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The prevalence of Chronic Ankle Instability and Associated Self-reported Function in Professional Ballet Dancers in South Africa

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Dissertation submitted in accordance with

the academic requirements for the degree

M.Sc. Physiotherapy

Faculty of Health Sciences: School for Allied Health Professions

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Bloemfontein

South Africa

April 2018

Study leader: A. van der Merwe

DECLARATION

I, Cherezane Marais, certify that the report hereby submitted for the degree M.Sc. Physiotherapy at the University of the Free State (UFS) is my independent effort and had not previously been submitted for a degree at another university/ faculty. I furthermore waive copyright of the report in favour of the UFS.

Cherezane Marais

Researcher **Date**

I, Mrs. A van der Merwe, approve submission of this dissertation for the M.Sc. Physiotherapy degree at the UFS. I further declare that this dissertation has not been submitted as a whole or partially for examination before.

Anke van der Merwe

Study leader **Date**

ACKNOWLEDGEMENTS

It is with appreciation that the researcher acknowledges the contribution of the following people:

Mrs. A. van der Merwe

Department of Physiotherapy

School for Allied Health Professions

Faculty of Health Sciences

UFS

My supervisor, for her patience, guidance and support

Me. R. Nel

Department of Biostatistics

Faculty of Health Sciences

UFS

For her professional input and prompt processing of data

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LIST OF ABBREVIATIONS

ADL	Activities of Daily Living
AII	Ankle Instability Instrument
CAI	Chronic Ankle Instability
CAIT	Cumberland Ankle Instability Tool
DFOS	Dance Functional Outcome System
FAAM	Foot and Ankle Ability Measure
FAOS	Foot and Ankle Outcome Score
FADI	Foot and Ankle Disability Index
FAI	Functional Ankle Instability
FI	Functional Instability
FPS	Faces Pain Scale
ICC	Intraclass Correlation Coefficient
IdFAI	Identification of Functional Ankle Instability
ICF	International Classification of Functioning, Disability and Health
MI	Mechanical Instability
PI	Perceived Instability
UFS	University of the Free State
WHO	World Health Organisation
95% CI	95% Confidence Interval

TERMINOLOGY

Company rank: Corp de ballet	A dancer who is part of the corp de ballet is a permanent member of a ballet company who dances in groups and provides the backdrop for the principle dancers and the soloists (Wikipedia).
Company rank: Graduates	Dancers who form part of the apprenticeship program at a ballet company and who is in full-time training at the ballet company
Company rank: Principle dancer	"A dancer at the highest rank within a professional dance company, particularly a ballet company" (Wikipedia).
Company rank: Soloist	"A soloist is a dancer in a ballet company above the corps de ballet but below principal dancer" (Wikipedia).
Demi-pointe	"Supporting one's body weight on the balls of one or both feet, heels raised off the floor." (Glossary of Ballet – Wikipedia)
Elite athlete	"A person who is currently or has previously competed as a varsity player (individual or team), a professional player or a national or international level player" (Segen's medical dictionary 2012).
En Pointe	"Supporting one's body weight on the tips of the toes, usually while wearing structurally reinforced pointe shoes" (Glossary of Ballet – Wikipedia)
Giving way	"The regular occurrence of uncontrolled and unpredicted episodes of excessive inversion of the rear foot, which do not result in an acute ankle sprain" (Gribble *et al.* 2013).

Initial ankle sprain	The very first significant ankle sprain (Gribble *et al.* 2013).
Perceived joint instability	"The situation whereby during activities of daily living (ADL) and sporting activities the subject feels that the ankle joint is unstable and is usually associated with the fear of sustaining an acute ligament sprain" (Gribble *et al.* 2013).
Pliè	"A smooth and continuous bending of the knees outward with the upper body held upright" (Glossary of Ballet – Wikipedia)
Recurrent sprain	"Two or more sprains to the same ankle" (Gribble *et al.* 2013).
Rolling over/ twisting/ giving way	For the purpose of this study the terms rolling over, twisting or giving way will be used as synonyms as described on the Identification of Functional Ankle Instability Questionnaire.
Significant ankle sprain	An ankle sprain which had symptoms of pain and swelling and resulted in at least one day of interrupted physical activity (Gribble *et al.* 2013).

ABSTRACT

The prevalence of Chronic ankle instability and associated self-reported function in professional ballet dancers in South Africa

Introduction and aim:

Chronic ankle instability (CAI) is characterised by a regular sense of the ankle giving way and recurrent sprains. This condition is thought to arise following acute ankle sprains. Due to a high ankle sprain rate, as well as other sport-specific factors, CAI may be a significant problem in professional ballet dancers. Previous studies have investigated the prevalence of CAI in dancer populations, but no studies have been done on South African dancer populations and none examined the functional impact this condition might have on this population. The aim of this study was to determine the prevalence of CAI, describe the level of associated self-reported function in professional ballet dancers in South Africa and to determine if dancers with CAI differ in respect to ankle injury history, treatment of previous ankle injuries and the presence of pain during functional activities in comparison to dancers who have not developed CAI

Methodology:

Three professional ballet companies in South Africa were visited by the researcher who supervised the completion of the following questionnaires: the Identification of Functional Ankle Instability Questionnaire (IdFAI); the Foot and Ankle Ability Measure (FAAM); and the Dance Functional Outcome System (DFOS); as well as a self-compiled, literature-based injury history questionnaire. Descriptive statistics, namely frequencies and percentages for categorical data and medians and percentiles for continuous data were calculated. Dancers with/without CAI were associated by means of Fisher's exact test for categorical data and Kruskal-Wallis test for continuous data.

Results:

Thirty-three dancers were included. Approximately 76% of the participants reported having sustained at least one significant ankle sprain and 88% of those went on to develop CAI. A total of 67% of participants included in the analysis had CAI. The self-reported function of the participants suffering from CAI was not found to be significantly affected. The median score for dancers who had CAI was 95% on the

FAAM (Activities of daily living subscale), 88% on the FAAM (Sport subscale) and 93% on the DFOS. Dancers with CAI demonstrated a tendency to experience more pain in the previously injured ankle during functional activities when compared to dancers who have not developed CAI.

Conclusion(s):

Although the prevalence of CAI in professional ballet dancers in South Africa was found to be high, their self-reported function was not significantly affected. These findings could stimulate further research to identify possible explanations for the reported level of function despite injury.

CHAPTER 1 – INTRODUCTION AND BACKGROUND

In this chapter introductory information on Chronic Ankle Instability (CAI) and the potential effects of the condition on the self-reported functional levels in a professional ballet dancer population will be provided.

CAI is a condition arising following acute ankle sprains and is characterized by a regular sense of the ankle giving way and recurring ankle sprains (Koboyashi & Gamada 2014; Gribble, Delahunt, Bleakley, Caulfield, Docherty, Fourchet, Fong, Hertel, Hiller, Kaminski, Mc Keon, Refshauge, Van Der Wees, Vincenzino & Wikstrom 2013; Webster & Gribble 2010).

Simon, Hall & Docherty (2014) suggests that ballet dancer populations may be significantly affected by CAI and many reasons for this suggestion have been proposed. Some factors which could influence the development of CAI in ballet dancer populations include the high ankle injury rate, the unique environmental risk factors to which the dancers are exposed and factors relating to the specifics of the ballet dance technique as well as the societal demands placed on dancers (Hutt & Redding 2014; Simon, Donaheu & Docherty 2014; Russell 2010; Potts & Irrgang 2001; Liederbach 2000; Sammarco & Tablante 1997). These concepts will be further explored and discussed in the literature review.

During the literature search only a limited number of studies on CAI in dancers in general could be found. One such a study, determined the prevalence of CAI in collegiate dancers at an Australian University (Simon *et al.* 2014). These results, however, cannot be generalised for a professional ballet dancer population, nor for a South African ballet dancer population. The impact CAI has on the function of different physically active populations have been studied previously, but no such studies could be found which specifically aimed to determine the associated functional impact CAI has on ballet dancers.

Although previous studies have investigated the prevalence of CAI in dancer populations, no studies have been done on South African dancer populations and none examined the functional impact this condition might have on professional ballet dancers. Deriving from this problem statement, the following research question was

formulated: What is the prevalence of CAI in professional ballet dancers in South Africa and how does this condition impact their function?

The main aim of this research study was to determine the prevalence of CAI in professional ballet dancers in South Africa and to describe the level of self-reported function associated with this condition.

