, 2010).

The availability of a sponsored item for use by the chiropractic treatment facility may have resulted in over use of the item for use by the trainee chiropractors and due to this being advertised, the participants may have requested that it be used. The item sponsored at the 2013 UWS CF Games was Rock Tape, a branded form of kinesiology tape.

Previous studies have found that misinformation about the scope of chiropractic could lead to patients unknowingly not utilising chiropractic treatment (Kazemi and Shearer, 2008). This may have resulted in fewer participants using the chiropractic facilities at the UWS CF Games.

1.6 Conclusion

To date there is little evidence-based literature regarding the injuries CF athletes present with. There has also never been research on injuries presenting during a competitive CF event. Therefore, the aim of this study was to compile an injury profile of participants attending the chiropractic treatment facility at the UWS CF Games in Durban Kwa-Zulu Natal, 2013.

In chapter one, the following was covered: an introduction to CF, the gap in the literature regarding the workout program, the aim and objectives, and limitations of the study. Chapter two provides an overview of the literature in order to facilitate a greater understanding concerning the study of injury profiles in participants of a CF competition. In chapter three, the materials and methods used in this study are discussed and explained. Chapter four presents the results obtained in the study, as well as a discussion of each result. In chapter five, conclusions and recommendations are presented.

Chapter 2 : Literature Review

2.1 Introduction

An overview of the literature is provided in Chapter Two in order to facilitate a greater understanding concerning the study on injury profiles in participants of a CF competition. The chapter begins by introducing the reader to CF by defining the workout program, providing background information on its popularity and discussing broadly relevant controversies. In addition, this chapter discusses the potential for injury that CF could possibly have by providing a brief summary of associated disciplines in terms of their injury prevalence rates, incidence and common injuries. It further examines the possible risk factors at play in CF related injuries. In conclusion, sports chiropractic and its involvement in treating athletes is mentioned.

2.2 CrossFit

CF is a workout program founded by Greg Glassman in 2000 as a trademark of CF Inc. (Gerhart, 2013). A strength and conditioning program, CF is based on the principles of high intensity interval training and resistance training (Smith *et al.,* 2013). Workouts are fashioned to include constantly varied, high intensity, functional movements (Glassman, 2007). CrossFit incorporates a lot of what is already practiced by the majority of people in various workout programs (e.g. push-ups, squats, resistance training, circuit training and rowing using a machine); therefore CF is a general, broad and inclusive program. It combines various movements from other disciplines such as powerlifting and weightlifting and gymnastics. In addition to body weight and functional exercises; objects such as kettle bells, skipping ropes, rowing machines, and water resistance are also utilised (Glassman, 2010). These different modalities are undertaken simultaneously in workouts of the day (WOD), in which intensity, volume, tempo, frequency and load are manipulated to create ever changing and more demanding workouts (Gerhart, 2013).

An example of a WOD would be to complete as many rounds as possible in 10 minutes, with a combination of the following exercises (Kuhn, 2013):

- 10 push-press,
- 20 air squats,
- 30 pull-ups.

In the above context, CrossFit Inc. is an online community and corporate business involved in the affiliation of gyms around the world and training of coaches based on the common understanding of high intensity interval training and resistance training (Kuhn, 2013). As a result of the popularity of CF, there are currently a growing number of affiliate gyms worldwide. This number is stated to be in excess of 7000, with over ten million CrossFitter's and 35 000 trainers (Oh, 2013). This popularity may be attributed to the backing and sponsorship of Reebok as title sponsor and is additionally enhanced by the fact that international CF games are aired on ESPN (Oh, 2013; Reebok CrossFit Games, 2013). High-intensity interval training (HIT), body weight training and functional fitness are all predominant features of CF workouts, and they have been labelled by The Worldwide Survey of Fitness Trends for 2014 as the top three fitness trends to watch (Thompson, 2013). Similarly in South Africa, there are over 100 affiliate gyms nationwide, with the first gym having opened in 2008 (email Du Preez personal communication, 2014).

Widespread use and publicity of CF has seen it being adopted in both military and civilian populations, and remarkable fitness gains have been anecdotally reported. These reports are consistent with the literature that HIT is effective with minimal time investment (Boutcher, 2010; Garber *et al.,* 2011; Buchheit and Laursen, 2013). A study conducted by the US Army found that substantial improvements were noted when CF was implemented in the training program for soldiers (Paine *et al.,* 2010). Improved metabolic capacity, $V0_2$ max and body composition werefound in a study using CF workouts in healthy subjects of varying fitness levels and both genders. The improvements were noted across subjects of all levels of fitness and both genders (Smith *et al.,* 2013). A study on the energy expenditure and relative intensity of two CF workouts found that values of intensity using heart rate relative to heart rate maximum and VO_2 max were both within the accepted training range recommended by the American College of Sports Medicine (Babiash, 2013).

A recent study comparing CF training to traditional anaerobic resistance training in terms of selected fitness domains found that CF resulted in no significant differences in the tested fitness domains. One significant finding was that maximum strength was found to be higher in the CF group (Gerhart, 2013). Acknowledgment of the benefits of CF means there is significant interest in furthering the literature related to CF as well as addressing the safety concerns brought forward by authors such as Paine *et al*., 2010; Gerhart, 2013; and Smith *et al.*, 2013.

2.2.1 United We Stand CrossFit Games in Durban, South Africa

For the last three years, teams from around South Africa have met in Durban to compete in the United We Stand (UWS) Games. In 2011 the inaugural event brought teams of four, consisting of two men and two women, together to compete for the UWS title. The goal of the games is to highlight CF and functional training in South Africa by exposing the games to more participants and spectators. In 2011, it was not a requirement to belong to a CF affiliated gym, and thus the UWS Games was open to anyone wishing to compete. Since then the games have grown and have become exclusive to teams from CF affiliated gyms. Simultaneously, the games have evolved over the last three years from 2011, starting with five events over two days to eight events spanning three days in the 2013 games.

The 2013 UWS CF games were structured around teams of six made up of four men and two women, competing in eight separate events through knockout heats. All teams competed in the first five events. The field was then cut to the top 60 moving onto the first part of the sixth event. Event seven saw the top 40 teams competing for position where only the top 20 teams competed in the final eighth event. 110 teams entered the 2013 UWS CF Games, with 660 competitors participating.

Table 2.1: A summary of events performed by participants at the 2013 UWS CF games

Event	Day	Time	Name	Description	Notes
1	1	8:00	20min AMRAP	▪ 50 Pull-ups ▪ 50 Hand release power burpees ▪ 50 Kettlebell swings ▪ 50 Double-unders	▪ Any team member could go in any order ▪ Before progressing each set of 50 had to have been completed ▪ One athlete worked at a time
2	1	13:00	Trail Run	▪ Four kilometre trail run including ten water ditches and mud obstacles	▪ Each team completed four loops
3	2	07:30	Team Splits three/three	1. Ascending burpee prowler push ten minutes 2. 20 one repetition maximum (RM) front squat	▪ Ascending burpee prowler push ▪ For distance and reps ▪ All three could push prowler ▪ Chest to floor burpees with clap above the head ▪ One athlete at a time completed the burpees ▪ 20 RM maximum front squat ▪ Each member has a minimum of two repetitions to find their maximum
4	2	11:30	15min Chipper Ascending ladder in tens	▪ Toes to bar ▪ Alternating pistols 20/12kg* ▪ Shoulder to overhead 70/40kg* ▪ One length hand stand walk	▪ One team member at a time ▪ One athlete completed ten repetitions before the other team member took over ▪ Not all team members had to complete a movement
5	2	14:00	Team Splits three/three	1. Ascending burpee prowler push ten minutes 2. Establish maximum weight bear complex for one repetition	▪ Ascending burpee prowler push • For distance and repetitions • All three team members may push prowler • Chest to floor burpees with clap above the head • One team member completed the burpees ▪ Bear complex one repetition maximum • Athletes were given as many attempts but only maximum weight counted • Each team member found their maximum • Other team members could assist with putting on and taking off weights
6	3	08:00		1. Zercher hold while team completed: ▪ 100 box jumps ▪ 300 SDHP ▪ 500 ball slam	

				5min rest 2. Ten minutes to establish max distance zercher carries	▪ Zercher carries • Women carried first • Only completed laps counted • No extra padding was used for zercher carry and hold
7	3	10:30		1. Each team member found their maximum weight snatch into overhead squat 10min time cap Followed by 2. Shuttle runs for 26 lengths	▪ One team member ran a length at a time
8	3	14:00		Two team members at a time completed in a 20 min time cap: ▪ Cluster fran 60/40* ▪ Ten deadlifts 120/80* and ten over bar burpee's ten rounds ▪ 50 squats and ten muscle-ups three rounds	
* Different weight values (kilograms) stipulated for male and female contestants, higher weights for males.					

2.2.2 Exercises encountered during the 2013 UWS CF Games

Accurate diagnoses and treatment of sports injuries develops from an understanding of the sport in which the athlete participates (Shamus and Shamus, 2001).The ability of the sports practitioner to associate impairment based on aetiology in relation to the period of exposure and the transfer of energy is pertinent to the development of accurate diagnosis and management of the injured athlete (Timpka *et al*., 2014). A number of exercises and exercise configurations were encountered by the competitors at the 2013 UWS CF Games and understanding the potential mechanisms and biomechanics behind these enables better recognition of the injury patterns which are influenced by this type of event. The exercises, some of which may be unfamiliar to the reader, are described in the definitions section of the preamble.

2.3 CrossFit and injury

The rise in CF's popularity draws extensive attention from proponents and opponents alike. This is, however, in contrast to the fact that few studies have been published in the medical literature, which has allowed biased, opinionated and anecdotal statements to stimulate scientifically unsupported arguments from both sides. For example: the risk-benefit ratio of the CF prescription of exercise and the potential risk of musculoskeletal injury (Smith *et al.,* 2013).

Notwithstanding the above, preliminary studies have tended to show that CF can be highly effective and yield beneficial overall health outcomes (Kuhn, 2013; Smith *et al*., 2013). Nonetheless criticism has emerged in the medical literature with regards to particular and disproportionate musculoskeletal injury risk (Bergeron *et al.,* 2011). This is further supported by comments in social media, magazines and on blogs with regards to the safety of CF (Hashish, 2013; Moon, n.d.; Ross, 2013). This is best expressed by the published cases of exertional rhabdomyolysis that have been reportedly linked to CF (Ciccolella *et al.,* 2014; Bellovary, 2014). Rhabdomyolysis is the result of muscular tissue damage which leads to the release of tissue breakdown products into the bloodstream (Bellovary, 2014). This negative publicity has the potential to mar the reputation of CF, particularly without research and further substantiation of the subjective links between musculoskeletal injury / conditions and

CF participation. To date there is little evidence-based literature to refute or support the notion that CF participants are more at risk of musculoskeletal injury than participants in traditional strength and conditioning workouts (Grier *et al.,* 2013).

Investigating the proposed mechanisms involved in CF injuries require exploring the different aspects that constitute the CF system of exercise. CF utilises a random selection of multiple exercises to be completed in varied time domains (Smith *et al.,* 2013). Exercises can include functional lifts such as the squat, deadlift, snatches and clean and jerk which are methods derived from power and weight lifting. Exercises may also incorporate gymnastic techniques such as ring work, bar efforts, hand stands and rope climbs. Furthermore, short bursts of cardiovascular efforts may be included such as sprints, rowing, cycling and swimming (Glassman, 2010).

Olympic weightlifting is a well-known sport consisting of neuromuscular coordination, fine kinetic perception, agility and the ability to perform accelerated and explosive movements in a specific line of technique with maximum accuracy (Szabo, 2012). Lifting requires superior strength, speed, flexibility and coordination, and because of this lifting provides an adequate background for many other sporting codes (Szabo, 2012). Powerlifting and weightlifting have been found to have similar if not lower injury rates to other sporting disciplines, with injuries occurring most commonly to the shoulder, low back and knee (Butragueño *et al.,* 2014). Common injuries in strength training include strains and tendinitis (Calhoon and Fry, 1999). Injuries occur as a result of overuse, poor technique or excessive collisions with the bar (Hedrick and Wada, 2008). Lifts should not be done in a fatigued state, as they require great technical skill and form, due to the high spinal loads (Hedrick and Wada, 2008).

Gymnastic techniques also feature strongly in CF workouts, as previously mentioned. Gymnastics is defined as an exercise that increases strength, suppleness and agility, especially when using special apparatus in the gymnasium (Adamson, 2007). Gymnastic activities are characterised by high-impact loading of the musculoskeletal system; for immature athletes, gymnastics presents a unique risk of injury during growth (Adamson, 2006). Lower limb injuries are reported more often in female gymnasts and upper extremity injuries are found predominately in male gymnasts (Meeusen and Borms, 1992; Kruse and Lemmen, 2009). Specific and gender related rates of injury have been reported with regards to gymnastics

(Adamson, 2007), however these rates cannot be compared to CF as this involves a select combination of artistic, floor and other gymnastic disciplines across all genders. Injury epidemiological studies have tended to focus on female gymnasts resulting in the possibility of gender bias (Adamson, 2007).

CF can involve a variety of cardiovascular exercises from shuttle runs to trail running. Running is one of the most popular recreational sports due to its convenience and low economic investment (Taunton *et al.,* 2002). However, running related injuries are well documented, with annual injury rates of between 25% and 50% (Novacheck, 1998). Running injuries have a multifactorial aetiology and have been associated with mostly overuse injuries (Saragiotto *et al*., 2014). There exists a dose-response relation between weight-bearing volume and the risk of lower extremity injury (Hootman *et al.,* 2001). Taunton *et al.* (2002) provided data on common diagnoses based on 2002 cases of running injuries; patello-femoral pain syndrome, ‘runners knee’, plantar fasciitis, meniscal injuries and medial tibial stress syndrome were some of the most commonly reported injuries (Taunton *et al.,* 2002). The study by Taunton *et al.* (2002) also provided a breakdown of common injury locations which were the knee, foot/ankle, lower leg, hip/pelvis, Achilles/calf, upper leg and low back. A study performed in KwaZulu-Natal, South Africa, over a 12 month period which documented musculoskeletal injuries among recreational half-marathon runners found that the knee, tibia/fibula and low back/hip were the most commonly reported sites of injury (Ellapen *et al.,* 2013). This correlates with the study mentioned previously by Taunton *et al.* (2002).

To date two studies have investigated CF related injuries, namely, Hak *et al*. (2013) and Weisenthal *et al*. (2014). Hak *et al.* (2013) found that the prevalence of shoulder injuries in CF training was higher than those previously reported for weightlifters only. By contrast, spinal injuries in the study reflected those seen in other lifting disciplines (Calhoon and Fry, 1999; Raske and Norlin, 2002). The study by Hak *et al.* (2013) concluded that the injury rates reported were similar to those seen in other sports as well as traditional fitness training; however these injury rates were lower than those reported for contact sports.

The second study on CF injuries by Weisenthal *et al*. (2014) reported an injury rate of 20%. The shoulders, knees and low back were the most frequently reported injuries. Even though these injuries occurred most often during the execution of gymnastics and power lifting movements, the current data in the gymnastics literature seems to suggest that Weisenthal *et al*. (2014) injury rate is a lot lower than that noted by Meeusen and Borms (1992).These differences may however be in part accounted for by the definition of injury and/or the mechanism of reporting which is inconsistent between these studies (Meeusen and Borms, 1992; Weisenthal *et al*., 2014).

Additionally it needs to be considered that males seem to be more likely to sustain injuries in CF than females and CF coach supervision was inversely proportional to injury rate (Weisenthal *et al*., 2014); which may imply that there are other factors that may influence injury rates reported in the literature.

2.4 Risk factors

Physical activity has been associated with numerous benefits including improved quality of life and reduction of mortality and morbidity; however there remains an activity-related risk of injury and re-injury (McBain *et al.,* 2014). Complicated and multifactorial interactions occur between numerous risk factors and complex events to elicit a sports injury. Since the early 1990's, several models have been put forward to describe injury aetiology, and have been the foundation for most risk factor and sports injury studies (Verhagen *et al.,* 2010). The sports injury model describes the dynamic interaction between the multifactorial nature of sports injuries and the sequence of events which eventually leads to an injury (Bahr and Holme, 2003). This model takes into account internal risk factors which impact the individual, as well as exposure to external factors. External factors influence the already predisposed athlete and create a situation in which the athlete is susceptible to an inciting event, ultimately resulting in injury. During a given situation, a pre-disposed athlete is exposed to the interaction of multiple risk factors and the inciting event is usually directly associated with the onset of injury.

The presence of risk factors does not necessarily result in injury but renders the athlete susceptible to the manifestation of injury (Bahr and Holme, 2003). Risk factor identification is a vital step in sports injury prevention (Finch *et al.,* 1999). Risk factors have been described in the literature as intrinsic/internal, extrinsic/external or modifiable, non-modifiable (Bahr and Holme, 2003).

2.4.1 Intrinsic risk factors

Intrinsic risk factors consist of internal factors specific to the athlete that contribute to their injury (Bahr and Holme, 2003). These include factors such as perception, age, gender, history of previous injury and aerobic fitness.

2.4.1.1 Perception

The perception of the effectiveness of a training program should not be measured by the fatigue or tiredness felt post workout, as this may lead to over-training, exercise-related pain and over-use injuries (Shiner *et al.,* 2005). The group setting of CF promotes camaraderie and teamwork; individuals are often encouraged to push themselves to excess (Bergeron *et al.,* 2011). Athlete perception of the risk-benefit ratio of their efforts could be a contributing factor for concomitant injury (Bergeron *et al.,* 2011). A higher perception of effort can lead to premature feelings of fatigue and diminished movement technique as a result of the high volume nature of these extreme conditioning programs. Extreme conditioning programs are characterised by the use of “high intensity, aggressive training at high volume and times, and maximal number of repetition with short rest periods between sets” (Bellovary, 2014).

Pain is experienced differently by each individual, and can be influenced by susceptibility, motivation and physical activity (Maffulli *et al.,* 2010). For example, minor pain which is aggravated by movement can hamper athletic performance, thus is perceived as being a greater hindrance than in the normal population (Maffulli *et al.,* 2010). Further to this, a highly-motivated athlete may ignore pain in order to continue training and may only adapt the type of training rather than stopping or seeking medical treatment (Maffulli *et al.,* 2010). An athlete’s perception of his/her ability and reactions to an injury can be as or more destructive to the athlete as the physical injury (Sands *et al.,* 2011). Pain perception affects an athlete’s health status and is important with regards to the prevention of overuse injuries.