In order to achieve the main aim, the following objectives were addressed:

- determining the prevalence of CAI in professional ballet dancers in SA;
- determining the level of self-reported function in order to describe the impact CAI has on the functioning of these dancers; and
- determining if dancers with CAI differ in respect to ankle injury history, treatment of previous ankle injuries and the presence of pain during functional activities in comparison to dancers who have not developed CAI.

The study population consisted of all professional ballet dancers who were affiliated to professional ballet companies in South Africa. In South Africa a total of three professional ballet companies existed at the time of data collection and participants were contacted through these three companies. Due to the small size of the study population, no sample was drawn and all professional ballet dancers affiliated with these three companies at the time of data collection were considered for inclusion in the study.

The study made use of three standardised questionnaires and one self-compiled, literature-based questionnaire in order to obtain the relevant data. The Identification of Functional Ankle Instability (IdFAI) questionnaire was used to identify participants with and without ankle instabilities. The Foot and Ankle Ability Measure (FAAM) and the Dance Functional Outcome System (DFOS) were used to evaluate the dancers' self-reported function. A literature-based injury history and demographic information questionnaire was also compiled and included in the study.

In order to maximise response rates, the researcher travelled to the three companies to conduct the study. Each participant received a copy of all four questionnaires and was given sufficient time to complete the questionnaires.

Following data collection the data was captured in Excel spreadsheets and verified in order to enhance the integrity of the data. The data analysis was performed by the

Department of Biostatistics of the University of the Free State. The results were interpreted by the researcher and presented in the form of a dissertation. Figure 1.1 contains a schematic overview of the dissertation.

The results obtained through this study will provide a better understanding of CAI in a professional ballet dancer population in a South African context and the impact this condition has on the function of these dancers. These results could be used as motivation for further studies. In a wider context, the results from this study could be used to create and promote awareness of CAI in professional ballet dancers in South Africa, as well as in those responsible for the medical treatment of these dancers and the management of the companies with which the dancers are affiliated.

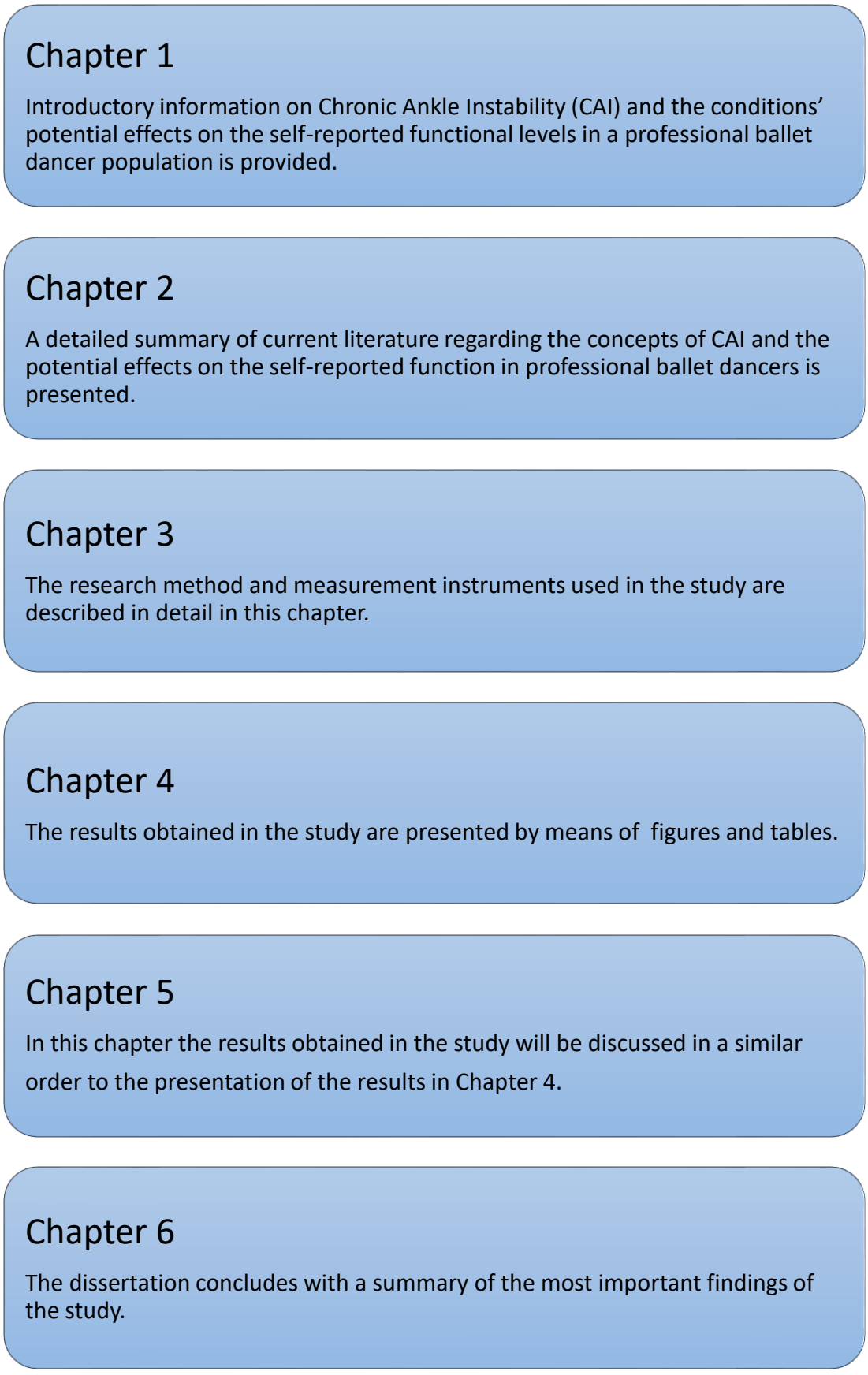

Figure 1.1 Schematic overview of the contents and order of the dissertation

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

In this chapter a summary of the relevant literature is discussed. The review starts with some background information on CAI, followed by a detailed description of the anatomy of the ankle, focusing on the anatomical features which contribute to the stability of the ankle. This review is then followed by information on how CAI affects these stabilising features, theories concerning the development of CAI, treatment options for CAI and how this condition might affect the professional ballet dancer population.

The literature study includes articles published in English obtained through searching multiple databases including CINAHL and MEDLINE. Articles published between 2007 and 2017 were included. Where no relevant information could be found published between these dates, the search was extended to include articles published from 2000. One article published in 1997 was also included due to the lack of recently published information regarding the specific topic being researched.

2.2 Prevalence and impact of ankle sprains and Chronic Ankle Instability

Ankle sprains are considered to be the most common acute injury sustained by dancers (Ramkumar, Farber, Arnouk, Varner & McCulloch 2016; Russell 2010). The reported ankle injury rate in ballet dancers varies between 4.7% and 48.8% in the published literature (Ramkumar *et al*. 2016; Russell 2010; Liederbach 2000). The discrepancy in the prevalence rates in published literature could be attributed to methodological differences and variations in operational definitions used in these studies.

The recurrence rate of acute lateral ankle ligament injuries is generally estimated to be between 70% and 80% in a sporting population (Webster & Gribble 2010; Hubbard, Kramer, Denegar & Hertel 2007; Denegar & Miller 2002). Considering that recurring lateral ankle ligament injuries are believed to lead to the development of CAI, this high recurrence rate is reason for concern (Webster & Gribble 2010). Unfortunately, no specific data on the re-injury rate of ankle sprains in ballet dancers could be found.

According to the position statement of the International Ankle Consortium published in 2013, between 32% and 74% of patients who sustained injuries to their lateral ankle ligaments continue to experience residual laxity, recurrent sprains and CAI (Gribble *et al.* 2013). It is estimated that 20% to 47% of patients who sustained a previous injury to the lateral ankle ligaments develop CAI (Simon *et al.* 2014). CAI is considered to be a very widely prevalent condition amongst both the sporting population (with a prevalence of >25%) as well as the general population (with a prevalence of >20%) (Gribble, Bleakley, Caulfield, Docherty, Fourchet, Fong, Hertel, Hiller, Kaminski, McKeon, Refshauge, Verhagen, Vicenzino, Wikstrom & Delahunt 2016).

The number of patients developing CAI may be even higher in dancers, as demonstrated in a study which found the prevalence of CAI in university dance majors to be approximately 53% (Simon *et al.* 2014). It is interesting to note from the study of Simon *et al.*(2014) that about 36% of the participants did not seek treatment from a healthcare professional and that 75% of those developed CAI. Therefore, evidence is provided that ankle sprains and the subsequent development of CAI may be a significant problem in dancers.

2.3 Chronic Ankle Instability

CAI is a multi-dimensional and complex disorder (Gribble *et al.* 2013; Hiller, Kilbreath & Refshauge 2011; Hubbard *et al.* 2007). There seems to be some confusion regarding the exact definition of CAI, and many terms are being used interchangeably, for example functional ankle instability, functional instability, chronic instability, chronic lateral instability, recurrent ankle sprain and multiple ankle sprain. (Delahunt, Coughlan, Caulfield, Nightingale, Lin & Hiller 2010). The term “Chronic Ankle Instability” seems to be the most commonly used in current literature and is thought to be an umbrella term describing persistent symptoms after an ankle sprain (Delahunt *et al.* 2010). A systematic review by Delahunt *et al.* (2010) proposed the following operational definition of CAI: “The encompassing term used to classify a subject with both mechanical and functional instability of the ankle joint.” For the purpose of this study CAI will be defined as “persistent symptoms after an ankle sprain” and will include both mechanical and/or functional instabilities of the ankle.

2.4 Symptoms of Chronic Ankle Instability

The most commonly reported symptoms of CAI include a regular sense of giving way or perceived instability and recurring ankle sprains (Koboyashi & Gamada 2014; Gribble *et al.* 2013; Webster & Gribble 2010). A fear of the ankle giving way and re-injury has also been reported (Hiller *et al.* 2011). This study utilises the standard definitions of "giving way", "perceived instability" and "recurrent ankle sprains" as presented by the International Ankle Consortium.

The International Ankle Consortium defines the term "giving way" as: "the regular occurrence of uncontrolled and unpredicted episodes of excessive inversion of the rear foot, which do not result in an acute ankle sprain" (Gribble *et al.* 2013; Delahunt *et al.* 2010).

Perceived joint instability is defined as: "the situation whereby during activities of daily living (ADL) and sporting activities the subject feels that the ankle joint is unstable and is usually associated with the fear of sustaining an acute ligament sprain" (Gribble *et al.* 2013).

The term "recurrent ankle sprains" refers to "two or more sprains to the same ankle" (Gribble *et al.* 2013).

Before discussing the mechanism of CAI, a detailed discussion of the normal ankle anatomy and factors contributing to normal ankle stability will be provided.

2.5 Ankle joint stability and anatomy

Joint stability is defined as "the state of a joint remaining or promptly returning to proper alignment through an equalisation of forces" (Riemann & Lephart 2002). Joint stability is thought to arise due to complex interactions between static and dynamic components (Gutierrez, Kaminski & Douex 2009; Riemann & Lephart 2002). Static components include: ligaments, joint surfaces and the joint capsule, while dynamic components refer to the neuromuscular control of the joint (Riemann & Lephart 2002).

2.5.1 Static components

The ankle is a complex joint, both in structure and function (Sizer, Phelps, James & Matthijs 2003). It consists of the distal tibiofibular joint, the talocrural joint and the subtalar joint (Hertel 2002). Each joint is discussed separately in the following section.

2.5.1.1 The distal tibiofibular joint

The distal tibiofibular joint is a syndesmosis formed by the distal tibia and fibula and forms a mortise over the talus (Hermans, Beumer, De Jong & Kleinrensink 2010; Sizer *et al.* 2003). The bony parts of the distal tibiofibular joint are formed by the distal ends of the tibia and fibula (Hermans *et al*, 2010). The ligamentous part of the joint includes: the anterior tibiofibular ligament, posterior tibiofibular ligament, transverse ligament (or deep component of the posterior tibiofibular ligament) and the interosseous ligament (Hermans *et al*. 2010; Golanó, Vega, De Leeuw, Malagelada, Manzanares, Götzens & Van Dijk 2010). (See Figure 2.1).

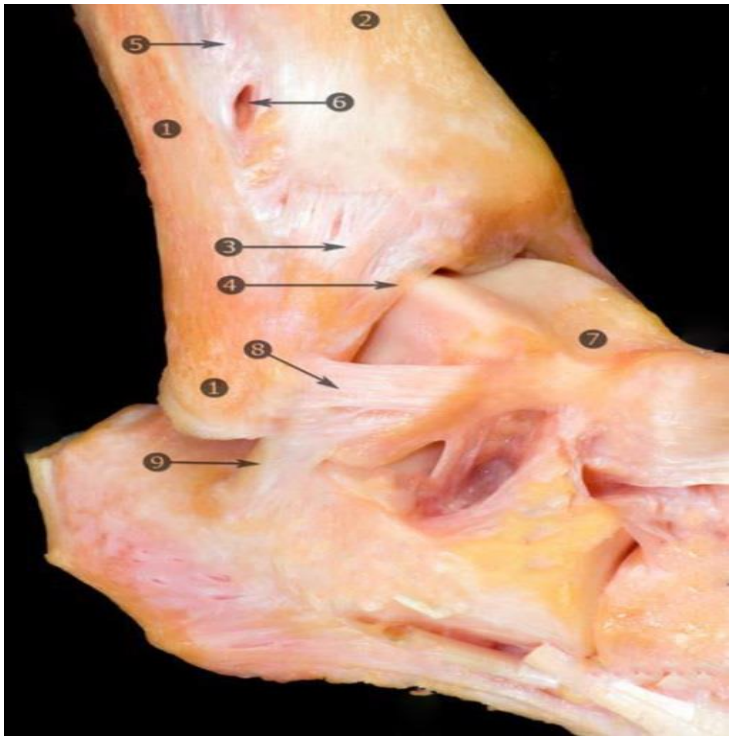

Figure 2.1 Anatomy of the anterio-lateral ankle 1 – Fibula; 2 – Tibia; 3 – Anterior Tibiofibular ligament; 4 – Tibiofibular ligament; 5 – Interosseous membrane; 6 – Foramen for peroneal artery; 7 – Talus; 8 – Anterior Talofibular ligament; 9 – Calcaneofibular ligament (Golanó *et al*. 2010)

2.5.1.2 The talocrural joint

The talocrural joint is formed by articulations between the talar dome, medial surface of the medial malleolus, medial surface of the lateral malleolus and the tibial plafond (Hertel 2002). The talocrural joint is regarded as a hinge joint and is mainly involved in plantarflexion (±50°) and dorsiflexion (±30°) (Hertel 2002; Sizer *et al.* 2003).

There are three important factors which are required for stability in this joint namely: the structure of the joint, the ligaments and joint-capsule and the muscles attached near the joint (Sizer *et al*. 2003).

The articulating surfaces of the talocrural joint are thought to be some of the most congruent in the body (Hubbard & Hertel 2006).

The ligaments that contribute to the stability in this joint are divided into the medial ligament complex and the lateral ligament complex (Galonó *et al*. 2010). The lateral ligament complex consists of the anterior talofibular ligament, the calcaneofibular ligament and the posterior talofibular ligament (Galonó *et al*. 2010). (See Figure 2.1.) The medial ligament complex is also sometimes referred to as the deltoid ligament (Galonó *et al*. 2010). (See Figure 2.2).

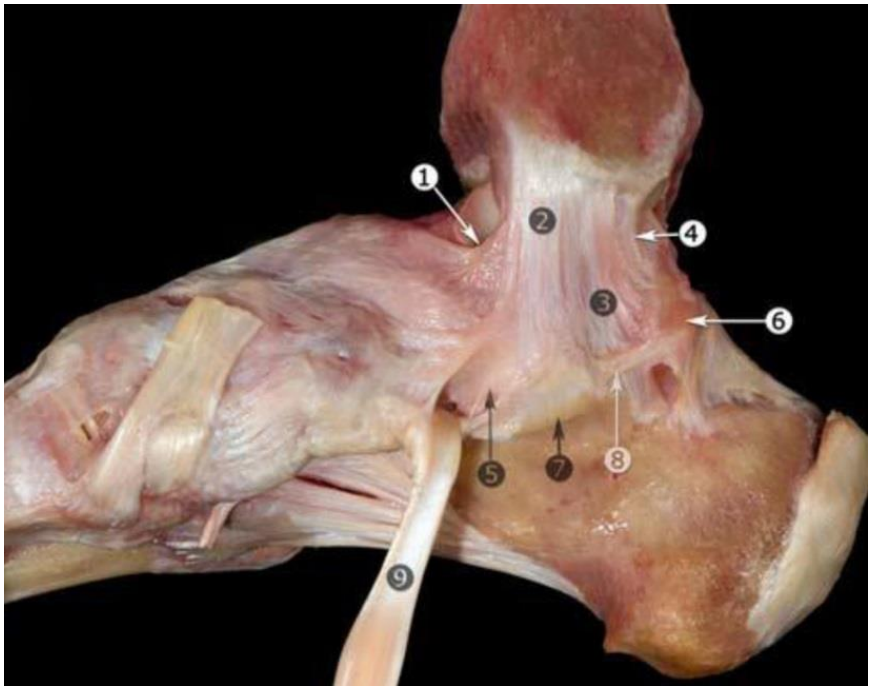

Figure 2.2 Anatomy of the medial ankle 1 – Tibionavicular ligament; 2 – Tibiospring ligament; 3 – Tibiocalcaneal ligament; 4 – Deep posterior Tibiotalar ligament; 5 – Spring ligament complex; 6 – Medial talar process; 7 – Sustentaculum tali; 8 – Medial talocalcaneal ligament; 9 – Tibialis posterior tendon (Golanó *et al.* 2010).