2.4.1.2 Age

Particular age groups can sustain age related injuries. In strength training, these groups have been identified as skeletally immature and masters athletes. In the adolescent group, theoretical concerns over growth plate and growth velocity are noted (Lavallee and Balam, 2010). The younger weight lifter has a greater risk of injury due to accident or lack of supervision than due to any growth plate injuries (Lavallee and Balam, 2010). In the aging lifter, degenerative joint disease and chronic conditions pose the greatest influence on injury rates. Additionally, tendon rupture increases in prevalence among the masters age group (Lavallee and Balam, 2010).

In gymnasts, increased age is likely to result in an increased likelihood of sustaining injuries as they have had a greater accumulated exposure to training and performing complex and difficult skills (Adamson, 2007). During puberty there is a transition resulting in a difference in the power to weight ratio and may be a contributing factor to injury in the pubescent gymnast (Adamson, 2007).

There has been an increase in the number of older runners and a reported increase in the number of running-related injuries among this population (Fukuchi *et al.,* 2013). Fukuchi *et al.* (2013) sought to investigate differences in flexibility, muscle strength and running biomechanical factors between younger and older runners. The study reiterated that biological ageing results in alterations in running biomechanics, reduced muscle force output and reduced joint flexibility. The underlying mechanisms at play in age-related biomechanical and clinical changes are obscure and multifactorial in nature (Fukuchi *et al.,* 2013).

2.4.1.3 Gender

The majority of injuries reported in female gymnasts are found in the lower extremity; ankle and knee sprains being the most common injury type (Lund and Myklebust, 2011). The majority of injuries reported in male gymnasts involve the upper extremity. This disparity is most likely due to the difference in apparatus used between male and female gymnasts (Lund and Myklebust, 2011).

In general, female participation in lifting is uncommon and thus thorough literature documenting gender differences in terms of injury epidemiology is scarce (Quatman *et al.,* 2009). Injury epidemiology of men and woman in power lifting appear similar. However, the injury rate for men was found to be marginally higher than that of women in a study by Keogh *et al.* (2006); which was attributable to previous thigh and chest injuries. However a study on gender differences in weightlifting found that females were at a higher risk of lower extremity injuries compared to males. This finding is consistent with reports in other sports (Quatman *et al.,*2009). This finding may be due to significant differences in neuromuscular patterns after the onset of puberty (Quatman *et al.,* 2009). Increases in strength, power and coordination have been demonstrated in males during puberty. However, no similar increases have been found in females (Quatman *et al.,* 2009). This may place females at a higher risk of injury due to the neuromuscular imbalances experienced after puberty (Quatman *et al.,* 2009).

Male weightlifters experience higher rates of sprains and strains compared to females. These injuries often result from exertion during activity, and due to males training at a higher relative intensity during resistance training; lifting heavier weight and attempting more complex lifts than females. This may predispose men to develop exertion type injuries such as sprains and strains (Quatman *et al.,* 2009).

Taunton *et al.* (2002) retrospectively studied data collected over a two year period in which 2002 patients were examined. The study reported that 46% of patients were male and 54% were female; furthermore injury distribution was not uniform across the sexes. Although the men in this study experienced significantly more injuries such as plantar fasciitis, meniscal injuries and patellar tendinopathy than females, the study concluded that no distinct trends can be described as few published studies have differentiated injuries by sex (Taunton *et al.,* 2002).

2.4.1.4 History of previous injury

Competitive and recreational athletes, of every age, are at risk of a wide variety of soft tissue, bone, ligament, tendon and nerve injuries, caused either by direct trauma or repetitive stress (Maffulli *et al.,* 2011).Injury results in an alteration in the mechanical characteristics of the muscle. These alterations, often from a prior minor injury, may precede a major injury (Croisier, 2004).

Serious injury, such as a tear of the anterior cruciate ligament (ACL) of the knee, results in joint instability, compromise of the static and dynamic stabilisers of the joint and compromised joint proprioception (Beynnon *et al.,* 1999; Hopkins *et al*., 2001). All these features that are related to the instigating injury contribute to altered muscle recruitment patterns and fear of re-injury, which contribute to placing the athlete at a greater risk of injury (Suter *et al.,* 1999; Vlaeyen and Linton, 2000).

2.4.1.5 Aerobic fitness

Musculoskeletal injury risk is one of the few adverse effects of a physically active lifestyle (Hootman *et al.,* 2001). Breckenridge (2007) states that according to the current literature a decreased level of aerobic fitness is associated with an increase in musculoskeletal injuries. Muscle readiness and muscle endurance may explain the lowering of injury risk reported. Furthermore, an increase in mental status may also contribute to the lowered risk of injury seen in aerobically fit individuals (Vlaeyen and Linton, 2000).

2.4.2 Extrinsic risk factors

Conversely, extrinsic risk factors are those which are environmental or external in nature. Examples of these would be training sessions/hours per week, coach involvement, sports equipment, temperature and competition rules (Bahr and Holme, 2003).

2.4.2.1 Sport specificity

Different sports and even different player positions in the same sports are associated with different patterns and types of injuries. Sports specific injuries are well documented e.g. volley ball shoulder (Notarnicola *et al.,* 2012), tennis elbow (Orchard and Kountouris, 2011), and emphasises the effects of biomechanics and repetitive stress on the prevalence of injuries. The manipulation of time, intensity and load in these sports results in the activities involved becoming a risk factor for injury e.g. constant wrist extension and gripping is a risk factor for lateral epicondylitis (Orchard and Kountouris, 2011).

It has been postulated that even slight angular differences, for example low or high bar squat positions, within the same exercise discipline may change the biomechanical risk of injury (Keogh *et al.,* 2006). Powerlifting utilises the low-bar squat which has been shown to reduce the mean compressive patella-femoral forces as compared to the high-bar squat (Keogh *et al.,* 2006). This proposed reduction of knee kinematic stress is one of the main contributing factors leading to the relatively low number of knee injuries in power lifting compared to other weight training sports (Keogh *et al.,* 2006).

With regards to gymnastics, the different forms of this discipline may demonstrate many of the same acrobatic and dance skills, but as there are significant differences in rules, regulations and apparatus, these differences result in alterations in injury risk and patterns. These injury patterns are in direct relation to the nature of the sport, for example gymnasts land from height while performing elements with twist and rotations, which correspond to the large amount of ankle injuries reported (Lund and Myklebust, 2011).

However, CF's manipulation of time, intensity and load on their set of exercises may or may not have a negative result on injury prevalence, type and severity. For example, CF performs a random selection of exercises, which might reduce chronic overuse injuries; conversely complex lifts done for time may increase the likelihood of acute injuries.

2.4.2.2 Repetition and intensity

The high repetition and high intensity nature of CF done with heavy weights could lead to poor form, and thus result in injury (Hak *et al.,* 2013).The prevalence of shoulder injuries in CF training is higher than previously reported for weightlifters (Weisenthal *et al*., 2014). This is due to the at-risk position that the shoulder is placed under. This involves the shoulder being in a hyper flexed, internally rotated and abduction position (Hak *et al.,* 2013). This shoulder position can be seen in movements such as the front squat, pull-up, kippling pull up and Olympic style lifting with overhead movements. These movements are used in the majority of the CF benchmark workouts.

During Olympic lifting, focus is placed on performing one repetition of the movement with a maximum load. However, CF performs many repetitions of these movements against time, with the emphasis placed on speed. High repetitions and intensity under load may lead to poor form and fatigue. Strict form is needed when performing movements such as the deadlift and squat. This may contribute to the reported high prevalence of spinal injury reported in CF compared to powerlifting and weightlifting (Hak *et al.,* 2013). High intensity, repetitions and heavy weighted movements were distinguished as contributing factors to lower back injury (Hak *et al.,* 2013).

2.4.2.3 Timed workouts

High-intensity training (HIT) is a key component of the CF system (Oh, 2013). HIT is a strategy by which alternating short periods of intense exercise are coupled with less-intense recovery periods (Babiash, 2013). CF uses HIT with complex and technical lifts and movements; research in the component disciplines (weight lifting, powerlifting and gymnastics) has suggested that good form is protective against injury (Szabo, 2012). Timed workouts ensure competitiveness and that exercises are performed at high intensity (Kuhn, 2013). With CF's focus on time and repetitions, form and technique may be neglected. Improper technique holds great risk for injuries to the low back, ranging from a strain to a herniated disc when doing weight lifting (either for recreation or competition) (Hak *et al.,* 2013).

HIT without proper rest periods can also result in fatigue and tiredness (Bergeron *et al.,* 2011). This fatigue may promote additional oxidative stress, less resistance to future exercise strain, greater perception of effort and unsafe movement form (Bergeron *et al.,* 2011). Motor control strategies can be altered by fatigue, which can contribute to injury (Winwood *et al*., 2014). A study on injuries in strongman/woman competitions reported that 44% of the injuries occurred late in the competition, which may point to fatigue and possible decreased concentration as contributing factors to injury (Winwood *et al*., 2014). Overtraining and overreaching are risks of continued disproportionate recovery during training (Bergeron *et al.,* 2011). Optimising the recovery-stress state is essential for continued positive athletic performance (Kellmann, 2010).

2.4.2.4 Coach supervision

Coach supervision is a considerable protective mechanism if present or a risk factor if absent in CF training (Weisenthal *et al*., 2014). A recent study illustrated how females were less likely to be injured during CF training, which they attributed to the fact that female subjects ask for more help from coaches (Weisenthal *et al*., 2014). Good form during technical movements is paramount, and movements can be unsafe if not performed correctly (Paine *et al.,* 2010). Coaches can ensure proper technique.

A study conducted on TeamGym, a new form of gymnastics, found that there was a greater likelihood of injuries occurring in competition compared to warm ups. The authors provided a possible explanation for this greater likelihood of injuries in that during the warm up period, coaches are present to provide spotting thus providing support and in a way, protecting them from injury (Lund and Myklebust, 2011). This provides an illustration of how a coach's presence decreases the risk of injury.

Skills that are required to perform movements correctly and consistently must first be developed before intensity and weights are added (Bergeron *et al.,* 2011). Trained coaches are fundamental to establish proper movement mechanics in athletes. However, not all training occurs under the supervision of a coach or in an affiliated gym. Due to CF online presence, persons following the main CF HQ website programming may not be able to suitably tailor the programming published as

WOD's (Hak et al., 2013). This lack of coaching and individualisation, which is missing outside of an affiliate gym, has been proposed as a potential negative risk of CF training (Hak *et al.,* 2013).

2.4.2.5 Random selection of exercises/progression

CF is a system of exercise that includes a random selection of multiple exercises completed against time or for time (see Table 2.1 and 2.2). CF aims to prepare the body for the unknown by training with "constantly varied, high intensity, functional movement" (Glassman, 2007). This aspect of the CF workout program may actually avoid the risk of sports specific injuries associated with repetitive stress during long monotonous training, as well as due to technical sports that involve repetition of similar movement patterns (Clarsen *et al*., 2013). Conversely, the random and unplanned use of complex lifts or any conditioning drill without proper progression, has the ability to increase injury and the potential to allow for inappropriate physiological adaptation (Waller *et al.,* 2007). In the study by Hak *et al.* (2013), the random selection of CF workouts allowed for lack of progression and little focus on skill-specific complex lifts, such as those in weight and powerlifting. It is argued that to prepare the athlete for the unknown, greater sporting capacity lends itself to the intersection of all sports demands (Glassman, 2007). The authors of a study performed by the US Army believe that the prescription of the CF workouts allows for the greatest fitness gains in persons with above average fitness (Paine *et al.,* 2010). The prescription of CF is supposed to be constantly varied, which is at odds with commonly accepted progression models which are fixed and predictable (Glassman, 2007). Optimal adaptation occurs by providing appropriate stimuli within the borders of proper efficiency and safety (Waller *et al.,* 2007).

2.4.2.6 Competition demands

Besides the potential for injury during workouts, in competition there is a greater demand on athletes to perform optimally to ensure the best results, and this can place remarkable strain on their physical capabilities (Smith and Hillman, 2010). There is a consensus among researchers that the risk of injury is greater during competition than training (Murphy *et al.,* 2003). Injury surveillance data gathered

during gymnastic competitions noted that athletes experienced a two times higher risk of injury during competition than practice (Lund and Myklebust, 2011).

Competing at events is often the final point in a long-term training program experienced by athletes (Kellmann, 2010). Injuries during training and competitive events have been shown to be substantially different (Feddermann-Demont*et al.,* 2014). Higher competition injury rates may be the result of fatigue when athletes perform multiple efforts throughout the day over consecutive days (Lund and Myklebust, 2011). Athletes exert maximum effort to better their chances of triumphing against competitors and to beat previous personal bests; this consequently may place the athlete at a relatively high risk of injury (Winwood *et al.,* 2014).

2.5 Medical treatment at sports events

Based on the presentation of both internal and external factors contributing to injury, medical attention to these injuries may vary and may include a diverse complement of medical personnel. As guided by the Safety at Sports and Recreational Events Act 2009, the minimum requirements for event medical measures during a sporting event are that of a fully equipped and appropriately staffed paramedic vehicle (Safety at Sports and Recreational Events Act, 2010). As a result, any CF event is required to have at least emergency and ambulance provision. The addition of a medical doctor and various support personnel to deal with the repetitive micro trauma / overuse-type injuries is left to the discretion of the event organisers.

2.5.1 Chiropractic

Chiropractic is defined as:

> The diagnosis, treatment and prevention of mechanical disorders of the musculoskeletal system and the effects of these disorders on the function of the nervous system and general health. There is an emphasis on manual treatments, including spinal manipulation or adjustment.(Ernst and Posadzki, 2012)

Chiropractors have become increasingly popular in the treatment of athletes, both in amateur and professional sports (Labuschagne, 2009). The role of the chiropractor

within the sporting world is varied. Other sports medical professionals see sports chiropractors as having a primary and limited role as spinal specialists, treating lower back and other musculoskeletal injuries (Miners, 2010). However, this is not the only role of chiropractors in the sporting locale. Chiropractors have the ability to interact with coaches, sports health and emergency care providers in order to impact beneficially the overall health of the athletes they treat (Miners, 2010). From the perspective of sports healthcare, the role of the chiropractor is to facilitate an athlete's performance by early detection and timely treatment of injury, and by co-operative interaction between coaches and other sports healthcare professionals in the identification and correction of any health deficits that may impact performance directly or indirectly (Miners, 2010). The chiropractor often fills the role of the primary team healthcare provider, and is responsible for diagnostic triage with diagnosis and treatment of injuries inside the scope of practice of chiropractic and outside referral for management of red flag signs (Julian *et al.,* 2010). Restricted budgets often limit the use of large multidisciplinary medical teams, though these are preferable for the management of athletes (Julian *et al.,* 2010).

Given the whole body nature of sports injuries that may present at a CF competition, it is of importance for treatments to be time conscious and multimodal in nature, involving both active and passive variants (Hoskins *et al.,* 2009). Chiropractic management incorporates an interactive approach to treatment with the use of a variety of modalities, but lays focus on high-velocity low-amplitude manipulation, soft tissue and stretching techniques, therapeutic and rehabilitation exercises and taping (Hoskins *et al.,* 2009). Other modalities often utilised by the majority of chiropractors include electromodalities, physical therapies, gait retraining, nutrition and a variety of advice on ergonomics and exercise cross training (Hoskins *et al.,* 2009).

Chiropractors have at their disposal a vast array of treatments and modalities to offer their patients, but often event facilities limit the availability of the electromodality driven treatments e.g. ultrasound and interferential current therapy. Manual and physical therapies remain the core treatments sports chiropractors are able to offer in the field. Treatment rendered is often a function of circumstance, as not all treatments that are available in practice are established in field, though this is not the only space in which a sports chiropractor practices.

The treatment of musculoskeletal injuries is a primary focus of chiropractic training and thus the chiropractor is integral to the management of musculoskeletal injuries. Chiropractic is suited to the treatment of athletic injuries as it focuses on mechanical stresses that are often directly linked to the onset of symptoms (Cloete, 2008). Additionally, chiropractic provides drug-free care which is in line with many anti-doping regulations in sport (Labuschagne, 2009). Even so, little research has been conducted to determine the type of injury care provided by chiropractors at sporting events.

A small number of sports events are serviced by senior chiropractic trainees in South Africa. These students attend the University of Johannesburg and Durban University of Technology (DUT) chiropractic programs. The CSSA form completed by DUT chiropractic trainees at sporting events was developed by Korporaal (2002) as a standardised clinical document utilised to record a participant's injury and treatment over the time period of an event. The form underwent validation by means of a focus group and pilot study (Korporaal, 2002). Validity in this context represents the accuracy and dependability of a research tool (Bernard, 2000). It is standard clinical practice to record all clinically relevant information at each visit at any of the chiropractic treatment facilities (Government Gazette, Act 63 of 1982 (as Amended)).

The typical chiropractic treatment facility provided by a DUT contingency usually consists of six to eight portable chiropractic beds and all the basic equipment the chiropractic trainees need in order to treat athletes efficiently. Massage and stretching are some of the pre-heat warm-up or post-exercise warm down techniques offered. All athletes are treated under the supervision of a qualified chiropractor, as defined in Act 63 of the Government Gazette (1982 (as amended)). If the athlete's complaint does not fall within the chiropractic scope of practice, they are referred to another medical professional onsite, if available, or offsite.

Patients seeking care from a chiropractic treatment facility are requested to complete the first part of the CSSA form (Appendix B). This section consists of participant demographic details and a section where the participant is required to sign consent to treatment and consent to the use of their data for future research. The subsequent sections of the form relate to the participants case history, physical examination, diagnosis and treatment/management. Once the trainee chiropractor has formulated

a diagnosis and treatment plan it is then discussed with a qualified clinician who either modifies or confirms the proposed plan, as is standard practice at the DUT Chiropractic Day Clinic (Government Gazette, Act 63 of 1982, (as amended); Clinical manual, 2013).