The talocrural joint capsule is not confined to the talocrural joint, but stretches into the distal tibiofibular syndesmosis (Sizer *et al*. 2003). Although being quite extensive, the capsule is strengthened by ligaments on both the medial and lateral aspects (Sizer *et al.* 2003).

The muscles which have a stabilising role on the talocrural joint will be discussed at a later stage.

2.5.1.3 The subtalar joint

The subtalar joint is a very complex joint which is formed by the articulations between the talus, the calcaneus and the navicular bone (Sizer *et al.* 2003). The movement in the subtalar joint has been described as “hinge-like”, “screw-like” or “multi-axial” (Barg, Tochigi, Amendola, Phisitkul, Hintermann, Saltzman 2012). This joint is mainly involved in inversion/ supination (25° - 30°) and eversion/ pronation (5° - 10°) (Barg *et al*. 2012). Two, sometimes three, different compartments of the subtalar joint are described in the literature (Sizer *et al.* 2003; Linklater, Hayter, Vu, Tse 2009). The three compartments are: the posterior compartment, the middle compartment and the anterior compartment (Linklater *et al.* 2009; Sizer *et al.* 2003).

There are many variations in the descriptions of the ligaments associated with the subtalar joint in literature. The ligaments thought to contribute significantly to the stability of the subtalar joint can be divided into two groups, namely: intrinsic ligaments and extrinsic ligaments (Barg *et al*. 2012).

The intrinsic ligaments include the interosseous talocalcaneal ligament, which is thought to be the primary stabiliser of the subtalar joint, and the cervical ligament (Barg *et al*. 2012). The calcaneofibular ligament and some parts of the deltoid ligament are included in the extrinsic ligaments (Barg *et al*. 2012). The extensor retinaculum is also thought to play an important role in the stability of the ankle and subtalar joint (Barg *et al*. 2012; Linklater *et al.* 2009). The retinaculum is defined in literature as a: “localised thickening of the crural fascia covering the deep structures of the distal portion of the foot and ankle” (Barg *et al*. 2012).

2.5.2 Dynamic components

The dynamic components necessary for the maintenance of joint stability are referred to as neuromuscular control (Riemann & Lephart 2002). Gutierrez *et al.*

(2009) define neuromuscular control as: “the interaction between the nervous and musculoskeletal systems to produce a desired effect or response to a stimulus”.

2.5.2.1 Muscular components

The coordinated activation of stabiliser muscles is thought to be crucial to the maintenance of joint stiffness and joint stability (Sangwan, Green & Taylor 2014; Gutierrez *et al*. 2009; Hertel 2002). A recent systematic review on the characteristics of stabilising muscles defined stabiliser muscles as: “those that contribute to joint stiffness by co-contraction and show an early onset in response to perturbation” (Sangwan *et al*. 2014). Co-contraction is when the agonist and antagonist muscles are activated simultaneously in order to lead to joint compression, and thus joint stability (Sangwan *et al*. 2014).

The peroneal muscles act as ankle evertors and are thought to play an important role in ankle stability (See Figure 2.3) (Ziai, Benca, Von Skrbensky, Graf, Wenzel, Basad, Windhager & Buchhorn 2013; Gutierrez *et al*. 2009; Hertel 2002). The peroneal group consists of the peroneus longus muscle and the peroneus brevis muscle (Moore & Dalley 2006). The peroneus longus muscle stretches from the superior part of the fibula to the base of the first metatarsal and medial cuniform bone in the foot (Moore & Dalley 2006). The peroneus brevis muscle runs between the inferior part of the fibula and the base of the fifth metatarsal bone (Moore & Dalley 2006). Hertel (2002) proposes not only looking at the concentric actions of muscles, when examining their contributions to ankle stability, but also observing their eccentric function. The peroneal muscles play a significant role in the control of supination and are thus considered to be a vital contributor to ankle stability (Hertel 2002).

The muscles located in the anterior compartment of the lower leg are also thought to play a significant role in maintaining dynamic ankle stability (Hertel 2002). These muscles include: the m. tibialis anterior, m. extensor digitorum longus, m. extensor hallucis longus and m. peroneus tertius (See Figure 2.3) (Moore & Dalley 2006). These muscles work eccentrically to decelerate the plantarflexion component of supination and thus protect the lateral ankle ligaments against injury (Hertel 2002).

Figure 2.3 Anatomy of the muscles and tendons of the anterio-lateral ankle 1 Calcaneofibular ligament; 2 peroneus longus tendon; 3 peroneus brevis tendon; 4 fibula; 5 talofibular ligament; 6 calcaneus; 7 subtalar joint; 8 septum in the peroneal tubercle; 9 superior extensor retinaculum; 10 inferior extensor retinaculum; 11 extensor digitorum longus tendon; 12 peroneus tertius tendon; 13 extensor digitorum brevis; 14 extensor digitorum brevis tendon; 15 calcaneal tendon; 16 Kager's fat pad; 17 tuberosity of the fifth metatarsal bone; 18 lateral plantar fascia; 19 abductor digiti minimi (Golanó *et al.* 2010).

2.5.2.2 Neural components

The interaction of the neural and musculoskeletal system to provide stability to a joint is a very complex process and only some of the key concepts will be discussed in this literature review.

Proprioception was originally described by Sherington in 1906 (Riemann & Lephart 2002). He referred to proprioception as being the "afferent information arising from proprioceptors located in the proprioceptive field", and proposed that proprioception was an important contributor to both posture and joint stability (Riemann & Lephart 2002). Ligaments, joint capsules and musculotendinous tissue are richly supplied with mechanoreceptors for proprioception (Riemann & Lephart 2002). The mechanoreceptors in the musculotendinous tissue include the Golgi tendon organs, which convey information on the muscle tension, and the muscle spindle apparatus which provides information on the muscle length and changes in muscle length (Fox 2008; Riemann & Lephart 2002).

The information from the mechanoreceptors is integrated at the spinal cord level and most of the proprioceptive information travels further to the higher central nervous system levels via the dorsal lateral tract and/or the spinocerebellar tract (Riemann & Lephart 2002). The dorsal lateral tracts convey information to the somatosensory cortex, while the spinocerebellar tract terminates in the cerebellum (Riemann & Lephart 2002).

Activation of motor neurons/ efferent neurons in response to the information from the mechanoreceptors can occur at different levels in the central nervous system (Riemann & Lephart 2002). The motor neurons can be activated in the spinal cord, the brain stem, the cerebral cortex, the cerebellum or the basal ganglia, and may be activated as a direct result of peripheral sensory input, as in the case of a reflex reaction, or may be activated via the descending orders from the higher central nervous system levels (Riemann & Lephart 2002).

When the foot is moved into inversion, the mechanoreceptors located in the lateral ligament complex and the ankle joint capsule register the movement and send afferent information to the spinal cord (Gutierrez *et al*. 2009). In the spinal cord the sensory/ afferent neurons synapses with motor/ efferent neurons (Fox 2008). Stimulation of the motor neurons leads to the contraction of the peroneal muscles (Gutierrez *et al*. 2009). This then opposes the inversion movement and stabilises the ankle (Gutierrez *et al*. 2009). The reflex reaction explained is an example of a feed-back or closed-loop control mechanism (Sangwan *et al.* 2014; Gutierrez *et al*. 2009). Sangwan *et al.* (2014) describe feedback control as: “modification of the ongoing movement using information from sensory receptors, so that muscle onset would be expected in response to sensory feedback”.

In contrast with feedback control mechanisms there are the feed-forward mechanisms. Feed-forward mechanisms are defined as: “an anticipatory correction in the motor behaviour that allows rapid muscle action before movement” (Sangwan *et al.* 2014). An example of this would be the preparatory muscle action exhibited by the ankle muscles during jump landings (Gutierrez *et al*. 2009). The muscle activation is adjusted to take into account the demands of the task such as the jump height and landing surface before the landing occurs (Gutierrez *et al*. 2009). Only after the landing causes input to the mechanoreceptors in the joint structures do

feed-back mechanisms come into play to contribute to joint stability (Gutierrez *et al*. 2009).