2.6 Sports injury recording and surveillance

The collection of useful and quality injury information is underpinned by appropriate methods of data collection, injury definitions, and cooperation of practitioners. The injury report form should be simple, flexible, acceptable, sensitive, representative and timely (Junge *et al.,* 2008). Important aspects of injury reporting have been identified as: a consensus definition of injury, and that the report is completed by a sports practitioner. The report form should document the following information in a simple and concise manner: date and time of injury, sport and event, injured body part, type of injury and cause of injury (Junge *et al.,* 2008). In order to do this, some major considerations should be taken into account. Firstly, data for medico-legal reasons need to be collected; these include personal details, diagnosis and treatment information. Secondly, the report should be simple but still provide areas for more detailed description. Thirdly, the form may be constrained to limitations imposed by organisers with regards to logistics, printing costs and reporting deadlines. Lastly, the form should be designed so that it is easily completed in a quick and timeous manner (Finch *et al.,* 1999).

Injury surveillance is a systematic structured collection of injury data that has an important role in injury control programs, as it identifies problems, monitors injury trends and acts as a guide to further research and investigation (Finch and Mitchell, 2002). Sports event data collection on injury benefits the organisers, athletes and future practitioners involved in treatment by presenting valuable information concerning the types of injuries, anatomical locations and high risk methods of injury. Collection of data during sporting events increases the level of knowledge about the sports injury problem, provides epidemiological data on the athletes, and provides the opportunity to identify areas of priority. Injury surveillance is significant as it is crucial for sports injury prevention research, necessary for planning of medical coverage of sports events, as well as the planning of resources needed to treat and

manage injuries (Finch and Mitchell, 2002). Nevertheless fundamentally, the most important role of injury surveillance at sporting events is to make future events safer.

2.7 Conclusion

To the researcher's knowledge, the research conducted by Hak *et al*. (2013) and Weisenthal *et al*. (2014) are the only studies which have investigated the injury profiles of CF athletes during training, and no studies have been conducted on injury profiles during a competitive event. The previous authors' research identified the injury rate, location and common injuries among CF athletes.

This study aims to benefit the organisers, participants and future practitioners involved in treatment by presenting valuable information concerning the types of injuries, anatomical locations and high risk methods of injury. Injury data obtained during sporting events is useful to plan for future events, in terms of resources, medico-legal purposes and it plays an important role in the duty of care to the competitors. Notably the most significant function of injury surveillance at sporting events is to help make future competitions safer (Finch *et al.,* 1999).

Therefore, the primary aim of this study was to compile an injury profile of patients attending the chiropractic treatment facility at the 2013 UWS CF Games in Durban, Kwa-Zulu Natal. Key objective outcomes were to determine demographic information regarding patients who presented to the chiropractic treatment facility during the UWS CF Games for treatment. Secondary objective outcomes were to determine an injury profile in terms of injury type and mechanisms involved. Corresponding outcomes included determining the treatment profile used in the management of patients who presented to the chiropractic treatment facility, investigating associations between demographic and injury profiles and making recommendations, if any, to provide recommendations to improve the clinical record form.

Chapter 3 : Materials and Methods

3.1 Introduction

This chapter will discuss the research methodology and data collection used in this study with regards to study design, sampling, inclusion and exclusion criteria, data collection procedure and statistical methodology.

3.2 Study design

This was a retrospective, quantitative, descriptive cohort injury profile study. The standard injury report form (Appendix B), used at sporting events by chiropractic interns from the Durban University of Technology is known as the Chiropractic Student Sports Association (CSSA) form. The form has been previously validated (Korporaal, 2002). Validity refers to the accuracy and credibility of an instrument, data and findings in the research study therefore guaranteeing that future research utilising that particular tool is accurate (Bernard, 2000).

The above study designed was approved by the Faculty of Health Sciences Research and Ethics Committee at the Durban University of Technology (Appendix A).Approval by this committee implies that the research complies with the requirements of the Declarations of Belmont, Nuremberg and Helsinki of 1975 (Johnson, 2005).

3.3 Study sample

The interns at the UWS CF Games gathered 179 CSSA forms during the three day event. Of the 179 CSSA forms gathered, 17 were excluded according to the exclusion criteria as described below, and 162 were used for data purposes as they met the inclusion criteria.

3.4 Permission required for the study

Permission was granted by the organisers of the 2013 UWS CF Games in order to provide a chiropractic treatment facility at the event (Appendix C and D). At the treatment facility, participants could access treatment free of charge.

In order to receive assessment and treatment all participants were required to sign the patient portion of the CSSA form (Appendix B).

Patients that refused to sign the CSSA form were excluded from being treated at the chiropractic treatment facility at the 2013 UWS CF Games.

By signing the patient portion of the CSSA form, the participant gave consent to be treated, in addition to any data generated to be used as part of a research process.

3.4.1 Inclusion criteria

The inclusion criteria were as follows:

- Signed CSSA form, which includes signatures from the patient, student and clinician.
- Complete data sheets. Such sheets may include sections of the CSSA report form which were left incomplete such as those where the treatment had not been recorded or where no treatment was done.

3.4.2 Exclusion criteria

The exclusion criteria were as follows:

- CSSA forms in which a signature is missing, whether that of the patient, student or clinician.
- Incomplete data sheets. Such sheets may include those where more than one of the following was omitted: patient details, region of complaint, mechanism of injury, clinical impressions.

3.5 Permission required for the study

3.5.1 Background to the process and procedure at the event

Permission was granted by the organisers of the 2013 UWS CF Games to use the data collected during the event (Appendix C and D).

During the three day event participants who made use of the chiropractic treatment facility were required to complete the patient section of the CSSA form (Appendix B), and were briefed as to the possible use of the data. The student took a case history pertaining, but not restricted to, the injury and event. Following this a standard

clinical assessment was performed relating to, but not limited to, the anatomical area of concern. The CSSA report forms were completed by a 6th year chiropractic student or qualified chiropractor.

3.5.2 Data management

All forms were collected after the three day event and were kept in a secure locked cabinet in the Chiropractic Department offices, until IREC and RHDC approval was granted. Thereafter, data collection used a coding system which allowed for all identifying information to be omitted, thus no patient names were used.

3.5.3 Data collection tool

The CSSA Form (Appendix B) (Korporaal, 2002) was the data collection tool used by the students to record the injuries and treatment performed during the 2013 UWS CF Games. The form is a standardised document used to treat patients at all sporting events by students from the DUT Chiropractic Department in order to obtain sporting hours for community service. The form includes a section which describes the possible use of the data collected, and this was signed by the patient prior to any work-up being performed. The form includes the following sections: patient details, region of complaint, mechanism of injury, clinical impressions, treatment and continuation of play. The CSSA form is signed by both the student and clinician.

3.5.4 Measurement frequency

The CSSA form was utilised each time a patient presented to the chiropractic treatment facility, whether as a new patient, or repeat patient for a new complaint or continuation of treatment.

3.6 Statistical methodology

The data was reduced and analysed with the help of a statistician, using the statistical software SPSS version 22.0. The statistical aspect of the research encompassed the following:

- Descriptive statistics using frequency and cross-tabulation tables and various types of graphs (including pie charts, bar charts, etc.).

- Inferential statistics using Pearson's and/or Spearman's correlations at a significance level of 0.05.
- Testing of hypotheses using Pearson chi-square tests / Fisher's Exact Test for nominal data at a level of significance of 0.05.
- Risk and odd ratios where applicable.
  (email Singh personal communication, 2013)

3.7 Conclusion

This chapter outlined the methodology that was used to accomplish thus study. It described the CSSA form which was used to gather data at the sports event, as well as the sample size and research procedure. Additionally the statistical methodology was also presented.

Chapter 4 : Results and Discussion

4.1 Introduction

This chapter presents the results and discusses the findings obtained from the participant records in this study as per the outlined objectives (section 4.2). The Chiropractic Student Sports Association (CSSA) form was the primary tool used to collect data and was distributed to participants that attended the United We Stand (UWS) CrossFit (CF) Games chiropractic treatment facility (CTF). The data collected from the responses was analysed with SPSS version 22.0. The results present the descriptive statistics in the form of graphs, cross tabulations and other figures for the qualitative data that was collected. Inferential techniques include the use of correlations and chi square test values; which are interpreted using the *p*-values. *P*-Values which are <0.05 are considered statistically significant.

4.2 Methodological flow

Figure 4.1 below illustrates the way in which clinical data in this research was collected, organised and analysed. The number of complete UWS CF Game forms gathered represents the number of visits made by participants who presented to the CTF during the 2013 UWS CF Games.

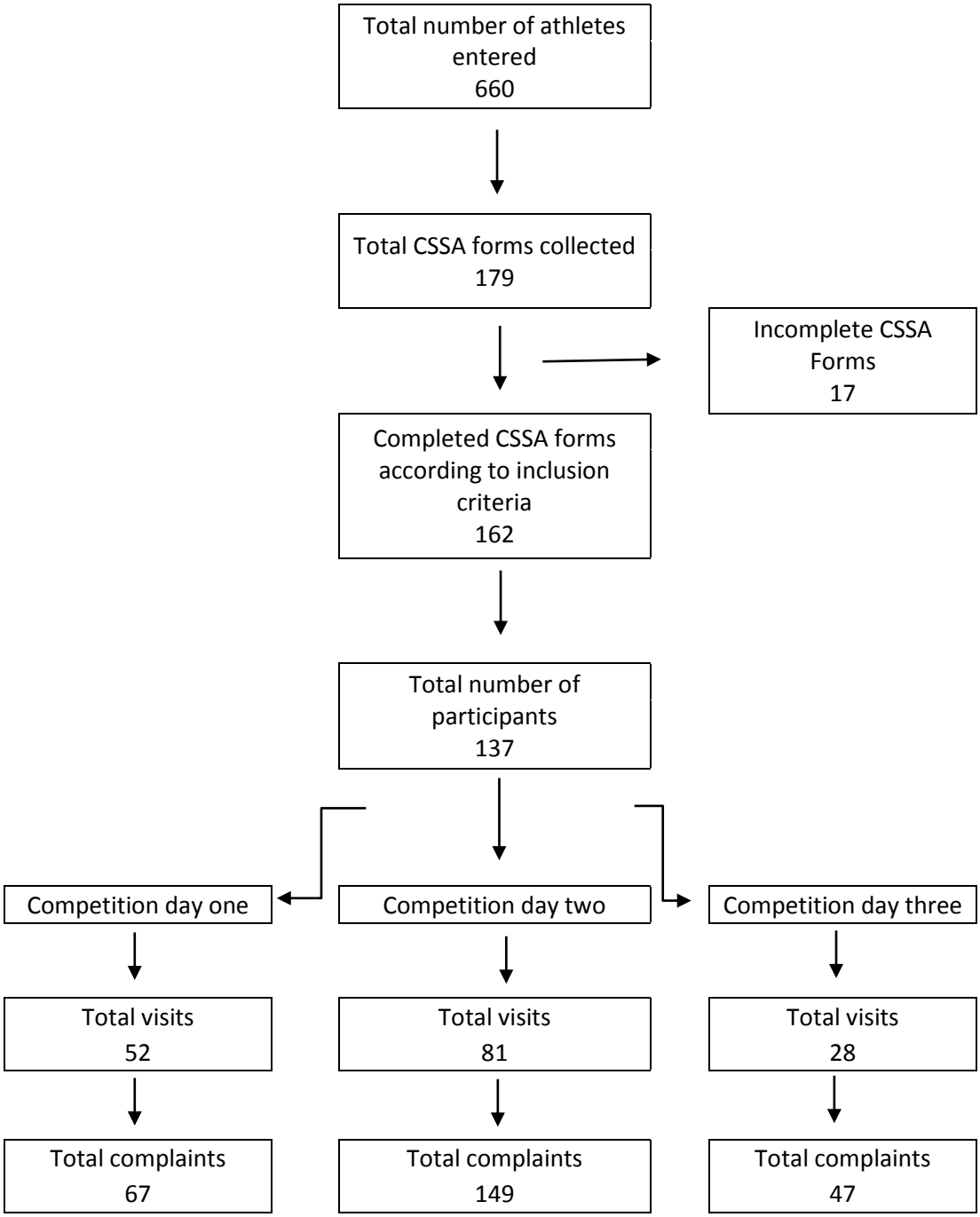


Figure 4.1: Methodological flow diagram

4.3 Demographic information

The First Objective was to determine the demographic information on participants who presented to the CTF during the UWS CF Games for treatment. The demographic profile includes gender, ethnicity, age, as well as the type of participant.

4.3.1 Total patients, visits and complaints per day

Data was collected from 137 study participants who visited the CTF at the UWS CF Games 2013. These 137 participants required a total of 162 visits, with 263 complaints being treated over the three days. There were 39 visits to the CTF on day one, 69 visits on day two, 22 visits on day three, however 32 visits were recorded with missing data.

Due to the knock-out format of the 2013 UWS CF Games, the number of participants involved in events decreased as the days progressed. This could account for the decrease in participant numbers presenting to the treatment facility. Although the majority of participants in the study sample presented with only one complaint, more than a quarter of the participants receiving treatment presented with two complaints, which suggests that participation in competitive CF events results in complaints which affect more than one area of the body at a time.

4.3.2 Age, gender and ethnicity

Table 4.1 shows that the age range of the sample was between 18 and 43 years, with a mean age of 27.49 years. Regarding gender, Table 4.1 shows that two thirds (66.4%) of the sample were male, while 28.5% were female. The vast majority of participants that presented to the treatment facility were White (81%), 2.2% were Indian, 1.5% were Coloured with 0.7% being African.

Table 4.1: Age, gender and ethnicity

		Count	Column N %
Age (years)	Minimum	18	n/a
	Maximum	43	
	Mean	27.49	
	Std. Deviation	5.19	
Gender	Female	39	28.5
	Male	91	66.4
	Missing	7	5.1
	Total	137	100.00
Ethnicity[1]	African	1	0.73
	Coloured	2	1.46
	Indian	3	2.19
	White	111	81.02
	Other	1	0.73
	Missing	19	13.87
	Total	137	100.00

Figure 4.2 shows that just over a third of the sample was between the ages of 26-30 years.

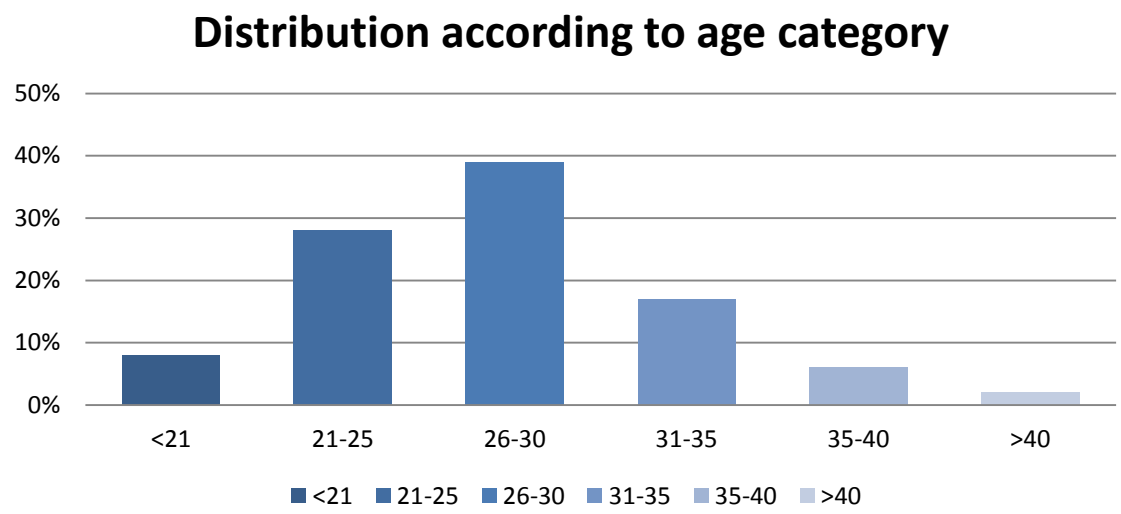


Figure 4.2: Age distribution of participants

[1]*the race categories used are consistent to those used in the study/survey cited.

4.3.3 Participant type

Table 4.2 shows that 97.1% of the persons attending the CTF were athletes. This is to distinguish persons who attended the event from those competing in the events. The remaining sample consisted of non-athletes, such as judges, staff and other medical personnel.

Table 4.2: Frequency of participant type

	Athlete			
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	133	97.1	97.1	97.1
No	4	2.9	2.9	100.0
Total	137	100.0	100.0	

4.3.4 Nature of visit per day

The majority of new patients visiting the treatment facility attended on the second day of the competition. Day three of competition resulted in more repeat visits (10/22) to the treatment facility than new visits (8/22).It must be noted that the majority of the data in Table 4.3 with regards to competition day was missing; this may skew the frequencies presented in Table 4.3.

Table 4.3 reveals an inherent flaw in the UWS CF Games form, as a repeat visit was not coded along with new complaint, but separately as two entries, resulting in a duplication of visits, hence affecting the total number of visits recorded. However, it may be understood that for a new complaint to be recorded, it too would have been recorded as a repeat visit. This requires further enquiry as to reduce any duplication and misinterpretation in future studies.

Table 4.3: Frequency of nature of visit per day

Nature of visit	Competition Day				Total
	One	Two	Three	Missing	
New patient	36	58	8	24	126
Repeat visit	0	3	10	2	15
New complaint	2	8	4	3	17
Missing	1	0	0	3	4
Total	39	69	22	32	162

4.3.5 Patient history of injury

Table 4.4 reflects that 28.4% of participants had a history of previous injury, leaving just under half (49.3%) of the sample without a history of previous injury. It must be noted that 22.2% of the data was missing; this may have skewed the frequencies presented in Table 4.4.

Table 4.4: Frequency of patient history of previous injury

	Count	Column N%
Yes	46	28.40
No	80	49.38
Missing	36	22.22
Total	162	100.00

From the data received it would appear that half of the participants did not have a history of previous injury. A comparison with the study by Wiesenthal *et al.* (2014) was not possible as exact numbers were not reported, though the authors elucidated that the majority of respondents in their study did not have a previous history of pain or discomfort. Hak *et al.* (2013) did not account for history of previous injury in their study.