Neuromuscular control arises from a complex interplay between these feed-back and feed-forward mechanisms (Gutierrez *et al*. 2009). Previous experience with similar situations, visual input and vestibular input also play a very important role in neuromuscular control (Riemann & Lephart 2002).

In order for muscles to provide sufficient stability to joints during motor tasks, the muscles should be activated in the correct sequence and at the correct time (Sangwan *et al.* 2014). This is referred to as the "recruitment pattern" and is regarded as being another vital characteristic of the neuromuscular control of stabiliser muscles (Sangwan *et al.* 2014). The recruitment patterns are adjusted to take into account the demands that the motor activity will place on the joint (Sangwan *et al.* 2014).

The function and stability of the ankle joint are thus the result of a complex interplay between various systems and tissues in the body. If injury interrupts one or more of these components, joint stability could be compromised.

2.6 Mechanism of Chronic Ankle Instability

The models illustrating the mechanism of CAI have been developed extensively since the traditional models were advocated between 1965 and 1985. These models theorised the cause of CAI as being due to either mechanical instability (MI) or functional instability (FI) (Hertel 2002). In 2002, Hertel suggested a model in which mechanical instability and functional instability are not exclusive entities, but rather part of a continuum. Hertel (2002) identified three sub-groups which attempted to classify patients with CAI (Figure 2.4). In 2011 Hiller *et al.* expanded the model of Hertel (2002) to include seven sub-groups in order to classify patients with CAI, who could previously not be classified using the Hertel model (Figure 2.5) (Hiller *et al.* 2011). To avoid confusion regarding the exact meaning of the terms, Hiller *et al*. (2011) proposed the term 'perceived instability' (PI) instead of 'functional instability', used in the explanation and graphical presentation of the model below (Figures 2.3 and 2.4). According to Hiller *et al.* (2011), the perception of the ankle being unstable is a universal symptom of Functional Ankle Instability (FAI).

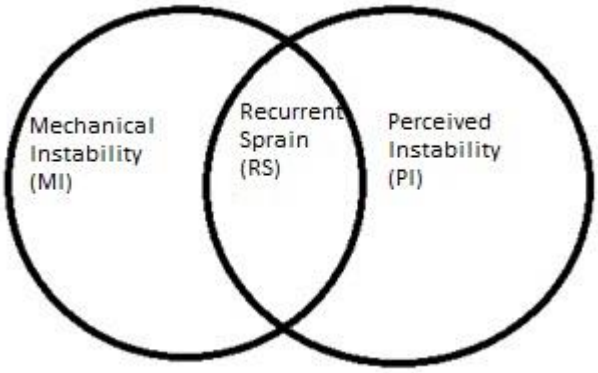

Figure 2.4. The CAI model by Hertel (Hiller *et al.* 2011)

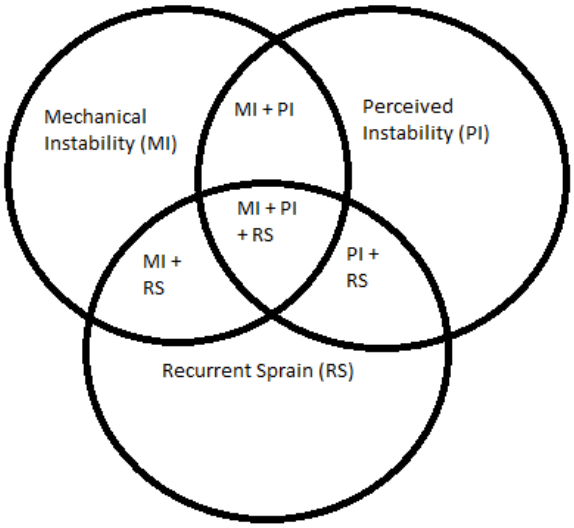

Figure 2.5. The New CAI model (Hiller *et al.* 2011)

Mechanical instability is referred to as an increase in range of motion in both physiological and accessory ranges (Hiller, Nightingale, Lin, Coughlan, Caulfield & Delahunt 2011). Mechanical instability may be the result of pathological laxity after ligamentous injury, altered joint arthrokinematics or synovial or degenerative changes (Kobayashi & Gamada 2014; Hubbard *et al.* 2007; Mattacola & Dwyer 2002).

Hertel (2002) proposed that pathologic laxity could be due to damage to the ligamentous structures of the ankle, especially those of the talocrural and subtalar joints. When the anterior talo-fibular ligament and calcaneo-fibular ligaments are injured, this could lead to instability of the talocrural joint (Hertel 2002). Injury to the calcaneo-fibular ligament is often associated with injuries to the ligamentous structures of the subtalar joint, such as the joint capsule and cervical ligaments (Hertel 2002). A systematic review revealed that inversion joint laxity and anterior joint laxity are most commonly associated with CAI (Cordova, Sefton & Hubbard 2010).

It is speculated that the lateral malleolus of the fibula may become stuck in an anterior and inferiorly displaced position which could put the anterior talo-fibular ligament in a slackened position and contribute to mechanical ankle instability (Hubbard, Hertel & Sherbondy 2006; Hertel 2002). Hiller *et al.* (2011) could, however, not confirm this in their systematic review, as there were only a limited amount of papers available to include in their study.

Another arthrokinematic impairment being advocated is a restriction in dorsiflexion (Hertel 2002). Limitations in dorsiflexion of the ankle may be compensated for by increased subtalar motion and may thus also contribute to ankle instability (Hertel 2002). Hiller *et al*. (2011) could not find significant results in the literature to confirm this theory. The systematic review by Hiller *et al.* (2011) also included two studies which investigated the shape of the talus and found an increased talar curve in subjects with CAI.

Joint instability may lead to abnormalities in the mechanical loading of joints, which may in turn contribute to articular cartilage damage and finally result in post-traumatic osteo-arthritis (Blalock, Miller, Tilley& Wong 2015; Magerkurth, Frigg, Hintermann, Dick & Valderrabano 2010; Hertel 2002). In a 2014 study, researchers found a causative relationship between FAI and early signs of osteo-arthritis (Golditz, Steib, Pfeifer, Uder, Gelse, Janka, Hennig & Welch 2014). Uneven loading of a joint can lead to structural changes of the articular cartilage and thus contribute to the development of osteo-arthritis (Golditz *et al.* 2014).

FI refers to a state in which patients regularly have episodes of the ankle giving way and perceive their ankle/s as feeling unstable (Delahunt *et al*. 2010). FI is thought to

arise from altered proprioceptive abilities, impaired neuro-muscular control and reaction time for muscular activation, deficiencies in muscular strength and decreased balance or postural control (Kobayashi & Gamada 2014; Hubbard *et al.* 2007; Matacola & Dwyer 2002). A systematic review and meta-analysis by Munn, Sullivan & Schneiders (2010) identified sensorimotor deficits which could be found among subjects with FI. The sensorimotor deficits identified were joint position sense and postural control (Munn *et al.* 2010).

It is clearly established in the literature that subjects with ankle instability will have deficits with regards to balance and postural control (Hiller *et al.* 2011; Munn *et al*. 2010; Arnold, De La Motte, Linens & Ross 2009; Wikstrom, Naik, Lodha & Cauraugh 2009). Evidence was also found for deficits in time to stabilisation of the ankle joint after perturbation (Hiller *et al.* 2011; Munn *et al*. 2010). It is thought that ankle injuries could cause sensorimotor and neuromuscular control impairments, which could lead to impairments in balance and postural control (Arnold *et al*. 2009; Wikstrom *et al*. 2009).

There are some inconsistencies in the literature regarding muscular strength deficiencies relating to CAI (Hiller *et al.* 2011; Arnold, Linens, De La Motte & Ross 2009). Hiller *et al*. (2011) only found concentric weakness of the invertors and concluded that deficiencies in muscle strength of the ankle musculature did not appear to be related to recurrent sprains. Arnold *et al*. (2009), however, found small, but significant deficits in muscle strength of the evertors in subjects identified as having FI. Evidence for deficiencies in the reaction time of the peroneal muscles could however not be found in the literature (Hiller *et al.* 2011; Munn *et al*. 2010).

2.7 Theories for the development of Chronic Ankle Instability

Although much evidence exists for the prevalence of CAI and the signs and symptoms of CAI, there is a lack of information on the reasons for the development of CAI (Gribble *et al*. 2016). A recent evidence review by the International Ankle Consortium summarised four likely theories for the development of CAI (Gribble *et al*. 2016).