4.3.6 Discussion

The vast majority of the participants who presented to the treatment facility were between the ages of 22 and 32 years of age (SD=27.4; M=±5.1). It was found that 39% of the participants treated fell within the 26 to 30 year old bracket. This is dissimilar to the study by Weisenthal *et al.* (2014), where results showed that the mean age in their sample was 23.5, yet similar Hak *et al.* (2013) who reported a mean of 32 years. This demonstrates that the mean age reported in this study (27.49) was between the two values detailed in the CF literature.

In the South African context the following was found:

- In the general South African population (Department of Sports and Recreation of South Africa, 2005): 50% of persons who participated in sport were between the ages of 16-20 years of age.
- In recreational half-marathon runners in KZN, South Africa (Ellapen *et al.,* 2013): there was a mean age of 43.6 years
- In Club level gymnasts in the greater Durban area, South Africa (Adamson, 2007): there was a mean age of 13.4.

The local studies mentioned do not seem to be congruent with the age results of this study even though the CF sample presented in this study included running and gymnastic movements which are part of CF and specifically the events of the 2013 UWS CF Games. Reasons for this could include:

- There are no prescribed age restrictions to CF participation while training; however it is unlikely that persons under the age of 18 would participate in a competitive event, due to financial constraints which include belonging to a CF gym requiring a monthly subscription and travel and entry expenses, as well as the logistics of attending a national competition which is not associated with school or other community sports clubs.
- Gymnastics is associated with athletic participation from an earlier age of entry; training for elite male and female gymnasts begins as early as 9 and 6 years old respectively, and performance peaks within 10 years (Caine and Nassar, 2005).
- Exclusion criteria of studies presented. The study on the general SA population was limited to persons over the age of 16 with no upper age limit (Department of Sports and Recreation of South Africa, 2005). Thus even when comparing this study with the one on gymnastics (Adamson, 2007), direct comparisons cannot be made.

The gender distribution of this study favoured the male gender. When one looks at the makeup of teams participating in the 2013 UWS CF Games, which consisted of four male and two female members per team (email Ridgeway personal communication, 2014), it is then consistent with the gender distribution of participants who presented to the CTF. The reported male dominance in this study is

consistent with previous CF studies (Hak *et al.,* 2013; Wiesenthal *et al.,* 2014) which noted that 70.5% and 60.7% respectively of their samples were male. This is further consistent with local studies such as the study conducted on the general population of South Africa which reflected that 42.6% of the males and 11.2% of the females reported that they participated in sporting and recreational activities (Department of Sports and Recreation of South Africa, 2005) and the study by Ellapen *et al.* (2013), which illustrated a 60%:40% male to female distribution in recreational half-marathon runners in KZN.

This however contrasts with club level gymnasts in the greater Durban area, South Africa where Adamson (2007), reported 26.7% male and 73.3% female participation. This contrast may be due to the nature of gymnastics disciplines; in which rhythmic gymnastics is strictly a woman's only sport (Adamson, 2007). The study by Adamson (2007) contained artistic and rhythmic female respondents as well as male artistic respondents.

Further gender differences between studies may be related to limitations of the various studies:

- The age restrictions in terms of participation. For example, the study conducted on the general South African population illustrates less female participation in sport, which can be attributed to the fact that the majority of the sample were between the ages of 21-25 years of age, an age group in which females are less likely to participate in sport due to leaving school and starting a family.
- The location at which the survey was completed. The local studies cited(on club level gymnasts and recreational marathon-runners) were confined to populations in the greater Durban area and KZN, however the current study presents data recorded at a national event with participants travelling from all over South Africa to compete. Thus there could be age differences between different geographical locations around South Africa, their knowledge and utilisation of chiropractic, as well as their propensity to be injured; which could point to the influence of individual CF gym's and trainers to the presentation and frequency of injuries.
- The type of environment in which the study was conducted, namely a general survey of athletes, or a study on injured participants who present to a CTF.

For example the study by Ellapen *et al.* (2013) utilised a self-reported questionnaire to collect data on injuries of half-marathon runners over the preceding 12 months which is more likely to reflect the characteristics of the greater population. This is in contrast to the current study which was performed on individuals seeking chiropractic treatment during a competitive event limiting the characteristics to those with injury.

- Utilisation characteristics of persons seeking chiropractic care. The typical South African patient who utilises chiropractic is female (Mahomed, 2007); this however is not consistent with the gender utilisation patterns presented in this study. This affirms that the gender arrangement in the study sample is dissimilar to that of the normal patient base seen in private chiropractic practice.

From the data presented it is evident that the majority of the participants in this study were White (81.0%). Further comparison in the CF literature was limited as other related studies failed to report racial distribution. It was considered necessary to take racial grouping into account in this study as this was the first study of its kind in South Africa. It was therefore pertinent to develop a biographical profile of CF participants in a growing and emerging sport in South Africa.

Local studies however provide insight into racial distributions in South Africa with regards to sporting populations:

- A study on the general South African population (Department of Sports and Recreation of South Africa) reported the following distributions according to the ethnic group and their active participation in sports and recreation: White (36.6%); African (25.0%); Asian/Indian (24.4%) and Coloured (15.2%).
- Recreational half-marathon runners in KZN, South Africa (Ellapen *et al.,* 2013): White (50%); Indian (33%); African (12%) and Coloured (6%).
- Club level gymnasts in the greater Durban area, South Africa (Adamson, 2007): White (60%); African (23%); Coloured (15%) and Asian (3%).

These local studies are not consistent with the current study as the racial distribution reported is not as disparate, but are similar as the trend is toward a greater White participation. Reasons for this could be:

- The environment in which a study is conducted. As discussed above, the studies conducted on general sporting populations as opposed to the current study which was conducted on participants presenting to a treatment facility during a national competitive event. There will be a disparity between those who train at a gym which would be accounted for in a general survey, compared to those who would attend a national competition; factors which could influence this could be financial, logistical and circumstantial. For example, it is assumed that the high percentage of White participants in this event could be attributed to the fact that they have greater financial flexibility to travel to attend events, as well as the cost of entry into such events.
- The sporting code of CF is a fitness movement developed in North America created to combat the physical ailments faced by the western world, such as obesity. The cultural landscape of western sports participation lends itself to focus on strength training, aesthetic training, and contact sports such as American Football, rugby and ice-hockey. However, in general, the African sporting culture is centred on endurance, agility and economically low cost sports, such as soccer and running. Thus the perception of what constitutes sport may be culturally influenced and therefore may have influenced the dominance of White participation reflected in the current study as it is more culturally familiar to the White population.
- Further to the above, chiropractic utilisation patterns reveal that the typical South African chiropractic patient is White (Mahomed, 2007). This suggests that the participants who presented to the CTF could have been influenced by their perceptions of chiropractic and not necessarily by their injuries.

The utilisation rate of the CTF at the 2013 UWS CF Games was 20.75%; this figure is calculated by dividing the total number of participants treated at the CFT by the total number of participants entered in the UWS CF Games (Junge *et al.,* 2008).The trend of chiropractic utilisation at the CTF is consistent with the overall demographic profile of participants entered in the competition. Conversely, the demographic profile of the typical South African patient who utilises chiropractic is 42 years old, female, and White (Mahomed, 2007). These results are dissimilar to the current study which describes the typical participant who presented to the CTF to be 27 years old, male and White.

The following points could provide insight into the utilisation rates which were reported in the current study:

- Perceptions of chiropractic use in respect to ethnic groups, as discussed previously, resulting in a greater frequency of White participants presenting to the CTF.
- Availability of other health care services such as the presence of massage therapists, qualified chiropractors and mandatory paramedic services; not to mention participants who made use of self-treatment and self-medication, which would result in the decrease of participants making use of the services offered by the CTF.
- Mahomed (2007) found that the age of the typical chiropractic patient was 42 years old and attributed this finding to the fact that musculoskeletal complaints were more frequently associated with increasing age. Yet the majority of participants who made use of the CTF were between the ages of 26 and 30 years of age, which points to the assumption that the involvement in CF by this group of younger participants, and thus their utilisation of the CTF, to be as a result of a focus on elite health and fitness as driven by the Western culture.

From the above it has been shown that the typical CF participant who presented to the CTF was a 27.4 year old, male, White athlete.

4.4 Injury profile

The Second Objective was to determine an injury profile in terms of diagnosis, injury type, location and mechanisms involved.

4.4.1 Region of complaint

Figure 4.3 shows lower limb injuries (34.2%) were the most presented region of complaint, with the shin/calf and knee making up 29/90 and 28/90 respectively (Table 4.5). The most commonly presented region of complaints were the lumbar region (20.9%), wrist/hand (14.4 %), shin/calf (11.0%), knee (10.6%), shoulder (10.2%) and neck (8.7%).

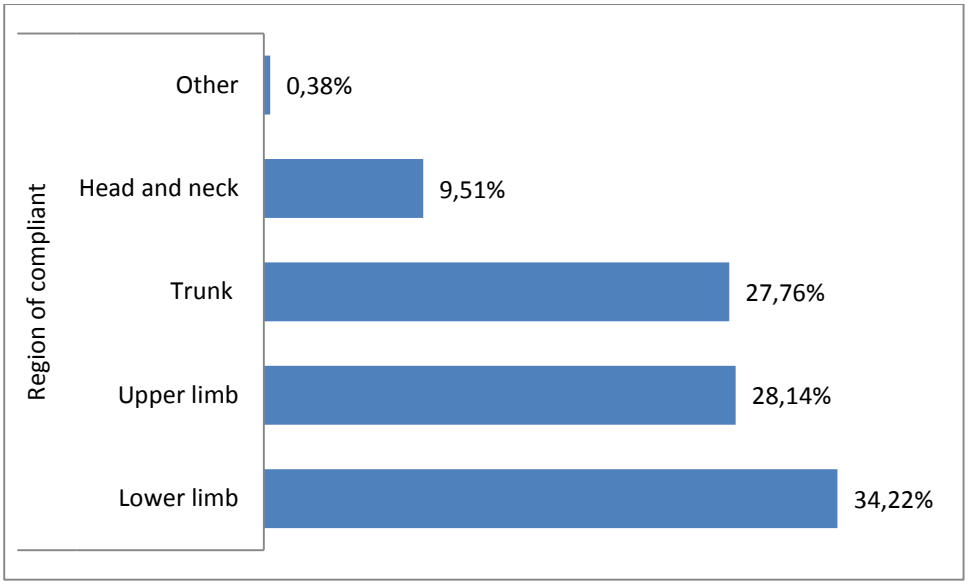


Figure 4.3: Frequency distribution of region of complaint

Table 4.5: Frequency of region of complaint

		Count	Column N %
Head and neck	Head	2	0.76
	Neck	23	8.75
	Total	**25**	9.51
Upper limb	Shoulder	27	10.27
	Elbow	7	2.66
	Forearm	2	0.76
	Wrist/hand	38	14.45
	Total	**74**	28.14
Trunk	Thorax	18	6.84
	Lumbar	55	20.91
	Total	**73**	27.76
Lower limb	Hip	12	4.56
	Thigh	17	6.46
	Knee	28	10.65
	Shin/calf	29	11.03
	Foot/ankle	4	1.52
	Total	**90**	34.22
Other		1	0.38
Total		263	100.00

The site of complaints reported in the current study were to some extent consistent with previous reports by Hak *et al.* (2013) and Wiesenthal *et al*. (2014) who reported that the most common injury locations were the shoulder, spine, low back, knee and arm/elbow.

The results of this study corresponded with the CF literature which showed a dominance of low back injuries (Hak *et al.,* 2013; Wiesenthal *et al.,* 2014). Ellapen *et al*. (2013) reported the prevalence of low back/hip injury among 15.8% of runners, which is a unique finding with regards to previous running literature as low back pain is not a commonly reported injury. This finding of a high number of low back complaints is however consistent with published work on gymnastics, in which athletes commonly experience low back complaints (Kruse and Lemmen, 2009). Similar trends for low back pain have been described for Olympic and power lifters (Lavallee and Balam, 2010). The prevalence of low back pain among CF athletes requires further study, as the use of high intensity, high repetition, complicated techniques and heavy weights may create opportunities for the development of low back pain and injury (Hak *et al.,* 2013).

Wrist/hand complaints represented the second most frequently recorded region of compliant, whereas the CF injury literature at the time of the study did not feature wrist/hand injuries as being frequently reported in their surveys (Hak et al., 2013; Wiesenthal *et al.,* 2014). A possible explanation for this could be the nature of the events encountered during the 2013 UWS CF Games, which incorporated a considerable amount of 'holding' exercises, such as pull-ups, kettlebell swings, deadlifts and muscle ups. In the field of strength training, wrist/hand complaints are commonly caused by the deadlift (powerlifting), snatch and clean and jerk (Olympic weightlifting); particularly due to callous tears (Lavelle and Balam, 2010).

The lower limb area was reported as having the most injuries as a collective group (lower limb area is made up of the hip, thigh, knee, shin/calf and foot/ankle). The shin/calf and knee consisted of the majority of complaints in this group. The shin/calf region was also noted as being the third most reported region of complaint in this study. The knee has been described in the CF literature as being a common area of complaint, whereas the shin/calf has not (Hak *et al.,* 2013; Wiesenthal *et al.,* 2014). The knee complaints may be due in part to heavy weights which put significant and

extreme stress on joint structures (Lavelle and Balam, 2010). However, the shin/calf is a common region of complaint in endurance sports such as running (Taunton *et al.,* 2002; Ellapen *et al.,* 2013; Nielsen *et al.,* 2013). Ballistic-type lifts such as the snatch and clean and jerk focus on the rapid movement of heavy weights. Great stress is placed on the soft tissue structures leading to strains, thus there is a greater risk of momentum and inertia-related injuries (Lavelle and Balam, 2010). The mix of ballistic style lifting and endurance type running which occurs in CF events may put an athlete at a greater risk of injury.

4.4.2 Mechanism of injury

Table 4.6 shows the distribution of complaints according to mechanism of injury. The highest mechanism of injury was that of overuse, consisting of 22.4% of all injuries. Running presented 19.0%, followed by competition (14.0%), prevention (8.7%) and pull-ups (5.3%).

Table 4.6: Frequency of mechanism of injury

		Count	Column N %
Trauma		9	3.42
Overuse		**59**	22.43
Idiopathic		7	2.66
Lifting	Push-press	7	2.66
	Squat	6	2.28
	Deadlift	2	0.76
	Total	15	5.70
Gymnastics	Pistol squat	5	1.90
	Pull-ups	14	5.32
	Handstandpush-up	0	0.00
	Fall from handstand push- up	2	0.76
	Total	21	7.98
Competition	Competition	34	12.93
	Burpees and squats	3	1.14
	Total	**37**	14.07
Non-traditional	Kettlebells	3	1.14
	Burpees	4	1.52
	Ball-slam	2	0.76
	Total	9	3.42
Running	Running	**50**	19.01
Other	Postural	2	0.76
	Rugby	5	1.90
	Preventative *	23	8.75
	Total	**30**	11.41
Missing		26	9.89
Total		263	100.00

*see definitions section in the preamble

The mechanism of injury as used in this study, describes the perceived inciting event; this provides insight into the causes of a particular injury in a given sport (Bahr and Krosshaug, 2005). It was identified that 22.4% of injuries were as a result of

overuse mechanisms; the term overuse is defined as an injury without a specific, identifiable cause as a result of repetitive micro-trauma (Clarsen *et al.,* 2013).

Overuse mechanisms predominantly involve monotonous exercises such as running, or technical movement patterns that demand repetition in order to perfect specific form, such as cricket (Clarsen *et al.,* 2013). CF is well known for excessive repetition ranges compared to accepted standards, which involves repetition ranges such as 8-12 (Garber *et al.,* 2011). The athletes of the 2013 UWS CF Games encountered repetition ranges between 20-500, as well as performing movements against the clock, i.e. for time. Hak *et al*. (2013) believes these high repetition ranges may contribute to the injuries seen in CF.

In the study by Wiesenthal *et al*. (2014), it was found that power lifting (N=19/84), gymnastics (N=17/84) and “not associated” (N=16/84) accounted for the majority of movements performed which resulted in injury. It was not clear as to the meaning or what comprised “not associated”. The current study found that just 5.7% of complaints were reported to be caused by lifting mechanisms, 7.9% were caused by gymnastics movements and 14.0% were due to competing in the events of the UWS CF Games. Due to the inconsistencies with regards to the grouping of mechanisms and movements performed, comparisons between the study by Wiesenthal *et al*. (2014) and the current one were not possible.

Running was frequently reported as being the cause of complaints by participants who visited the CTF. The type of running encountered in the 2013 UWS Games (Table 2.1) involved a four kilometre trail run loop with obstacles which were completed four times by each team, as well as shuttle runs. This is in contrast to the survey by Wiesenthal *et al*. (2014) which found that endurance contributed the least to injury (N=5/84), and the endurance category was made up of a collective group of rowing, running and sprints.

Anecdotal evidence suggests that the participants at the 2013 UWS CF Games reported that the trail run was the most strenuous atypical activity encountered throughout the duration of the event. Trail running can be said to be outside that of the normal training program followed by the majority of CF participants, which usually includes shorts sprints and shuttle runs. Therefore, it is suggested that

further research or development of questionnaires should include the distinction of type and nature of endurance activity.

The term “competition” used as a type of mechanism of injury, described the overall participation in the 2013 CF UWS CF Games; this group also included the combination of burpee’s and squats. It seems reasonable that the combined effects of events done in a competitive environment as well as the arrangement of different disciplines would result in a good portion of participants presenting to the CTF with complaints. This premise, that there is a higher risk of injury during competition, is accepted in sport injury epidemiology (Murphy *et al.,* 2003; Kellmann, 2010; Lund and Myklebust, 2011; Maffulli *et al.,* 2011; Winwood *et al.,* 2014).

A further explanation for the relatively high portion of this perceived mechanism might be as a result of poor recall by the participants during questioning by senior students, seeing that athletes are performing multiple events per day, which consist of different movements executed in rapid succession in a competitive environment. This could have created difficulty in determining the exact mechanism of injury, resulting in participants misattributing ‘competition’ as the cause of their complaint.

Further research is needed to explore the injury incidence during both training and competition in order to study the role a competitive environment places on CF participants, as it has been suggested by Murphy *et al.* (2003) that behaviours in competition take on an aggressive and high risk attitude, which in turn may increase the risk of injury.

4.4.3 Clinical impression

Table 4.7 shows that acute injuries accounted for 59.32% of all injuries, with the remaining 22.81% being chronic injuries.

Table 4.7: Frequency of clinical impression

	Count	Column N%
Acute	156	59.32
Chronic	60	22.81
Missing	47	17.87
Total	263	100.00

Most reported injuries in this study appear to be of an acute nature, also in view of the fact that the majority of participants reported no history of previous injury. This confirms the accepted premise which states that participating in competition represents a high risk situation for injury (Murphy *et al.,* 2003; Kellmann, 2010; Lund and Myklebust, 2011; Maffulli *et al.,* 2011; Winwood*et al.,* 2011). However, it has been proposed that level of competition has an effect on the nature of injury; Caine and Nassar (2005) have examined studies which report that elite athletes suffer a greater proportion of chronic injuries than recreational athletes. The participants of the 2013 UWS CF Games consisted of teams who were not all elite athletes, thus it can be assumed that because of this, more acute injuries were reported. Due to the fact that this is the first injury profile to be conducted on injury data during a competitive CF event, no further discussion relating to the CF literature is possible.

In the previous section on mechanisms of injury (section 4.7.2) it was reported that overuse mechanisms, viewed as chronic in nature in sports medical literature (Clarsen *et al.,* 2013), were the most commonly noted cause of complaints in the study, which is in opposition to the majority of acute findings in Table 4.7. These indistinct terms however may suggest that the majority of complaints are actually acute on chronic in nature, which could explain the acute nature of an overuse injury seen in this study. In section 4.6.5 (patient history of injury), it was shown that the majority of participants who presented to the CTF did not have a history of previous injury. This may be due to the fact that subclinical complaints (those complaints that do not warrant time off or modification of training), are not perceived as a reportable injury, however these ‘niggles’ could be viewed as the establishment of an overuse complaint.

4.4.4 Diagnosis

Table 4.8 shows that the vast majority of injuries presented to the treatment facility were of a muscular origin, with myofascial trigger points (MFTP) making up 21.6% of all injuries, followed closely by 19.7% of injuries consisting of muscle strains. Facet syndromes of the spinal column accounted for 13% of diagnoses. It must be noted that 8.7% of the data was missing; this may have skewed the frequencies presented in Table 4.8.

Table 4.8: Frequency of diagnosis

	Count	Column N %
MFTP	57	21.67
Muscle Strain	52	19.77
Missing	23	8.75
Laceration	18	6.84
L-facet	16	6.08
Joint Sprain	14	5.32
DOMS	13	4.94
Asymptomatic	13	4.94
SI Syndrome	12	4.56
C-facet	9	3.42
Tendonitis	8	3.04
T-facet	6	2.28
ITBS	5	1.90
MTSS	4	1.52
Rotator cuff syndrome	3	1.14
Abrasion	2	0.76
Meniscal injury	2	0.76
Joint instability	2	0.76
Head/concussion	1	0.38
Contusion	1	0.38
Nerve Entrapment	1	0.38
Nerve entrapment and muscle strain	1	0.38
Total	263	100.00

The vast majority of diagnoses made at the 2013 UWS CF Games consisted of muscular injuries, including trigger points, muscle strains, delayed onset muscle soreness (DOMS) and contusions (in order of most frequent to less frequent). As a muscle is required to contract repetitively during high intensity physical activity such as CF, the repetitive motion required of the body during events results in fatigue and musculoskeletal pain (Coetzee, 2013).

Fatigue causes alteration of muscle recruitment patterns which in turn modifies the distribution of forces across different soft tissues structures related to a joint (Murphy *et al.,* 2003). This may have played a role in the frequency of muscular injuries which presented in this study. Another possible explanation for the high frequency of MFTP

and strains was that data recording was performed by senior students, who have a vast knowledge of MFTP's and muscle anatomy.

However, the definition of the term muscle strain remains unclear though frequently used with high variability to describe muscle injury (Mueller-Wohlfahrt *et al.,* 2012). Therefore without data on severity, the diagnosis of muscle strains in the current study remains vague. On the other hand, a diagnosis of MFTP presents a precise definition and clinical presentation of 'a discrete, focal, hyperirritable knot located in a tight band of skeletal muscle' (Travell and Simons, 1983; Chaitow and DeLany, 2002; Dommerholt *et al.,* 2006).

Several studies on a variety of sporting codes have shown a high frequency of muscular complaints. In a study on running injuries, Malisoux *et al.* (2014) found that the majority of running related injuries affected muscles. Similar trends have been reported in the gymnastics literature, which demonstrate that muscle sprains are consistently shown to be the most common injury type (Caine and Nassar, 2005; Kruse and Lemmen, 2009). Data from the strength training disciplines suggest that the most commonly reported injuries are muscular strains (Quatman *et al.,* 2009; Lavelle and Balam, 2010). Muscular functional deficits whether trigger points or strains, results in biomechanical changes in sports performance leading to pain and dysfunction (Kruse and Lemmen, 2009). Thus it is of clinical importance to further investigate muscular injuries sustained during CF and their influence on future injury.

Spinal complaints are commonly associated with particular groups of sports, such as heavy-weight lifting, gymnastics, wrestling, soccer and tennis (Maffulli *et al.,* 2011) and facet joints are accepted sources of pain (Manchikanti *et al.,* 2004). Spinal joint complaints accounted for 13% of all diagnoses which presented to the CTF.This may be attributable to the fact that chiropractors are trained to identify and treat spinal joint dysfunction (Conradie, 2013).

4.4.5 Summary of injury profile

The cause of injury is multifactorial in nature with numerous factors being implicated; furthermore the interactions of these factors are complex (Bahr and Holme, 2003).The findings in this study illustrate a representation of CF injuries in

accordance with injuries seen in the contributing disciplines, which are combined to form the heats and events encountered by participants.

The typical participant who presented to the CTF complained of pain or dysfunction in the lumbar region, as a result of overuse mechanisms particularly relating to acute on chronic MTPS or muscle strain diagnosis.

4.5 Injury profile cross tabulations

The following cross tabulations are presented to explore any associations with regards to the different mechanisms of injury recorded.

4.5.1 Region of complaint and mechanism of injury

As can be seen from Table 4.9, overuse mechanisms predominated across all regions of complaint. However, the lower limb and trunk injuries were reported to be mainly as a result of running rather than overuse mechanisms. A considerable portion of upper limb injuries were attended to at the CTF for preventative reasons, which accounted for the majority of the category 'Other' in Table 4.9. Besides a high frequency of overuse and preventative mechanisms, gymnastic movements accounted for a significant portion of upper limb complaints. Overall participation in competition accounted for between 15-17% of complaints for head and neck, trunk and lower limb regions.

Table 4.9: Cross tabulation of region of complaint and mechanism of injury

Mechanism of injury	Region of complaint					
	Head and neck	Upper limb	Trunk	Lower limb	Missing	Total
Trauma	0	7	1	1	0	9
Overuse	10	15	12	**22**	0	59
Idiopathic	0	1	3	3	0	7
Lifting	2	2	7	4	0	15
Gymnastics	0	14	0	5	0	19
Competition	4	6	13	14	0	37
Non-traditional	0	6	3	0	0	9
Running	1	2	**20**	**26**	1	50
Other	6	**17**	5	4	0	32
Missing	2	4	9	11	0	26
Total	25	74	73	90	1	263

4.5.2 Region of complaint and clinical impression

Table 4.10 shows the majority of complaints were of an acute nature irrespective of region of complaint. It must be noted that 25.6% of the data was missing in the upper limb category; this may have skewed the frequencies presented in Table 4.10 with regards to the acute or chronic nature of upper limb injuries.

The current study found that the foot/ankle was the only anatomical region with a greater number of chronic complaints than acute complaints. This is consistent with the current body of knowledge which states that athletes with ankle injuries are more likely to suffer recurrent sprains and develop chronic ankle instability (Clanton *et al*., 2012; Doherty *et al.,* 2013). Therefore, it can be speculated that participants who presented to the treatment facility with ankle complaints did so due to disruption of joint position sense, muscle activation patterns and changes in joint movement, which occurred as a result of prior ankle injuries (Lin *et al.,* 2012).

The lower limb region was predominately made up of shin/calf and knee complaints. Table 4.10 shows that over half of the lower limb injuries were of an acute nature, which can be further interpreted as being mainly shin/calf and knee injuries. This may be attributed to the presence of the above mentioned chronic ankle complaints which could have resulted in negative compensation mechanisms and thus predisposed the lower limb and kinematic chain to acute injury.

As mentioned in section 4.7.2 (mechanism of injury), the trail running event was anecdotally communicated as an atypical activity not commonly encountered in training, which may have predisposed those with previous ankle complaints or chronic overuse injuries to subsequent injury. Thus it is of clinical relevance to investigate in future studies the effects of poor conditioning, insufficient progression and inadequate rehabilitation which could result in injury (Lubbe *et al.,* 2014).

Table 4.10: Cross tabulation of region of complaint and clinical impression

Clinical impression	Region of complaint					
	Head and neck	Upper limb	Trunk	Lower limb	Missing	Total
Acute	14	45	46	**51**	0	156
Chronic	8	10	17	**24**	1	60
Missing	3	19	10	15	0	47
Total	25	74	73	90	1	263

4.5.3 Mechanism of injury and clinical impression

Table 4.11 shows that the majority of acute injuries were caused by competition and running, followed by overuse and gymnastic type mechanisms. Interestingly, 15% of acute injuries were recorded to have been caused by overuse mechanisms. Chronic injuries were recorded as being frequently caused by overuse (51%) and running (25%) mechanisms.

This cross tabulation (Table 4.11) brings to light inherent classification errors, as there is confusion as to the accuracy of the term: acute overuse injury. Overuse injuries are considered chronic, however it was reported in the current study that 35% of overuse injuries were acute in nature. Perhaps this misunderstanding can be attributed to the fact that there remains inadequate published consensus of definitions that adequately categorise all forms of sports injury (Finch and Cook, 2013). Thus it was considered adequate to label such complaints as acute on chronic as discussed in section 4.7.3.

Table 4.11: Cross tabulation of mechanism of injury and clinical impression

Mechanism of injury	Clinical Impression			
	Acute	Chronic	Missing	Total
Trauma	8	1	0	9
Overuse	21	**29**	9	59
Idiopathic	7	0	0	7
Lifting	13	0	2	15
Gymnastics	17	0	2	19
Competition	**29**	1	7	37
Non-traditional	8	1	0	9
Running	**29**	17	4	50
Other	7	8	17	32
Missing	17	3	6	26
Total	156	60	47	263

4.5.4 Mechanism of injury and diagnosis

Table 4.13 shows the relationship between the recorded diagnoses and mechanism of injuries according to the complaints which presented to the CTF at the 2013 UWS CF Games. Overall, MFTP were noted to be frequently associated with overuse, idiopathic, lifting, competition and running mechanisms of injury. Trauma resulted in lacerations (55.5%), and equal numbers of joint sprains, abrasion, T-facet and contusion (11.1%) diagnoses. Over and above MFTP (40%), DOMS (13.3%) presented more frequently than muscle strains (6.6%) due to lifting. Gymnastics resulted in lacerations (47.3%), muscle strains (16.2%) and MFTP (10.5%). Competition resulted in MFTP and muscle strain, and C-facet. However a considerable proportion of the data in the competition category was missing, which may skew the frequencies presented. Running resulted in MFTP and muscle strains in equal distribution, followed by L-facet and SI syndrome, as well as ITBS. The mechanism of injury category “other” comprised mostly of “preventative” resulted in 40% of the related diagnoses as asymptomatic.

Table 4.12: Cross tabulation of mechanism of injury and diagnosis

Diagnosis	Mechanism of injury										
	Trauma	Overuse	Idiopathic	Lifting	Gymnastics	Competition	Nontraditional	Running	Other	Missing	Total
Head/ concussion	0	0	0	0	0	0	0	0	1	0	1
C-facet	0	0	0	1	0	4	0	1	2	1	9
Tendonitis	0	2	0	1	1	0	0	1	1	2	8
MFTP	0	**18**	3	6	2	7	2	**11**	1	7	57
DOMS	0	2	0	2	0	0	0	2	0	7	13
Joint sprain	1	3	1	1	0	3	2	2	0	1	14
Abrasion	1	0	0	0	0	0	0	0	1	0	2
T-facet	1	0	0	1	0	2	0	1	1	0	6
Muscle strain	0	**21**	1	1	4	6	3	**11**	3	2	52
Contusion	1	0	0	0	0	0	0	0	0	0	1
SI Syndrome	0	2	1	0	0	0	1	6	2	0	12
Laceration	5	0	0	0	9	2	1	0	0	1	18
L-facet	0	2	1	0	0	3	0	8	1	1	16
MTSS	0	2	0	0	0	0	0	1	1	0	4
Meniscal injury	0	0	0	0	0	2	0	0	0	0	2
ITBS	0	0	0	0	0	1	0	4	0	0	5
RCS	0	2	0	0	0	0	0	0	1	0	3
Joint instability	0	1	0	0	0	0	0	0	1	0	2
Nerve entrapment	0	1	0	0	0	0	0	0	0	0	1
Nerve entrapment and muscle strain	0	0	0	0	1	0	0	0	0	0	1
Asymptomatic	0	0	0	0	0	0	0	0	**13**	0	13
Missing	0	3	0	2	2	7	0	2	3	4	23
Total	9	59	7	15	19	37	9	50	32	26	263

4.5.5 Summary

Section 4.5 provided cross tabulations which confirmed earlier findings discussed in section 4.4 with regards to frequencies and distributions.

The current study demonstrates a higher frequency of lower limb injuries and trunk injuries as a result of running. Similarly, the study by Weisenthal *et al.* (2014), which used a self-reported survey, found that of the endurance related injuries, all were found to be in the lower limb of CF athletes. The literature on running states explicitly

that lower limb injuries are the most common injuries sustained (Ellapen *et al.,* 2013; Malisoux *et al.,* 2014), which clarifies why lower limb injuries were associated with running rather than overuse mechanisms in the current study.

However, the trunk (spinal) region is not typically reported as a frequently occurring region of complaint in the running literature. For example, a retrospective analysis of 2002 running injuries revealed that the low back was the seventh most common injury location, and the thoracic region was not reported on (Taunton *et al.,* 2002). Likewise, in a study conducted on recreational half-marathon runners, using a self-reported survey, the low back and hip were grouped together and expressed as the third most frequent anatomical site (Ellapen *et al.,* 2013), while the thoracic region did not feature. The high frequency of spinal, specifically lumbar complaints may be attributed to pre-existing lower limb injuries such as chronic ankle injuries reported and the atypical type of running encountered, whose interaction may have resulted in kinematic chain disturbances, which has been associated with low back pain (Gilbert, 2004).

In addition to this, Table 4.12 shows the presence of various diagnoses (ITBS, MTSS and tendonitis) associated with running andwhich have been described in the literature as chronic overuse injuries (Maffulli *et al.,* 2010; Baker *et al.,* 2011; Brewer and Gregory, 2012) which may be as a result of the long term effects of chronic ankle injuries, and unaccustomed participation in atypical exercises such as the trail running event.

The term ‘preventative’ was used to code for participants who presented to the 2013 UWS CF Games for prophylactic reasons, and represented a large part of the ‘other’ category. The most likely reason for this was the availability of free kinesiotape applied at the CTF, which is commonly used among CF athletes (Rocktape, 2014). Kinesiotape has been endorsed as having the following in-competition uses: the protection of hand and wrists during lifting and suspension exercises; correction of improper tracking of the knee and shoulder; reduction of swelling; delayed fatigue by the promotion of blood flow; as well as stabilisation of soft tissue structures (Rocktape, 2014).

In addition, if participants were aware of the scope of chiropractic, as driven by an individual’s perception of chiropractic (discussed in section 4.3.6), they would have

presented to the CTF seeking chiropractic care, despite the fact that they were asymptomatic.

Relating to upper limb complaints in the current study, gymnastics was found to be a large contributor to complaints of this region. This finding is consistent with the gymnastics literature which describes how the upper limb is used as a weight bearing limb; however ill-adapted to this task; this results in an anatomical region that is frequently injured (Caine and Nassar, 2005; Adamson, 2007).

From the above the current study demonstrates that the individual sporting codes involved in the events of the 2013 UWS CF Games did not influence the majority of complaints which presented to the CTF, however the injuries of which they were the perceived cause do relate to previous injury profiles of those sports, e.g. gymnastics causing upper limb injuries. However running was a major contributor to participants presenting to the CTF. Thus further investigation is warranted to explore associations between running and injury in CF.

4.6 Treatment profile

The Third Objective was to determine the treatment profile used in the management of participants who presented to the CTF.

4.6.1 Distribution of treatment options utilised

Table 4.13 reveals that kinesiotape, manipulation, massage and ischemic compression were the top treatment interventions utilised at the CTF. It was also shown that rest, ice and referrals outside of the CTF were types of treatment that were not utilised.

Table 4.13: Distribution of treatment options utilised

	Count	Column N%
Kinesiotape	114	23.65
Manipulation	107	22.20
Massage	77	15.98
Ischemic Compression	62	12.86
Dynamic stretch/PNF	55	11.41
Dry Needling	24	4.98
Joint Strapping	15	3.11
Static Stretch	10	2.07
Disinfect	10	2.07
Mobilization	3	0.62
Cross friction	3	0.62
Iceman	2	0.41
Rest	0	0.00
Ice	0	0.00
Referral	0	0.00
Total	482	100.00

4.6.2 Treatment options utilised according to region of complaint

Table 4.14 illustrates the distribution of treatments for each specific region of complaint. It is further confirmed that manipulation and kinesiotape were the preferred form of treatment irrespective of the body part treated. Table 4.14 also confirms the full body nature of treatments provided by senior students at the CTF, though it is apparent that the trunk region (made up of the thoracic and lumbar spine) constituted the largest number of treatments (11% of all treatments), followed closely by kinesiotaping of the upper limb which made up 10.3% of all treatments.

Table 4.14: Distribution of treatment options according to region of complaint

	Region of Complaint					
	Head and neck	Upper limb	Trunk	Lower limb	Missing	Total
Manipulation	20	15	**53**	19	0	107
Mobilization	0	0	0	2	1	3
Massage	5	15	27	30	0	77
Stretch	7	6	22	19	1	55
Dry needling	5	6	11	2	0	24
Static Stretch	1	1	5	3	0	10
Ischemic Compression	13	6	23	20	0	62
Kinesiotape	8	**50**	22	34	0	114
Joint Strapping	0	3	0	12	0	15
Crossfriction	0	2	0	1	0	3
Iceman	1	1	0	0	0	2
Disinfectant	0	10	0	0	0	10
Total	60	115	**163**	142	2	482

4.6.3 Treatment options utilised according to diagnosis

Table 4.15 outlines each individual treatment modality and the associated diagnoses.