The first proposed theory links CAI to the common belief that lateral ankle sprains are minor injuries that do not require medical attention (Gribble *et al*. 2016).

According to this theory, patients who do not receive medical attention after an acute ankle sprain may be more prone to developing CAI due to the lack of assessment and management interventions by medical professionals (Gribble *et al*. 2016).

The second theory proposes that the development of CAI may be linked to the intensity of care a patient receives after an acute ankle sprain (Gribble *et al*. 2016). Health professionals treating patients with acute ankle sprains may sometimes be either too passive or too aggressive in their treatment approaches (Gribble *et al*. 2016). Especially when treating athletes, there is usually a great deal of pressure to return to play as soon as possible and the health professionals treating athletes may then be inclined to an overly aggressive approach (Gribble *et al*. 2016). This overly aggressive approach can include returning an athlete to weight-bearing and activity to soon after the injury and thus not allowing the injured ligaments enough time to heal (Gribble *et al*. 2016).

The third theory states that dysfunctions in the neuromuscular or sensorimotor systems are likely to persist after injury to the lateral ligaments of the ankle (Gribble *et al*. 2016). Combine this with little or no treatment after acute ankle sprains, and CAI becomes a real possibility (Gribble *et al*. 2016).

The fourth theory investigates the impact genetic factors have on the occurrence of lateral ankle sprains (Gribble *et al*. 2016). One preliminary study found that soldiers who had the ACTN3 genotype were less likely to sustain lateral ankle sprains (Gribble *et al*. 2016).

More research into all four theories is, however, still needed (Gribble *et al*. 2016).

2.8 Treatment of acute ankle sprain

Because the development of CAI is linked to the management of acute ankle sprains, it is worth reviewing current evidence for the management of acute ankle sprains (Gribble *et al*. 2016). Evidence for the treatment of acute ankle sprains include: exercise therapy, manual therapy, the use of electrophysical agents and the use of orthotics or other forms of external support (Doherty, Bleakley, Delahunt & Holden 2017).

In the systematic review by Doherty *et al.* (2017), good evidence for the use of exercise therapy in the treatment of acute ankle sprains was found. Rehabilitation exercises were found to be effective in achieving improvement of self-reported function and recurrence of ankle sprains (Doherty *et al.* 2017). Exercises which address components of range of motion, muscle strengthening, proprioception and function are included in the advised exercise programme following acute ankle sprain in the Clinical Sports Medicine textbook of Brukner and Khan (2017).

The use of manual therapy and electrophysical agents is still controversial and there is insufficient good quality evidence to draw definite conclusions (Doherty *et al.* 2017). According to Doherty *et al*. (2017) it is considered standard practice to include ice, compression and elevation (RICE protocol) in conjunction with exercise therapy in the treatment of acute ankle sprains but the use of other electrophysical agents such as ultrasound is not considered to be effective.

Taping, bracing and the use of other orthotics are all considered to be effective for the prevention of recurrent sprains and the improvement of self-reported function (Doherty *et al*. 2017). The systematic review and meta-analysis by Doherty *et al.* (2017) recommend the use of an external support for a minimum of six months after the acute ankle sprain and suggests that lace-up ankle braces are considered more desirable compared to more rigid ankle supports.

Although early mobilisation after an acute ankle sprain is regarded as desirable by many, a period of non-weight bearing mobilisation can be warranted in order to allow the injured ligaments time to heal (Dubin, Comeau, McClelland, Dubin & Ferrel 2011). Hiller & Refshauge in Grieve's Modern Musculoskeletal Physiotherapy (2015) recommends that a severe ankle sprain can be immobilised for up to 10 days in order for the ligament to heal optimally.

2.9 Treatment of Chronic Ankle Instability

The conservative treatment for CAI can include manual therapy, taping/ bracing and exercise therapy. A systematic review by Van der Wees, Lenssen, Hendriks, Stomp, Dekker & De Bie (2006) found that manual therapy interventions could be expected to have an effect on the dorsiflexion range of motion in patient who sustained an

ankle sprain of who was diagnosed with functional instabilities of the ankle. Although the literature cannot currently confirm this, a theory exists that decreased dorsiflexion could be compensated for by local increases in the range of movement of the subtalar joint and could thus contribute to ankle instability (Hertel 2002). Theoretically thus, an increase in dorsiflexion due to manual therapy interventions could possibly reduce ankle instability after an ankle sprain. A recent randomised trial also found that manipulative therapy could be an effective addition to rehabilitation in patient sustaining recurrent ankle sprains and living with ankle instabilities (Lubbe, Lakhani, Brantingham, Parkin-Smith, Cassa, Globe & Korporaal 2015). Kosik, McCann, Terada and Gribble (2017) found only limited evidence to support the use of manual therapy in the treatment of patients with CAI, and suggest that it should be used as part of a multi-modal treatment programme. When considering the above studies, is can be suggested that manual therapy be used in conjunction with other modalities in the treatment of CAI.

Taping/ bracing the ankle has been shown to be an effective measure taken to reduce the risk for re-injury and thus for recurrent sprains (Raymond, Nicholson, Hiller & Refshauge 2012). This effect is probably due to the tape/ brace limiting the joint range of movement, decreasing mechanical instability and enhancing the athlete's confidence (Raymond *et al.* 2012). The systematic review by Kosik *et al.* (2017) considered the effect of taping/ bracing on the self-reported function of patients with CAI and could not draw any definitive conclusions regarding the use of bracing/ orthotics in the treatment of CAI. Depending on the desired outcome and the outcome measures used to determine the effectiveness of taping/ bracing in the management of CAI, the inclusion of these devices can be motivated.

Van der Wees *et al.* (2006) found that exercise therapy was an effective measure taken to prevent recurrent sprains. Another systematic review, by Loudon, Santos, Franks & Liu (2008), found that active exercises could result in a decrease in perceived instability or episodes of giving way and included exercises for balance retraining, increasing proprioception and strengthening.

Most of the studies on exercise therapy included balance training, proprioception exercises, ankle strengthening exercises or functional rehabilitation (Kosik *et al.* 2017; O'Driscoll & Delahunt 2011; Webster & Gribble 2010; Loudon *et al*. 2008;

McKeon & Hertel 2008; Van der Wees *et al.* 2006). According to Kosik *et al*. (2017) the use of balance exercises may be the most important feature to include in the treatment of CAI and found substantial evidence that supported the use of balance exercises in treatment programmes for CAI. There is limited to moderate evidence supporting the inclusion of proprioception exercises in the treatment of CAI (O'Driscoll & Delahunt 2011; Loudon *et al*. 2008). The systematic review by O'Driscoll and Delahunt (2011) included studies that looked at, amongst others, postural stability, joint position sense, perceived stability and muscle onset time to provide evidence for use of proprioception exercises.

The systematic review by Webster and Gribble (2010) focused on functional exercises. They defined a functional exercise as a: "dynamic, closed-chain activity other than quiet standing" (Webster & Gribble 2010). Although the studies included in the review utilised different outcome measures, all of the studies demonstrated improvement to some extent, or reduction in risk of re-injury (Webster & Gribble 2010).

The systematic review by Kosik *et al.* (2017) found only limited evidence for the use of strength training in isolation in the treatment of CAI. A randomised controlled trial using strength training for the treatment of CAI in college students found that the strengthening exercises improved the strength and perceived instability of the study participants, but did not have a significant effect on functional outcomes (Hall, Docherty, Simon, Kingma & Klossner 2015). Hall *et al*. (2015) confirms the findings by Kosik *et al.* (2017) that strength training has to be included as part of a multi-modal treatment approach and not used in isolation in the treatment of CAI.

When considering the above evidence for the conservative treatment of CAI, literature seems to confirm the suggested multi-modal model of CAI management advocated by Donovan and Hertel (2012).These authors suggest assessing the individual CAI patients in order to identify and address specific deficits which can include range of motion restrictions, decreased muscle strength, loss of balance and altered movement patterns during activities such as walking or jumping (Donovan & Hertel 2012).