Table 4.15: Distribution of treatment options according to diagnosis

Diagnosis	Treatment options												
	Manipulation	Mobilization	Massage	Stretch	Dry needling	Static stretch	Ischemic compression	Muscle strapping	Joint strapping	Cross friction	Iceman	Disinfectant	Total
Head/ concussion	1	0	0	0	0	0	0	0	0	0	0	0	1
C-facet	9	0	3	5	3	1	4	2	0	0	1	0	28
Tendonitis	2	0	2	3	1	1	1	2	3	2	0	0	17
MFTP	**29**	0	**22**	17	10	3	20	**23**	0	0	0	0	124
DOMS	2	0	9	4	0	0	9	3	0	0	0	0	27
Joint sprain	3	1	3	1	0	0	1	1	7	1	0	0	18
Abrasion	0	0	0	0	0	0	0	2	0	0	0	1	3
T-facet	5	0	0	3	2	0	3	2	0	0	0	0	15
Muscle strain	**28**	2	**23**	7	5	1	11	**22**	1	0	0	0	100
Contusion	0	0	0	0	0	0	0	0	0	0	0	0	0
SI Syndrome	11	0	2	7	1	2	5	4	0	0	0	0	32
Laceration	0	0	0	0	0	0	0	17	0	0	1	9	27
L-facet	15	0	7	5	2	2	6	6	0	0	0	0	43
MTSS	0	0	0	0	0	0	0	4	0	0	0	0	4
Meniscal injury	0	0	0	0	0	0	0	0	1	0	0	0	1
ITBS	0	0	3	2	0	0	1	4	0	0	0	0	10
RCS	0	0	2	0	0	0	0	2	1	0	0	0	5
Joint instability	0	0	0	0	0	0	0	0	2	0	0	0	2
Nerve entrapment	0	0	0	0	0	0	0	1	0	0	0	0	1
Nerve entrapment and muscle strain	1	0	1	0	0	0	0	1	0	0	0	0	3
Asymptomatic	0	0	0	0	0	0	0	13	0	0	0	0	13
Missing	1	0	0	1	0	0	1	5	0	0	0	0	8
Total	107	3	77	55	24	10	62	114	15	3	2	10	482

4.6.4 Discussion

The treatments provided in this study reflect the nature and extent of injuries which occur as a result of CF. Chiropractors who treat athletes and provide their services at sporting events require a skilled knowledge of injury epidemiology, injury mechanisms, risk factors and appropriate treatment protocols (Julian *et al.,* 2010). The current study shows how the CTF provided a variety of treatments which were able to address acute and chronic pain, inflammation, dysfunction and the prevention of injuries.

It was demonstrated that treatments during the 2013 UWS CF Games involved predominantly the use of kinesiotape, manipulation, and massage (in order of greatest frequency to least; Table 4.13). However, a wide variety of treatment options were used to provide care to participants which are within the scope of practice for chiropractic in South Africa (AHPCSA – Act 63 of 1982 (as amended)).It was recorded that 482 treatments were performed to care for 163 complaints; this illustrates that on average there were 2.9 treatment modalities utilised per complaint.

Findings demonstrate that the use of kinesiotape accounted for 23.65% of all treatments utilised (Table 4.13), which is slightly higher than the chiropractic standard treatment; the adjustment (manipulation). These findings (though unusual as one would expect more manipulations to be performed at a CTF than any other treatment option), are possibly explained by the fact that kinesiotape was freely available, as well as due to a lesser number of reported joint dysfunctions which are commonly treated by manipulation. It can be seen that senior students at the CFT did not simply resort to the standard treatment of adjustment, but rather provided appropriate care to participants by taking into account their complaint and diagnoses. This is also in line with previous findings in section 4.4.4 whereby the majority of complaints were diagnosed as muscular, accounting for a large number of soft tissue techniques used (Table 4.13) such as kinesiotape, massage, ischemic compression and dry needling. These techniques are in line with accepted treatment protocols for soft tissue injury (Simons *et al.,* 1999).

Dry needling, though commonly utilised in clinical practice and in the management of muscular injuries was not frequently utilised in the current study. A possible explanation for this is the fact that needling is an invasive form of treatment and not recommended for the treatment of MFTPs when a participant is actively involved in competition. This is due to the residual effects of dry needling, which are known to be post-dry needling soreness, bruising, and activation of the inflammatory process (Maruggie, 2014).

In a study conducted on chiropractic management at the World Ice Hockey Championships of the New Zealand team by the team chiropractor (Julian *et al.,* 2010), it was reported that manipulation (119/337) was the most frequently employed treatment followed closely by soft tissue massage techniques (107/337), whereas

strapping (6/337) was not frequently used in the treatment of athletes. These findings are similar to the current study which highlights the use of manipulation as well as massage; however it was in contrast to the current studies utilisation figures for the use of kinesiotape. However the study is conducted on data recorded by a single team chiropractor during the pre-event tour, training camp and competition spanning four weeks. Thus the treatment detailed in the study by Julian *et al.,* (2010) illustrates the continuous management of ice-hockey athletes, which is unlike the current study.

It was also noted that rest, ice and outside referral were not utilised as forms of participant management. An explanation as to why rest was not employed could be due to the nature of the injuries being minor. Although the severity of injury was not recorded in the UWS CF Games form, it can be extrapolated that all injuries presenting to the CTF were minor and did not prevent the participant from continuing their involvement in the Games. This could be attributable to the presence of paramedic services, close proximity of a private hospital as well as participants taking care into their own hands. In addition to this, as all participants' cases and treatments were discussed with a qualified clinician, it can be suggested that no outside referrals were recorded as it was not deemed necessary by the senior student and attending clinician. This further verifies that the injuries treated at the CTF were not of a severe nature; however this does not imply that no severe injuries occurred during the event. It is thus recommended that future studies conducted at sporting events include injury reports from all medical staff servicing the event.

Cryotherapy, though a widely used modality in sports treatment was not utilised. This is due to the CTF not having the facilities to keep ice, as well as ice baths being provided (outside of the CTF), by organisers for the participants to make use of (email Ridgeway personal communication, 2014). It must be added that senior students would have advised participants to use ice in order to reduce pain and inflammation, however it was not coded as such. Thus it must be suggested that if advice was given it should be recorded as such on the report form.

It was also noted that a greater proportion of kinesiotaping was utilised in the upper limb region (Table 4.10.2), and it was found that there were significantly less upper limb complaints (Table 4.5). A possible explanation for this and opportunity for

further research would be that perhaps the use of the kinesiotape resulted in fewer complaints to areas where the kinesiotape was more utilised.

Table 4.15 shows that MFTPs and muscle strains made up the high frequency diagnoses treated by manipulation, massage and kinesiotape. The use of manipulation is validated in that it has been shown to provide optimal muscle function and stability of the spine while improving the ability of a muscle to contract and stretch (Conradie, 2013).

The frequency with which massage was utilised was also validated as it is widely used in the treatment of soft tissue injuries (Travell and Simons, 1983; Chaitow and Delany, 2002). The effect of kinesiotape strapping for muscular complaints is currently a contentious topic (Firth *et al.,* 2010; Álvarez-Álvarez *et al.,* 2013; Drouin *et al.,* 2013); however the frequency of its use in the current study was previously discussed (section 4.6.1). Additional treatments of muscular complaints consisted of the following: ischemic compression, dynamic stretch/PNF and dry needling.

Table 4.15 illustrates that manipulations were utilised not only to treat muscular complaints but also facet syndrome and sacroiliac syndromes as well as a case of head trauma/concussion, DOMS, joint sprain and nerve entrapment with concomitant muscle strain.

The current study demonstrates the wide range of diagnoses in which kinesiotape was utilised. Besides the already mentioned MFTP's and muscle strains, kinesiotape was used to treat a large portion of lacerations, and asymptomatic visits to the CTF. A possible explanation for these occurrences may be linked to the use of kinesiotape prophylactically to avoid lacerations. A common area for lacerations to occur was in the hand/wrist area, where it is common for calluses to develop and there is a high likelihood of tearing. However, this was not the only use of kinesiotape of participants who presented to the CTF as asymptomatic.

A paper published in 2009 highlighted key aspects of appropriate care by sports chiropractor's for the management of athletic injuries (Hoskins *et al.,* 2009). The treatment provided in the current study coincides with the criteria presented in the 2009 paper. Treatments were multimodal in nature; characterised as that which is not only manipulation-centred treatment but also provides soft tissue therapies.

Although short treatment times of 15-20 minutes (which was not measured in this current study) were used, it is reasonable to suggest that the shorter than 5 minute treatment intervals was not a feature of treatments at the CTF, and that shorter treatment times are not acceptable as being adequate for the assessment and treatment of athletes (Hoskins *et al.*, 2009). No mandatory X-rays were required, no treatment schedules were needed as the CTF was freely available to the participants. The final characteristic Hoskins *et al.* (2010) presented in their paper as a key principle was the use of medical terminology and diagnoses. This is evident in the current study by the use of the UWS CF Games form, which is a standardised medico-legal form for the use of injury recording.

Section 4.6 therefore presents a detailed description of the treatments provided at the 2013 UWS CF Games CTF, which were multimodal in nature and incorporated the treatment of all body regions, bar the chest and abdomen. Kinesiology tape as well as manipulation and massage were the most commonly used methods of treatment.

4.7 Cross tabulations between demographic and injury profiles

The Fourth Objective was to determine associations between demographic and injury profiles. Due to the presentation of multiple complaints per participant, analysis of the data in this section pertains exclusively to participants' first visit to the CTF in order to avoid clustering of demographic variables. Additionally, due to missing injury data with regards to one participant, the sample size (n) is equal to 136, and not the original sample size of 137. Kindly note that statistical significance tests were not possible due to zero figures (no reported findings) and large tables. Thus this section is purely descriptive, showing patterns which might highlight areas for further study.

Table 4.16: Cross tabulation of age groups and region of complaint

Region of Complaint	Age groups							
	<21	21-25	26-30	31-35	36-40	>40	Missing	Total
Head and neck	3	3	2	2	0	0	1	11
Upper limb	5	12	**20**	7	3	0	3	50
Trunk	1	6	11	7	3	0	0	28
Lower limb	2	15	**19**	7	2	2	0	47
Total	11	36	52	23	8	2	4	136

Table 4.17: Cross tabulation of age groups and mechanism of injury

Mechanism of injury	Age group							
	<21	21-25	26-30	31-35	36-40	>40	Missing	Total
Trauma	2	1	2	1	2	0	0	8
Overuse	0	**11**	**14**	8	2	0	2	37
Idiopathic	0	1	1	1	0	0	0	3
Lifting	1	1	1	0	1	0	0	4
Gymnastics	0	2	6	0	1	0	1	10
Competition	1	3	4	2	0	0	1	11
Non-traditional	0	3	2	0	0	0	0	5
Running	1	7	7	4	1	1	0	21
Other	4	3	8	4	0	0	0	19
Missing	2	4	7	3	1	1	0	18
Total	11	36	52	23	8	2	4	136

Table 4.18: Cross tabulation of age groups and clinical impression

Clinical impression	Age groups							
	<21	21-25	26-30	31-35	36-40	>40	Missing	Total
Acute	7	**21**	**33**	9	5	1	1	77
Chronic	2	10	10	8	3	1	2	36
Missing	2	5	9	6	0	0	1	23
Total	11	36	52	23	8	2	4	136

Table 4.19: Cross tabulation of age groups and diagnosis

Diagnosis	Age Group							
	<21	21-25	26-30	31-35	36-40	>40	Missing	Total
Head/ concussion	1	0	0	0	0	0	0	1
C-facet	1	1	0	0	0	0	0	2
Tendonitis	0	0	3	0	1	0	0	4
MFTP	3	6	8	2	0	0	0	19
DOMS	0	1	3	2	0	1	0	7
Joint sprain	0	2	4	1	1	0	0	8
Abrasion	0	0	2	0	0	0	0	2
T-facet	0	0	0	0	1	0	0	1
Muscle strain	0	**10**	**13**	5	2	1	2	33
Contusion	1	0	0	0	0	0	0	1
SI Syndrome	1	2	0	4	1	0	0	8
Laceration	1	3	4	2	1	0	1	12
L-facet	0	2	1	1	0	0	0	4
MTSS	0	2	1	0	0	0	0	3
Meniscal injury	1	0	0	0	0	0	0	1
ITBS	0	0	3	0	0	0	0	3
RCS	0	2	1	0	0	0	0	3
Joint instability	0	1	0	1	0	0	0	2
Nerve entrapment	0	0	0	0	1	0	0	1
Nerve entrapment and muscle strain	0	0	1	0	0	0	0	1
Asymptomatic	0	1	5	2	0	0	0	9
Missing	1	3	3	3	0	0	1	11
Total	11	36	52	23	8	2	4	136

Table 4.20: Cross tabulation of gender and region of complaint

Region of complaint	Gender			
	Male	Female	Missing	Total
Head and neck	6	4	1	11
Upper limb	30	14	6	50
Trunk	**22**	**6**	0	28
Lower limb	32	15	0	47
Total	90	39	7	136

Table 4.21: Cross tabulation of gender and mechanism of injury

Mechanism of injury	Gender			
	Male	Female	Missing	Total
Trauma	5	3	0	8
Overuse	20	13	4	37
Idiopathic	3	0	0	3
Lifting	2	2	0	4
Gymnastics	9	0	1	10
Competition	5	6	0	11
Non-traditional	3	1	1	5
Running	15	6	0	21
Other	13	5	1	19
Missing	15	3	0	18
Total	90	39	7	136

Table 4.22: Cross tabulation of gender and clinical impression

Clinical Impression	Gender			
	Male	Female	Missing	Total
Acute	55	20	2	77
Chronic	19	14	3	36
Missing	16	5	2	23
Total	90	39	7	136

Table 4.23: Chi-Square Tests cross tabulation of gender and clinical impression

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.474[a]	4	.242
Likelihood Ratio	5.456	4	.244
Linear-by-Linear Association	1.052	1	.305
N of Valid Cases	136		

a. 3 cells (33.3%) have expected count less than 5. The minimum expected count is 1.18.

Table 4.24: **Cross tabulation of gender and diagnosis**

Diagnosis	Gender			
	Male	Female	missing	Total
Head/ concussion	1	0	0	1
C-facet	1	1	0	2
Tendonitis	3	1	0	4
MFTP	**14**	4	1	19
DOMS	5	2	0	7
Joint sprain	3	**4**	1	8
Abrasion	2	0	0	2
T-facet	1	0	0	1
Muscle strain	17	**14**	2	33
Contusion	0	1	0	1
SI Syndrome	6	2	0	8
Laceration	**10**	1	1	12
L-facet	4	0	0	4
MTSS	3	0	0	3
Meniscal injury	1	0	0	1
ITBS	3	0	0	3
RCS	2	1	0	3
Joint instability	1	1	0	2
Nerve entrapment	0	0	1	1
Nerve entrapment and muscle strain	1	0	0	1
Asymptomatic	5	3	1	9
missing	7	4	0	11
Total	90	39	7	136

4.7.1 Discussion

Table 4.16 illustrates the trend discussed earlier in this chapter which shows that the majority of athletes were between the ages of 26 and 30, irrespective of the region of compliant. However, in contrast to this, head and neck injuries predominated in participants below the age of 26. The lower limb region presented almost equal distribution of complaints between the 21-25 and 26-30 age groups; however the 26-30 age group was larger, suggesting a higher association of lower limb complaints in the younger age group (Table 4.16). In addition, the lower limb region was the only area in which participants over the age of 40 presented.

Table 4.17 demonstrates that running related injuries presented in all age groups. As per patterns seen in section 4.4.2, the majority of participants presented with overuse injuries and were found between the ages of 21 and 30, which is consistent with the age range found in section 4.3.2.

Table 4.18 illustrates that there were mostly acute rather than chronic complaints irrespective of age, which has been previously presented in section 4.4.3.

Table 4.19 shows that persons under the age of 21 did not present with muscle strains. This could be due to suppleness, and less likelihood of previous injuries and strain to the area. But it is shown that although they did not have muscular strains, they did present with MFTP which can be a precursor to muscular strain (Chaitow and Delany, 2002). Table 4.19 demonstrates that those older than age of 35 did not present with myofascial complaints, which suggests a protective relationship between MFTP and increased age.

Table 4.20 demonstrates that the 2:1 distribution of males to females found in section 4.3.2 is consistent irrespective of region of complaint. However, it can be seen that the majority of participants with trunk complaints were male. Table 4.21 shows that there potentially exists a relationship between females and the following mechanisms of injury: overuse, lifting and competition. Males were shown to have a relationship between the following mechanisms of injury: idiopathic, gymnastics, non-traditional, running and other. Table 4.22 shows that a higher proportion of males presented with acute injuries, while females presented with a higher proportion of chronic injuries although the differences in both cases were not significant as shown in table 4.23 ($p>0.05$). Table 4.24 illustrates that the most common diagnosis for males and females was muscle strains.

Cross tabulations according to ethnicity were not provided nor discussed due to variance in the data. It must be noted that missing data could have skewed any proportions discussed in the above sections. All potential relationships, proportions and associations discussed above require further research in order to be validated.

4.8 **Recommendations to the CSSA form**

The Fifth Objective was to make recommendations, if any, to the clinical record form. Information about sports injuries collected from a variety of locations has the potential to provide valuable injury data (Finch and Mitchell, 2002). However, the significance of this data is dependent on methodological considerations which can influence quality and usefulness in sports injury epidemiology and prevention research (Finch *et al.,* 1999). Medical services may have a potential key role to play in sport injury data collection during medical coverage at sporting events (Finch *et al.,* 1999). The Chiropractic Students Sports Association (CSSA) provide treatment facilities to a number of sporting events in the greater Durban area in KwaZulu-Natal, South Africa; consequently CSSA (as suggested by Finch *et al*. (1999)), has the potential to provide valuable injury epidemiological data during coverage of sporting events.

It is the CSSA's standard procedure to fill in a clinical report form for medico-legal purposes as well as for research. A retrospective cohort analysis of the injury profile of competitive surfers was conducted using the data collected from clinical report forms filled in at the Mr. Price Pro CTF between 2000 and 2008 (Murgatroyd, 2009). Murgatroyd (2009) indicated that inaccuracies were found due to incomplete forms. This is consistent with the current study which revealed a significant proportion of missing data. Finch and Mitchell (2002) were able to show in a study comparing two injury surveillance methods that the system of data collection has the ability to influence the proportion of missing information and sensitivity of the data (Finch and Mitchell, 2002).

The CSSA clinical report form was developed and validated by Korporaal in 2002, by use of a focus group and pilot study. The injury report form was validated in reference to field hockey, and not as a broad injury surveillance tool for use in multi-sport events as a standardised form, though currently it is being used as such.

The following recommendations are proposed in order to maximise the efficiency of data collection i.e. changes to the form:

- Improve tracking during multi-day events by adding a file number, day number and visit number.
- Consider adding a schematic drawing of a body, anterior and posterior view, for ease of capturing affected areas.
- Consider adding range of motion diagrams for the tracking of spinal and extremity range of motion.
- All information should be collated onto a single double-sided page.
- All clinical questions should have various options to choose from using tick boxes, as well as making space to allow for ‘’other’’ for options not stipulated.
- The recording of treatments should include specifics of manipulation level, and technique used.
- There should be provision on the report form for senior students to note any advice they provided the participant regarding, for example, rest, rehabilitation, nutrition, exercise or the use of ice at home.

The CSSA holds a potentially significant position in injury epidemiology, as student interns service many sporting events in the greater Durban region. If injury reporting is prioritised, and an improved standard procedure of injury reporting is established, the DUT chiropractic department may hold the key to high quality epidemiological data and could possibly become leaders in the field of sports injury surveillance and prevention.

4.9 Summary of findings per objective

Objective One: It was found that the typical CF participant who presented to the CTF was a 27.4 year old, male, white athlete (section 4.3).

Objective Two: Typically injuries presented were located in the lumbar region, due to overuse mechanisms and diagnosed as acute on chronic MFTP or muscle strains (section 4.4).

Objective Three: The treatment profile performed at the UWS CF Games was primarily made up of the use of kinesiology tape, massage and manipulation in a multimodal fashion to all regions of the body, except the chest and abdomen (section 4.6).

Objective Four: Associations between the demographic profile and injury's profile were discussed, and it was shown that there were no significant associations (section 4.7).

Objective Five: Recommendations were made for the improvement of the CSSA form (section 4.8).

The following chapter will discuss the conclusions and limitations of this study and recommendations for further studies.

Chapter 5 : Conclusions and Recommendations

5.1 Introduction

In this chapter, the conclusions of the study are presented which are based on the results of the primary data collected at the 2013 UWS CF Games CTF. Further recommendations are then provided for future studies based on the results as well as limitations of the study.

5.2 Conclusions

In concluding this study, it has become evident that the majority of CF participants were White, male and between the ages of 26-30 years, concurring with the general profile of persons involved in sports in South Africa. It was found that most participants had not experienced any previous complaints or injuries. The majority of injuries presented were located in the lumbar region followed by hand/wrist. These findings with regards to the low back region are consistent with the current CF literature. It was also found that more than a quarter of the participants receiving treatment presented with two complaints per visit, which alludes to the full body presentation of CF injuries which tend to affect more than one part of the body at a time. It was also found that overuse mechanisms and running were the main contributors to injury. However, overuse injuries have not been termed as such in the CF literature, and endurance type mechanisms such as running contributed infrequently to injury in the previous studies cited. The majority of injuries were acute on chronic, which concurs with previous CF literature. Muscular injuries were the most commonly diagnosed complaints treated at the CTF, the majority of which were MFTP and muscle strains. These diagnoses influenced the treatment profile employed by senior students at the CTF, which included mostly kinesiotape, manipulation and massage; however a wide range of modalities was utilised. It was found that there were no significant associations between the demographic variables and injury profile of the CF participants. Various recommendations were presented to increase the value of data collected by the CSSA during sporting events. CF is a novel workout that is gaining increasing popularity in South Africa. It is important to

understand the potential risks and outcomes of such an exercise program and studies such as this one may therefore guide further research.

5.3 Limitations

- A retrospective study design has many inherent limitations such as information bias, selection bias, the interpretation of the data being based on the assumption that the data was collected accurately and that missing data may have influenced the results presented.
- The study only reported on injuries presented during competition. The proportion of training to competition is in favour of training, as CrossFitters spend a significant amount of time training at their home gyms compared to the short time spent in competition. Therefore, our study does not describe the whole range or extent of injuries in CF.
- The chiropractic utilisation at the 2013 UWS CF Games may have been influenced by a number of factors such as participant perception and promotion of the CTF by the organisers, which would have in turn affected the injuries presented to the CTF.
- The data recorded in this study were based on clinical observations established in part by senior chiropractic students under the guidance of clinical supervisors; therefore the diagnoses may be limited in their scope, and may have resulted in differences in inter-examiner/ student reliability.
- The opportunity for participants to seek chiropractic treatment free of charge may have resulted in over reporting of injuries. Participants are more likely to seek treatment if the services are offered free of charge.
- A brand of kinesiotape was freely used as it was a sponsored item for use by the CTF, which may have resulted in over use of the item.
- Various other medical staff were available during the 2013 UWS CF Games. These personnel did not contribute to the gathering of data thus this study may have under reported injuries which occurred during the event.
- Exclusion of incomplete forms as defined by the exclusion and inclusion criteria (Chapter 3) resulted in less injuries being included in the research sample.

- Lack of common understanding and consensus of particular clinical terms between senior students, participants, clinicians and the researcher would have resulted in inconsistencies during reporting, recording and capturing of injury data.

5.4 Recommendations

- An updated injury record form should be developed, piloted, validated and it's reliability tested for use in multi-sport events within a broad perspective. The injury recording form must take into account the important principles of injury surveillance as put forward by Junge *et al.* (2008) which are: standardised injury definitions, injury report completed by trained personnel, and all information collated onto a single page.
- Future studies could focus on a questionnaire exploring the various risk factors associated with the CF prescription of exercise (section 2.4).
- Where possible, prospective study designs should be adopted for large sporting events which will allow for data record forms to be produced around specific aims and research questions.
- In order to describe the whole magnitude of injuries in CF, a prospective cohort study that covers both training and competition is needed. In addition to this, injury report forms during these prospective studies should be available to all medical personnel by the organisers in order to collate a full picture of the magnitude of injuries during a particular sporting event.
- Introduce pre-event training in order to familiarise senior students with the workings of an off campus treatment facility, ensure a common understanding of definitions, ensure familiarity with the reporting form, provide orientation regarding the specific intricacies of injury mechanisms pertaining to the sport involved. Such pre-event training will influence the quality and consistency of diagnosis, management and reporting of injuries.
- Establish a system of project management during sporting events in order to improve the flow of patients through the CTF, administration of the filing system and electronic input of the data from the CSSA forms.
- Limiting the number of fields left blank to improve statistics. To improve consistency, it is recommended that one individual be responsible for the

recording of demographic information prior to the participant being attended to by a senior student at the CTF.

- Arising from the discussions in Chapter 4, the following areas require further investigations:
    - Low back pain due to high intensity, high repetition, complicated techniques while using heavy weights, as seen in CF.
    - Correlation of the different forms of running to injury presentation in CF athletes by including the distinction of type and nature of endurance activity on the injury report form.
    - The effect of high repetitions on the development of overuse injuries seen in CF.
    - The effects of the interaction between ballistic style lifting and endurance on soft tissue structures as seen in CF, and how they could influence injury.
    - The effectiveness of kinesiotape in the treatment of CF injuries, injury prevention, and performance enhancement.

REFERENCES

100 Meter Shuttle Run (Online). 2014. Available: http://steelcitycrossfit.com/skills-and-drills/agility/100-m-shuttle-run.html (Accessed 26 Oct 2014).

Adamson, I. 2007. Gymnastics injuries: a quantitative profile of injuries in the greater Durban area. M.Tech, Durban University of Technology.

Álvarez-Álvarez, S., José, F. G., Rodríguez-Fernández, A L., Güeita-Rodríguez, J. and Waller, B. J. 2014. Effects of Kinesio®Tape in low back muscle fatigue: randomized, controlled, double-blinded clinical trial on healthy subjects. *Journal of Back and Musculoskeletal Rehabilitation*, 27(2):203-12

Babiash, P. 2013. Determining the energy expenditure and relative intensity of two CrossFit workouts. University of Wisconsin, La Crosse. Masters Thesis.

Bahr, R and Holme, I. 2003. Risk factors for sports injuries – a methodological approach. *British Journal of Sports Medicine*, 37: 384-392.

Bahr, R and Krosshaug, T. 2005. Understanding injury mechanisms: a key component of preventing injuries in sport. *British Journal of Sports Medicine*, 39:324-329.

Baker, R., Souza, R. and Fredericson, M.2011. Iliotibial band syndrome: soft tissue and biomechanical factors in evaluation and treatment. *American Academy of Physical Medicine and Rehabilitation,* 3(6): 550-561.

Bellovary, B. 2014. The perceived demands of CrossFit. Northern Michigan University Master's Theses. Paper 3.

Bergeron, M., Nindl, B., Deuster, P., Baumgartner, N., Kane, S., Kraemer, W., Sexauer, L., Thompson, W. and O'Connor, F. 2011. Consortium for health and military performance and American College of Sports Medicine consensus paper on extreme conditioning programs in military personnel. *Current Sports Medicine Reports*, 10(6): 383-9.

Bernard, R. 2000. *Social research methods.* Thousand Oaks, CA: Sage Publications.

Beynnon, B., Ryder, S., Konradsen, L., Johnson, R., Johnson, K. and Renstrom, P. 1999. The effect of anterior cruciate ligament trauma and bracing on knee proprioception. *The American Journal of Sports Medicine,* 27(2):150- 155.

Boutcher, S. 2011. High-intensity intermittent exercise and fat loss. *Journal of Obesity* (online). Available: doi: 10.1155/2011/868305.

Breckenridge, D.2007. *Prevalence and risk factors for musculoskeletal injuries in members of the United States Army Markmanship Unit Shotgun Team*. ProQuest.

Brewer, R and Gregory, A. 2012. Chronic lower leg pain in athletes: a guide for the differential diagnosis, evaluation, and treatment. *Sports Health*, 4(2): 121-127.

Brumitt, J., Gilpin, H., Brunette, M. and Meira, E. 2010. Incorporating kettlebells into a lower extremity sports rehabilitation program. *North American Journal of sports Physical Therapy*, 5(4):257-265.

Buchheit, M. and Laursen, P. 2013. High-intensity interval training, solutions to the programming puzzle: Part I: Cardiopulmonary emphasis. *Sports medicine*,43(5): 313-338.

Butragueño, J; Benito, P; Mafulli, N. 2014. Injuries in strength training: review and practical application. *European Journal of Human Movement*, 32: 29-47.

Caine, D and Nassar, L. 2005. Gymnastics injuries. *Medicine and Sports Science*, 48: 18-58.

Calhoon, G. and Fry, A. 1999. Injury rates and profiles of elite competitive weight lifters. *Journal of Athletic Training,* 34(3): 232-238.

Chaitow, L. and DeLany, J. 2002. *Clinical application of neuromuscular techniques*. *Volume 2 – the lower body*. Edinburgh, Scotland: Churchill Livingston, Elsevier Science Limited.

Chiu, L. and Burkhardt, E. 2011. A teaching progression for squatting exercises. *Journal of Strength and Conditioning Journal*, 33(2): 46-54.

Ciccolella, M., Moore, B., VanNess, J. and Wyant, J. 2014. Exertional rhabdomyolysis and the law: A brief Review. *Journal of Exercise Physiology Online*, 17(1): 19-27.

Clanton, T and Matheney, L., Jarvis, H. and Jeronimus, A. 2012. Return to play in athletes following injuries. *Sports Health,* 4(6): 471-474.

Cloete, K. 2008. A study to determine the International Federations' perception and utilization of chiropractors and other sports personnel. M.Tech dissertation. Durban University of Technology.

Clarsen, B., Myklebust, G and Bahr, R. 2013. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury Questionnaire. *British Journal of Sports Medicine*, 47: 495-502.

Coetzee, C. 2013. An injury profile of amateur and semi-professional Kwa-Zulu Natal triathletes. M.Tech dissertation. Durban University of Technology.

Conradie, E. 2013. The effect of chiropractic adjustments on sprint times and vertical jump height in rugby players. M.Tech dissertation. University of Johannesburg.

Croisier, J. 2004. Factors associated with recurrent hamstring injuries. *Sports Medicine*, 34(10): 681-695.

Department of Sports and recreation of South Africa. 2005. Participation patterns in sport and recreation activities in South Africa: survey.

Doherty, C., Delahunt, E., Caulfield, B., Hertel, J., Ryan, J. and Bleakley, C. 2013. The incidence and prevalence of ankle sprain injury: A systematic review and meta-Analysis of prospective epidemiological studies. *Sports Medicine*, 44(1): 123-140.

Dommerholt, J., Bron, C. and Franssen, J. 2006. Myofascial trigger points: an evidence-informed review. *The Journal of Manual & Manipulative Therapy*, 14(4): 203-221.

Drouin, J., McAlpine, C., Primak, K. and Kissel, J. 2013. The effects of kinesiotape on athletic-based performance outcomes in healthy, active individuals: a literature review. *Journal of the Canadian Chiropractic Association,* 57(4): 356-365.

Ebben, W., Simenz, C. and Jensen, R. 2008. Evaluation of plyometric intensity using electromyography. *Journal of Strength and Conditioning Research*, 22(3): 861-868.

Ekegren, C., Donaldson, A., Gabbe, B. and Finch, C. 2014. Implementing injury surveillance systems alongside injury prevention programs: evaluation of an online surveillance system in a community setting. *Injury Epidemiology*, 1(19): 1-15.

Ellapen, T., Satyendra, S., Morris, J. and van Heerden, H. 2013. Common running musculoskeletal injuries among recreational half-marathon runners in KwaZulu-Natal. *South African Journal of Sports Medicine,* 25(2): 39-43.

Ernst, E. and Canter, P. 2006. A systematic review of systematic reviews of spinal manipulation. *Journal of the Royal Society of Medicine*, 99(4): 192-196.

Ernst, E. and Posadzki, P. 2012. Chiropractic for the prevention and/or treatment of sports injuries: a systematic review of controlled clinical trials. *Focus on Alternative and Complementary Therapies,* 17(1): 9-14.

Feddermann-Demont, F., Junge, A., Edouard, P., Branco, P. and Alonso, J. 2014. Injuries in 13 international athletics championships between 2007-2012. *British Journal of Sports Medicine*, 48: 513-522.

Finch, C. and Cook, J. 2013. Categorising sports injuries in epidemiological studies: the subsequent injury categorisation (SIC) model to address multiple, recurrent and exacerbation of injuries. *British Journal of Sports Medicine* (online). doi:10.1136/bjsports-2012-091729.

Finch, C. and Mitchell, D. 2002. A comparison of two injury surveillance systems within sports medicine clinics. *Journal of Science and Medicine in Sport,* 5(4): 321-335.

Finch, C., Valuri, G. and Ozanne-Smith, J. 1999. Injury surveillance during medical coverage of sporting events – development and testing of a standardized data collection form. *Journal of Science and Medicine in Sport*, 2(1):42-56.

Firth, B., Dingley, P., Davies, E., Lewis, J. and Alexander, C. 2010. The effect of kinesiotape on function, pain and motoneuronal excitability in healthy people and people with Achilles tendinopathy. *Clinical Journal of Sports of Sports Medicine*, 20(6): 416-421.

Forster, N. 2014. Burpees. Joe *Weider's Muscle and Fitness*, 75(2): 40.

Fukuchi, R., Stefanyshyn, D., Stirling, L., Duarte, M. and Ferber, R. 2013. Flexibility, muscle strength and running biomechanical adoptions in older runners. *Clinical Biomechanics*, 29(3):304-10.

Garber, C., Blissmer, B., Deschenes, M., Franklin, B., Lamonte, M., Lee, I., Nieman, D. and Swain, D. 2011. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise.*Medicine and Science in Sports and Exercise*,43(7): 1334-1359.

Gerhart, H. 2013. A comparison of CrossFit training to traditional anaerobic resistance training in terms of selected fitness domains representative of overall athletic performance. M.Sci, Indiana University of Pennsylvania.

Gilbert, J. 2004. Sagittal plane blockage of the foot and ankle- prevalence and association with low back pain. M.Tech, Durban University of Technology.

Glassman, G. 2007. Understanding CrossFit. *CrossFit Journal* (online). Available: http:journal.crossfit.com/ (Accessed 9 September 2013).

Glassman, G. 2010. CrossFit training guide. *CrossFit Journal* (online). Available: http://journal.crossfit.com (Accessed 12 September 2013).

Grier, T., Canham-Chervak, M., McNulty, V. and Jones, B. 2013. Extreme conditioning programs and injury risk in US army brigade combat team. *US Army Medical Department Journal*, Oct-Dec: 36-47.

Hak, P., Hodzovic, E. and Hickey, B. 2013. The nature and prevalence of injury during CrossFit training. *Journal of Strength and Conditioning Research/ National Strength and Conditioning Association.*

Hashish, R. 2013. Injury by CrossFit. *Huffington Post* (blog). Available: http://www.huffingtonpost.com/rami-hashish/crossfit-debate_b_3181435.html (Accessed 9 September 2013).

Hedrick, A. and Wada, H. 2008. Weightlifting movements: Do the benefits outweigh the risks. *Strength and Conditioning Journal*, 30(6): 26-34.

Hootman, J., Macera, C., Ainsworth, B., Martin, M., Addy, C. and Blair, N. 2001. Association among physical activity level, cardiorespiratory fitness, and risk of musculoskeletal injury. *American Journal of Epidemiology*, 154(3):251-258.

Hopkins, W., Marshall, S., Quarrie, K. and Hume, P. 2001. Risk factors and risk statistics for sports injuries. *Clinical Journal of Sports Medicine*, 17(3): 208-210.