Only after a failed comprehensive conservative management regime can surgery be considered (Guelfi, Zamperetti, Pantalone, Usuelli, Salini & Oliva 2016). Open surgical procedures, for example the Broström-Gould technique, have complication rates of up to 29.6% and include complications such as wound infections, range of motion limitations and sensory disturbances, to name a few (Guelfi *et al.* 2016). Another option for surgical intervention is arthroscopic surgeries. Arthroscopic procedures are more expensive and require more skilled surgeons than the open procedures (Guelfi *et al.* 2016). Complication rates are reported to be up to 35% and include similar complications to the open procedures (Guelfi *et al.* 2016). Despite possible complications, surgical interventions for CAI was found to be effective (Guelfi *et al.* 2016). Patient satisfaction after surgical interventions for CAI ranged between 91.7% and 96.4% and the post-operative outcomes as measured by a commonly used orthopaedic foot and ankle outcome measure was found to range between moderate to good (Guelfi *et al.* 2016). Surgery thus remains an effective intervention for patients who have had unsuccessful conservative management of CAI.

2.10 Impact of Chronic Ankle Instability

It has been suggested that not only the structural impairments associated with a condition should be investigated, but also the patient's experience of their abilities (Hoch & McKeon 2010). Hoch and McKeon (2010) noted that by only studying the structural impairments, an accurate idea of the functional loss experienced by the patient and thus the true impact these impairments have on the function of the patient is not formed. A suggestion is made that the patient's experience of his/her functional abilities thus form part of studies in order to get a more holistic view of the impact the impairments have on the function of patients (Hoch & McKeon 2010).

The above mentioned theory is supported by the World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF). The ICF examines "the influences of health conditions, environmental factors and personal factors on the domains of body structure and function, activity and participation" (Hoch & McKeon 2010). The schematic representation of the ICF below

demonstrates the dynamic relationship between the different components of the ICF (See Figure 2.6).

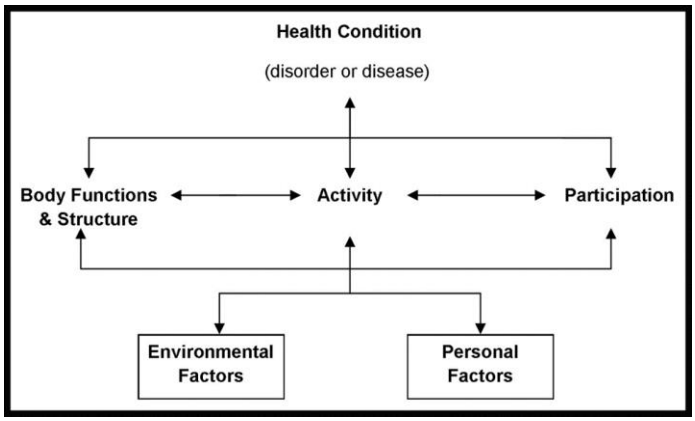

Figure 2.6 Schematic representation of the ICF (WHO 2013)

The impairments on the body function and structure, for example altered joint arthrokinematics or impaired neuro-muscular control, will have a negative impact on the patient's ability to participate in functional activities (Hoch & McKeon 2010). In professional dancers this could manifest as limitations in performing certain dance movements, which in turn will affect his/her ability to participate in his/her role as a professional ballet dancer.

Patients affected by CAI are observed to have significant limitations to their levels of function (Kosik *et al.* 2017). Houston, Hoch & Hoch (2015) found that participants who are living with CAI reported significant functional limitations, as measured on patient-reported outcomes such as the FAAM, when compared to participants who did not develop CAI after a significant ankle sprain.

CAI also places a financial burden on those who are living with the condition (Gribble *et al*. 2016). The costs incurred while treating CAI include direct costs such as consultations with health care professionals and indirect costs such as loss of income when patients are unable to work (Gribble *et al*. 2016).

According to a recent review released by the International Ankle Consortium, CAI may negatively affect a patient's quality of life and psychosocial status (Gribble *et al*. 2016). Patients living with CAI have been shown to have increased fear of re-injury and increased scores on the Fear-Avoidance Beliefs Questionnaire and Tampa

Scale of Kinesiophobia (Gribble *et al*. 2016). Houston, Van Lunen & Hoch (2014) also found that individuals with CAI demonstrated significant decreases in both global and local function. The decrease in function can lead to limitations in performing daily activities such as recreational and occupational activities which, in turn, can lead to decreases in a patient's quality of life (Houston, Van Lunen & Hoch 2014).

2.11 Development of Chronic Ankle Instability in Dancers

In order to obtain a more holistic perspective on the development of CAI in dancers, certain factors have to be considered. These factors include environmental, societal and task-orientated factors (Hoch & Mc Keon 2010).

Certain environmental factors have been thought to expose dancers to increased risks of injury. Raked stages or slippery surfaces may increase the chances of slips and falls (Liederbach 2000; Sammarco & Tablante 1997). The unnatural lighting levels used in theatres may also have a negative impact on the proprioception and balance of performing artists (Hutt & Redding 2014). Loss of balance, especially during high-risk movements, such as landing from a jump, may increase the likelihood for ankle injuries (Sammarco & Tabalante 1997).

The world of professional ballet is extremely competitive. There is a great deal of pressure on dancers to return to dancing soon after an injury in fear of being replaced by another dancer or being seen as lazy (Simon *et al.* 2014). This may result in dancers not taking adequate time off after an injury to allow for healing. In South Africa, where the ballet companies are far smaller, the pressure to return to dancing may be increased by added pressure from artistic staff. Many dancers also do not have access to on-site medical care, which in turn may delay the time until they receive medical treatment after an injury (Simon *et al.* 2014). Insufficient time for healing and inadequate rehabilitation after an ankle injury have been positively linked to CAI (Martin, Davenport, Paulseth, Wukich & Godges 2013; Denegar & Miller 2002).

Dancing involves a wide variety of movements ranging from fast, complex footwork and rapid, repeated jumps to slow, sustained movements requiring above average balance, co-ordination, flexibility and muscular strength (Potts & Irrgang 2001;

Sammarco & Tablante 1997). A common mechanism for lateral ankle ligament injuries in dancers involve landing from a jump (Sammarco & Tablante 1997). With repeated jumps, fatigue may set in and increase the risk for sustaining injuries (Hopper, Grisbrook, Newnham & Edwards 2014). A systematic review and meta-analysis on the characteristics of people with recurrent ankle sprains by Hiller *et al.* (2011) concluded that participants obtaining recurrent ankle sprains had longer time-to-stabilisation after a jump when compared to participants who did not obtain recurrent ankle sprains.

Ballet dancers require an ankle range of movement which far exceed the values typically observed in non-dancer populations (Russell, Shave, Kruse, Nevill, Koutedakis & Wyon 2011; Russell, Shave, Kruse, Koutedakis & Wyon 2011). This is due to the frequent utilisation of the maximally dorsiflexed (*plié*) and maximally plantar-flexed (*en pointe*) positions in ballet (Russell *et al.* 2011; Russell *et al*. 2011). It is estimated that ballet dancers need up to 90°/100° of plantarflexion in order to be able to dance efficiently *en pointe* (Russell *et al*. 2011). Most of the plantarflexion range (up to 70%) is thought to arise from the talocrural joint and the remaining range from the joints in the midfoot (Russell *et al*. 2011; Russell *et al*. 2011). The researcher hypothesises that the increased range of movement could possibly have an influence on the stability of the ankle joint.

It could thus be argued that, due to the unique demands placed on professional ballet dancers, this population may be particularly affected by CAI.

2.12 Conclusion

CAI and its impact on professional dancers have not been studied in depth. Very few studies have been done to determine the prevalence of CAI in ballet dancers. One study aimed to determine the prevalence of CAI in collegiate ballet students (Simon *et al.* 2014), but the results from this study cannot necessarily be transferred to professional ballet dancers. This may be because the collegiate students attend both dance classes and academic classes, while the numbers of hours spent dancing for professional ballet dancers may be significantly higher. Also, not much information is available on the impact this condition has on the lives of professional ballet dancers nor, could any information be found on CAI in a South African dancer population.

The literature suggests that CAI may significantly affect professional ballet dancers. The reasons for this could include the high ankle injury and re-injury rate, the unique environmental demands to which the dancers are exposed, aspects of dance technique and the daily demands to which these dancers are subjected (Hutt & Redding 2014; Simon *et al.* 2014; Russell 2010; Potts & Irrgang 2001; Liederbach 2000; Sammarco & Tablante 1997).

In the next chapter the study methodology and research process will be outlined and discussed in detail.

CHAPTER 3 – RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents a detailed description of the study methodology and research processes.

3.2 Study design

This study made use of a descriptive, cross-sectional study design.

According to De Vos, Strydom, Fouchè & Delport (2011) cross-sectional studies can be used to "determine whether a particular problem exists within a group of participants and what the level of the problem is."

3.3 Study population and sample

The study population consisted of all professional ballet dancers in the three South African professional ballet companies. Total population sampling was employed in this study due to the small population.

The participants were contacted through the three professional ballet companies in South Africa.