Hoskins, W., Pollard, H. and Garbutt, P. 2009. How to select a chiropractor for the management of athletic conditions. *Chiropractic and Osteopathy*, 17(3): 1-4.

Jacobson, M. 2013. Three reasons to get upset about CrossFit. *Huffpost healthy living* (blog). Available: http://www.huffingtonpost.com/max-jacobsonfried/crossfit-debate_b_3715259.html (Accessed 4 September 2013).

Johnson, C. 2005. On the Subject of Human Subjects. *Journal of Manipulative and Physiological Therapeutics*, 28:79-80.

Johnson, J. 2013. Why clustering should be part of your CrossFit training. *Every Last Rep* (blog). Available: http://www.everylastrep.com (Accessed 23 July 2014).

Julian, C., Hoskins, W. and Vitiello, A. 2010. Sports chiropractic management at the World Ice Hockey Championships. *Chiropractic and Osteopathy*, 18: 1-9.

Junge, A., Engebretsen, L., Alonso, J., Renstrom, P., Mountjoy, M., Aubry, M. and Dvorak, J. 2008. Injury surveillance in multi-sport events – the IOC approach. *British Journal of Sports Medicine*, 42(6): 413-421.

Karkucak, M., Can, I., Capkin, E., Önder, A., Baki, E. and Batmaz, I. 2014. Local steroid injection accompanied by ultrasonographic imaging in the treatment of facet syndrome. *Journal of Clinical and Experimental Investigations*, 5(1):125-127.

Kazemi, M. and Shearer, H. 2008. Chiropractic utilization in Taekwondo athletes. *The Journal of the Canadian Chiropractic Association,* 52(2): 96-109.

Kellmann, M.2010. Preventing overtraining in the athletes in high-intensity sports and stress/recovery monitoring. *Scandinavian Journal of Medicine and Science in Sports*, 20(2): 95-102.

Keogh, J., Hume, P. and Pearson, S. 2006. Retrospective injury epidemiology of one hundred one competitive Oceania power lifters: the effects of age, body mass, competitive standard and gender. *Journal of Strength and Conditioning research*, 20(3): 672-681.

Konczak, C. 2010. Chiropractic utilization in BMX athletes at the UCI World Championships: a retrospective study. *The Journal of the Canadian Chiropractic Association*, 54(4): 250-256.

Korporaal, C. 2002. A retrospective epidemiological investigation of the chiropractic students sports association sports questionnaire, with reference to field hockey: a methodological perspective. M.Tech dissertation, Durban University of Technology.

Kruse, D. and Lemmen, B. 2009. Spine injuries in the sport of gymnastics. *Current Sports Medicine Reports*, 8(1):20-28.

Kuhn,S. 2013. The culture of CrossFit: a lifestyle prescription for optimal health and fitness. Senior Theses – Anthropology, Illinois State University.

Labuschagne, K. 2009. Knowledge, perception and utilisation of chiropractic by National Olympic Committees. M.Tech dissertation, Durban University of Technology.

Lavallee, M. and Balam, T. 2010. An overview of strength training injuries: Acute and chronic. *Current Sports Medicine Reports*, 9(5): 307-313.

Liebenson, C. 2011. Functional training with the kettlebell. *Journal of Bodywork and Movement Therapies,* 15: 542-544.

Lin, C-W., Delahunt, E and King, E. 2012. Neuromuscular training for chronic ankle instability. *Physical Therapy,* 92 (8): 987- 991.

Lubbe, D., Lakhani, E., Brantingham, J., Parkin-Smith, G., Cassa, T., Globe, G. and Korporaal, C. 2014. Manipulative therapy and rehabilitation for recurrent ankle sprain with functional instability: a short-term, assessor-blind, parallel-group randomized trial. *Journal of Manipulative and Physiological Therapeutics*, 38(1): 22-34.

Lund, S. and Myklebust, G. 2011. High injury incidence in TeamGym competition: a prospective cohort study. *Scandinavian Journal of Medicine and Science in Sports,* 21(6):e439-44.

Maffulli, N., Longo, U. and Denaro, V. 2010. Novel approaches for the management of tendinopathy. *The Journal of Bone and Joint Surgery*, 92: 2604-2613.

Maffulli, N., Longo, U., Caine, D. and Denaro, V. 2011. Sports injuries: a review of outcomes. *British Medical Bulletin,* 97: 47-80.

Mahomed, F. 2007. Chiropractic patients in South Africa: a demographic and descriptive profile. M. Tech dissertation, Durban University of Technology.

Malisoux, L., Nielsen, R., Urhausen, A. and Theisen, D. 2014. A step towards understanding the mechanisms of running-related injuries. *Journal of Science and Medicine in Sport*, 7(14): 1-6.

Manchikanti, L., Boswell, M., Singh, V., Pampati, V., Damron, K., Beyer, C. and Damron, K. 2004. Prevalence of facet joint pain in chronic spinal pain of cervical, thoracic and lumbar regions. *BMC Musculoskeletal Disorders*, 5(1).

Manuel, D. 2011. What is a CrossFit chipper workout? *Dai Manuel* (blog). http://www.daimanuel.com Accessed 23 July 2014.

Maruggie, M. 2014. The effect of kinesio tape® on post dry needling soreness in the treatment of trigger point one. M.Tech dissertation, University of Johannesburg.

Matava, M. 2008. Overuse injuries. American Orthopaedic Society for Sports Medicine: Sports Tips.

McBain, K., Shrier, I., Shultz, R., Meeuwisse, W., Klügl, M., Garza, D. and Matheson, G. 2014. Prevention of sports injury: a systematic review of clinical science research. *British Journal of Sports Medicine*, 46:174-179.

Meeusen, R. and Borms, J. 1992. Gymnastics injuries. *Sports Medicine*, 13(5): 337-56.

Miller, J. 2013. 5 most dangerous recreational sports (online). Available: http://health.howstuffworks.com/medicine/5-most-dangerous0resreational-sports.htm (Accessed: 20 October 2013).

Miners, A. 2010. Chiropractic treatment and the enhancement of sports performance: A narrative review. *The Journal of the Canadian Chiropractic Association*, 54(4): 210-221.

Moon, J. Is CrossFit injury-ridden? n.d. *End of three fitness* (blog). Available: http:/www.endofthreefitness.com/is-crossfit-injury-ridden/ (Accessed: 9 September 2013).

Mouton, J. 1996. *Understanding social research*. 1st ed. Pretoria: J.L. van Schaik Publishers.

Mueller-Wohlfahrt, H., Haensel, L., Mithoefer, K., Ekstrand, J., English, B., McNally, S., Orchard, J., van Dijk, N., Kerkhoffs, G., Schamasch, P., Blottner, D., Swaerd, L., Goedhart, E. and Ueblacker, P. 2012. Terminology and classification of muscle injuries in sport: a consensus statement. *British Journal of Sports Medicine*: 1-9.

Murgatroyd, T. 2009. A retrospective cohort analysis of the injury profile of internationally competitive surfers. M.Tech dissertation, Durban University of Technology.

Murphy, D., Connolly, D. and Beynnon, B. 2003. Risk factors for lower extremity injury: a review of the literature. *British Journal of Sports Medicine*, 37: 13-29.

Nielsen, R., Nohr, E., Rasmussen, S. and Sorensen, H. 2013. Classifying running-related injuries based upon eitiology, with emphasis on volume and pace. *The International Journal of Sports Physical Therapy*, 8(2): 172-179.

Notarnicola, A., Fischetti, F., Gallone, D., Moretti, L., Pignataro, P., Tafuri, S. and Moretti, B. 2012. Overload and neovascularization of shoulder tendons in volleyball players. *BioMed Central Research Notes*, 5(397): 2-8.

Novacheck, T. 1998. Running injuries: A Biomechanical approach. *Journal of Bone and Joint Surgery*, 80(8): 1220-1233.

Oh, R. 2013. Coming out of the CrossFit closet. *The Uniformed Family Physician*, 7(1) ed. 25:31-33.

Orchard, J. and Kountouris, A. 2011. Clinical review: The management of tennis elbow. *British Medical Journal,* 342: 1199-1202.

Oxford Dictionary. 2015. Definition of niggle. (Online). Available: http://www.oxforddictionaries.com/definition/english/niggle (Accessed: 5 January 2015).

Oxford Learners Dictionary. 2015. Definition of perception. (Online). Available: http://www.oxfordlearnersdictionaries.com/definition/english/perception (Accessed: 5 January 2015).

Paine, J., Uptagraft, J. and Wylie, R. 2010. CrossFit Study. Command and General Staff College. Special Report.

Perry, C., Heigenhauser, G., Bonen, A. and Spriet, L. 2008. High-intensity aerobic interval training increases fat and carbohydrate metabolic capacities in human skeletal muscle. *Applied Physiology, Nutrition, and Metabolism,* 33(6): 1112-1123.

Quatman, C., Myer, G., Khoury, J., Wall, E. and Hewett, T. 2009. Sex differences in "Weightlifting" injuries presenting to United States emergency rooms. *Journal of Strength and Conditioning*, 23(7): 2061-2067.

Raske, A. and Norlin, R. 2002. Injury incidence and prevalence among elite weight and power lifters. *The American Journal of Sports Medicine*, 30(2): 248-256.

Reebok CrossFit Games (Online). 2013. Available: http://games.crossfit.com/ (Accessed 19 October 2013).

Renstrom, P. (editor). 1993. *Sports injuries – Basic principles of prevention and care.* Vol.IV of the Encyclopaedia of Sports Medicine, an IOC medical commission publication in collaboration with the international federation of sports medicine. London: Blackwell Scientific Publications.

Rishe, P. 2013. Reebok CrossFit Games personifies continued growth for sport and sponsor (Online).Available: http://www.forbes.com/ (Accessed 17 October 2013).

RockTape. (Online). Available: http://rocktape.com/ (Accessed 11 December 2014).

Rockwitz, E. 2013. Dealing with injury at the 2013 CrossFit Games. *Dai Manuel* (blog). Available: http://www.dai,amuel.com/ (Accessed: 17 October 2013).

Ross, B. 2013. The controversy behind CrossFit. *Livestrong (*blog). Available: http://www.livestrong.com/ (Accessed: 9 September 2013).

Sands, W., McNeal, J., Jemni, M. and Penitente, G. 2011. Thinking sensibly about injury prevention and safety. *Science of Gymnastics Journal*, 3(3): 43-58.

Saragiotto, B., Yamato, T., Hespanhol, L., Rainbow, M., Davis, I. and Lopes, A. 2014. What are the main risk factors for running-related injuries? *Sports Medicine*, 1-11.

Shamus, E and Shamus, J. 2001. *Sports Injury Prevention and Rehabilitation*. New York: McGraw-Hill.

Sharman, M., Cresswell, A. and Riek, S. 2006. Proprioceptive neuromuscular facilitation stretching, mechanisms and clinical implications. *Sports Medicine*, 36(11): 929-939.

Shiner, J., Bishop, T and Cosgarea, A. 2005. Integrating low-intensity plyometrics into strength and conditioning programs. *Journal of Strength and Conditioning Journal*, 27(6): 10-20.

Simons D, Travell J, Simons L. 1999. *Myofascial Pain and Dysfunction, The Trigger point Manual,* 2nd Edition. U.S.A.: Williams and Wilkins.

Smith, M. and Hillman, R. A. 2010. Retrospective service audit of a mobile physiotherapy unit on the PGA European golf tour. *Physical Therapy in Sport*, 13(1): 41-44.

Smith, M., Sommer, A., Starkoff, B., Brooke, E., Devor, S. and Steven, T. 2013 CrossFit-based high intensity power training improves maximal aerobic fitness and body composition. *Journal of Strength and Conditioning Research,* 27(11): 3159-3172.

South Africa. 1982. Allied Health Professions Act 63, 1982. Government Gazette no. 1746: 1 August.

South Africa. 2010. Safety at Sports and Recreational Events Act 2, 2010. Government Gazette no. 33232: 27 May.

Strock, G., Cottrell, E. and Lohman, J. 2006. Triathlon [Review]. *Physical Medicine and Rehabilitation Clinics of North America*, 17(3): 553-564.

Suter, E., McMorland, G., Herzog, W. and Bray, R. 1999. Decrease in quadriceps inhibition after sacroiliac joint manipulation in patients with anterior knee pain. *Journal of Manipulative and Physiological Therapeutics,* 22(3): 149- 153.

Szabo, A. 2012. Some questions of biomechanical character in weightlifting. *Sports Specific and Practical Aspects*, 9(1): 59- 64.

Taunton, J., Ryan, M., Clement, D., Mckenzie, D., Lloyd-Smith, D. And Zumbo, B. 2002. A retrospective case-control analysis of 2002 running injuries. *British Journal of Sports Medicine*, 36: 95-101.

Thompson, W. 2013. Now trending: Worldwide survey of fitness trends for 2014. *ASCM's Health and Fitness Journal,* 17(6): 10-20.

Timpka, T., Jacobsson, J., Bickenbach, J., Finch, C., Ekberg, J. and Nordenfelt, L. 2014. What is a sports injury? *Sports Medicine*, 48(7):483-90.

Travell, J. and Simons, G. 1983. *Myofascial pain and dysfunction: The trigger point manual*. Baltimore: Williams and Wilkins.

UWS Manual. 2013. Movement standards, judges manual.

Verhagen, E., Van Stralen, M. and Mechelen, W. 2010. Behaviour, the key factor for sports injury prevention. *Journal of Sports Medicine*, 40(11): 899-906.

Vlaeyen, W. and Linton, S. 2000. Fear avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain*, 85: 317-332.

Waller, M., Townsend, R. and Gattone, M. 2007. Application of power snatch for athletic conditioning. *Strength and Conditioning Journal*, 29(3): 10-20.

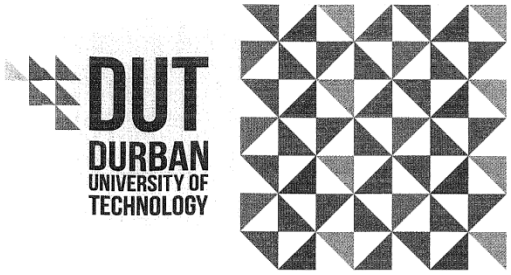
Weisenthal, B., Beck, C., Maloney, M., DeHaven, K. and Giordano, B. 2014. Injury rate and patterns among CrossFit athletes. *Orthopaedic Journal of Sports Medicine*, 2: 1-7.

Winwood, P., Hume, P., Cronin, J. and Keogh, J. 2014. Retrospective injury epidemiology of strongman athletes. *The Journal of Strength & Conditioning Research*, 28(1): 28-42.

Winwood, P., Keogh, J. and Harris, N. 2011. The strength and conditioning practices of strongman competitors. *The Journal of Strength & Conditioning Research*, 25(11): 3118-3128.

APPENDIXES

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



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

10 April 2014

IREC Reference Number: **REC 19/14**

Ms C A B da Silva
P O Box 911
Midstream Estate
Midrand
1692

Dear Ms da Silva

A profile of injuries among participants at the 2013 CrossFit Games in Durban

I am pleased to inform you that Full Approval has been granted to your proposal REC 19/14.

The Proposal has been allocated the following Ethical Clearance number **IREC 028/14**. 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 B: United We Stand Crossfit Games form (CSSA form)

UWS CrossFit Games

By signing alongside this statement, you agree to have the data collected at the UWS CrossFit Games 2013 in respect of your condition documented in research – without disclosure or your name or identifying details. Sign: _____Date:_____

Date: 25 26 27 October 2013 Time:_____ FILE No: _____

NAME: _____ POSITION: ATHLETE (state type), MANAGE, MEDT OTHER:_____

RACE: WBIN 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**

MECHANISM OF INJURY : _____

DID INJURY CAUSE THE PATIENT NOT TO PARTICIPATE IN THE EVENT? YESNO
HAS THE AREA BEEN INJURED BEFORE? YESNO
PREVIOUS TRAUMA: _____

CLINICAL IMPRESSIONS: ACUTE CHRONIC

HEAD/CONCUSSION	**JNT SPRAIN**	**MM STRAIN**	**PFPS**
HEAT EXHAUSTION	**ABRASION**	**CONTUSION**	**LACERATION**
C FACET	**T FACET**	**SI SYNDROME**	**L FACET**

TENDINITIS

MYOFASCIALOF:_____
GEN. MUS. TIGHT (DOMS) OF:_____
NEURO / SYSTEMIC / OTHER:_____
RANGE OF MOTION:_____
OTHER:_____

TREATMENT:

MANIPULATION	**MOBILISATION**	**MASSAGE**	**STRETCH / PNF**
STRETCH (STATIC)	**TENS**	**NEEDLE**	**ISCH COMP**
VOLTAREN USED	**TRANSACT USED**	**REFERAL**	

Indicate specific regions for the modalities

CONTINUATION OF PLAY: YESNOIF RESTRICTED - WHY?_____

CLINICIAN : NAME_____

SIGN_____

STUDENT : NAME_____

SIGN_____

Appendix C: Agreement between organisers and researcher

To whom it may concern,

By the signature hereto the parties agree that

1. Permission has been granted by Integrated Fitness to Chantel da Silva (“The researcher”), to use data collected by the Chiropractic delegation at the United We Stand CrossFit Games in the injury report forms.
2. All findings of the researcher, in the carrying out of the study shall be made available for use by Integrated Fitness, organisers of the United We Stand CrossFit Games at their request.
3. Written consent must be obtained by the researcher from Integrated Fitness should the researcher wish to publish the study outside of the associated institution.

Thus signed and dated Durban on this the ____ day of the _____ month 2013.

_____
Chantel da Silva

_____
AUTHORISED SIGNATORY
OF INTEGRATED FITNESS

_____
AUTHORISED SIGNATORY
OF INTEGRATED FITNESS

_____
WITNESS ONE

_____
WITNESS TWO

Appendix D: Correspondence with event organisers

Re: DUT research
18:22, 26 Sep

Hi Chantelle.

I have chatted to my business partner Andy and we both agree that you are more than welcome to conduct the research but on just two conditions.

1 - would you please make your findings available to us for the future planning of events.
2 - we would like to have an agreement in place that would require you seek our permission to publish the findings anywhere else but in your initial report.

I hope this will be fine with you
Chat soon

Dean Ridgway
072 605 3918