The inclusion criteria for participants are set out below:

- The participants had to be professional ballet dancers. Dancers were regarded as professional dancers if they made a living through dancing.
- The participants had to be literate in English. Since companies employ dancers from many different countries, English was chosen due to its universal nature. The dance classes were also instructed mainly in English and three of the questionnaires used in this study were also standardised in English.
- The participants had to be 18 years or older.
- Participants had to agree to participate voluntarily.
- Participants had to provide signed informed consent.

As recommended by the International Ankle Consortium, participants who had sustained either a fracture to their lower extremities or who had had to undergo surgery to their lower extremities were excluded from the study (Gribble *et al.* 2013). This is because of both fractures and surgery causing changes in the structural integrity of the limb (Gribble *et al.* 2013). It would be nearly impossible to isolate the symptoms of CAI with the possible added instability caused by a fracture or surgery (Gribble *et al.* 2013).

The size of professional ballet companies fluctuates according to the production they are staging. The exact size of the population was thus difficult to determine. At the time of the study Company A employed 14 dancers, Company B employed 41 dancers and Company C employed 10 dancers. This amounted to a total of 65 professionally employed dancers. Due to the limited size of the population, all participants who met the above-mentioned criteria were included in the study and no sample was drawn.

3.4 Ethical aspects

3.4.1 Avoidance of harm to the study participants

It is one of the key responsibilities of the researchers to protect the participants in their study from physical and/or emotional harm (De Vos, Strydom, Fouché & Delport 2011).

Seeing that no experimental procedures had been utilised during the study, the dangers of physical harm were minimal. The researcher did, however, make all reasonable attempts to ensure the safety of the participants who were participating in the study, for example, conducting the questionnaires in a safe environment. None of the participants suffered any physical harm while participating in the study.

The information gained through the questionnaires is not of a sensitive nature, and thus did not pose a risk of emotional harm to the participants. The individual results of each participant's questionnaires were only shared with the participant self, if requested by the participant. The company management of each company only received a final, summarised report (Appendix M) and individual dancers could not be identified, and their position in the company thus not compromised.

Dancers who indicated they wanted to receive feedback after the study was emailed and the dancers who were found to have CAI were advised to seek further treatment from qualified health professionals. The feedback report (Appendix M) to participants also contained information on how to identify CAI and what steps to follow should participants be worried that they might have CAI.

3.4.2 Avoidance of harm to the researcher

De Vos *et al.* (2011) also mention the risks involved for the researcher, such as travelling to and from appointments when conducting his/her research. The researcher made all necessary arrangements in order to minimise the risks imposed upon her. This included arranging adequate and safe accommodation and abiding by travel safety rules.

3.4.3 Voluntary participation in the study

Participation in the study was completely voluntary. The participants were allowed to withdraw from the study at any time, without having to fear the loss of any privileges or any other negative consequences. All participants were made aware of this before the commencement of the study.

3.4.4 Privacy and Confidentiality

All research participants have the right to confidentiality (Mouton 2001). In this study the participants' information was treated with the utmost respect and confidentiality. Each participant received a unique number indicated on the front of the questionnaire. This number was used in order to provide the individual results upon request to participants.

3.4.5 Informed consent

Written informed consent was obtained from each participant choosing to participate in the study, as well as from the institutions where the participants were employed (De Vos *et al.* 2011; McMillan & Schumacher 2006).

The participants received information- and informed consent documents (Appendices B and C) which gave a detailed explanation of what the study involved. The participants were also given verbal explanations before they started with the completion of the questionnaires.

Consent from the management of each company was obtained after they had received information on the study (Appendices D and E). The management of each company was contacted and suitable times and venues were arranged for the completion of the questionnaires. The researcher made all reasonable efforts to accommodate the company and its members.

3.4.6 Compensation

De Vos *et al*. (2011) suggest compensating participants for their time if the research resulted in a loss of income, or if the participants had to travel long distances in order to participate in the study.

The researcher travelled to a location convenient for the study participants and arranged for a time that suited the participants as well as the company management. The participants thus did not have any travel expenses and no loss of income was incurred. Consequently, there was no reimbursement or compensation for participating in the study.

The results obtained from this study, however, could be used to motivate for further studies regarding the management and prevention of CAI in professional ballet dancers. The results could also be used to promote an awareness of CAI in the dancers themselves and the company management as well as the health professionals responsible for the treatment of these dancers. The dancers participating in the study will thus, indirectly, benefit from the results obtained through the study.

The participants at each company was also entered into a lucky draw, as approved by the Health Sciences Research Ethics Committee. One of the clipboards used by the participants was marked with a sticker which could only be seen when the questionnaires were lifted up. Before commencing with the completion of the questionnaires, the participants were asked to check their clipboards. The participant, whose clipboard had been marked with the sticker, won a R500 Woolworths voucher.

3.4.7 Ethics committee

Study approval was obtained from the Health Sciences Research Ethics Committee of the University of the Free State (UFS) before the commencement of the study (ECUFS NR 236/2015) (Appendix E).

3.4.8 Publication of the findings

After completion of the study, the researcher will aim to publish the results of the study in an accredited, peer-reviewed journal.

Study participants had been made aware that results could be published and/or presented. All reasonable measures will be taken to ensure the confidentiality of the study participants for example no individual data will be presented and no company will be specifically named.

The researcher will ensure that the published results will not be manipulated, fabricated or falsified in any way (Mouton 2001). The shortcomings of the study will be stated clearly in order to avoid any misinterpretations and misleading information (De Vos *et al*. 2011).

The researcher will take all reasonable measures to eliminate plagiarism by submitting a Turnitin plagiarism report (Appendix L) (De Vos *et al.* 2011; Mouton 2001). Every person involved in the study, such as the study leader, will be recognised and receive an appropriate reference in the publication (Mouton 2001).

The results were made available to all the research participants in a modified research report (Appendix M). This report was written in a simpler, non-academic style in order to be suitable for the participants. Participants could also have access to their personal results, had they indicated on the attendance register that they would like to receive it.

3.4.9 The researcher

According to McMillan and Schumacher (2006) “the primary investigator of a study is responsible for the ethical standards to which the study adheres”.

The researcher in the study had taken all the necessary steps in order to ensure that the study was conducted in an ethical manner. This included reporting of all findings, whether negative or positive, avoiding plagiarism, ensuring the fair allocation of

resources, and honouring all commitments made to research participants and other members involved in the study (De Vos *et al.* 2011).

3.4.10 Storage of data

The study data will be kept for 5 year and then disposed of by means of shredding the hard copies and deleting all the digital material.

3.5 Pilot study

The pilot study was conducted on six adult, recreational ballet dancers in Bloemfontein and followed the same procedure as the main study.

Due to the fact that the dancers used in the pilot study were not professional ballet dancers, their results were not included in the study.

The pilot study aimed to identify any terms used in the questionnaires that might cause confusion or could be misinterpreted. It also aided in determining the amount of time necessary to complete the four questionnaires.

The questionnaire compiled by the researcher was subjected to the pilot study in order to enhance the validity and reliability of it.

The questionnaires completed in the pilot study were coded and the data entered into spreadsheets on EXCEL. This was done in order for the researcher to identify any challenges that might arise during this process and to ensure that the coding and data capturing process of the study was quick, accurate and effective.

After the completion of the pilot study, the following changes were made:

- More detailed general instructions regarding the completion of the questionnaires were added, for example including the explanation of “Not applicable” to the instruction page in front of the FAAM, and not only on the questionnaire itself. More details regarding the program and general procedure to be followed on were also included. This was done in order to avoid any misunderstandings and to provide the participants with more clarity regarding the program to be followed on the day of data collection.
- Clarity regarding the definition of a significant ankle sprain was provided by specifically mentioning it during the verbal instructions.

- In order to distinguish between the participants who had only one significant ankle sprain and those who had more than one significant ankle sprain an extra question was added to the Ankle Injury History Questionnaire (Question number 18). Participants who answered “yes” to question 18 were required to complete questions 19 to 29. Participants who answered “no” to question 18 could continue at question 30.
- It was decided to include a lucky draw for the study participants in order to encourage them to participate in the study.
- More detailed instructions for the DFOS and the FAAM were provided.

Following the pilot study it was determined that the participants required less than 60 minutes to complete all four of the questionnaires.

The Health Sciences Research Ethics Committee, UFS, was informed of all changes made after the pilot study.

3.6 Measurement

This study made use of the following questionnaires as measuring instruments:

- the IdFAI (Appendix F);
- the FAAM (Appendix G);
- the DFOS (Appendix H); and
- a questionnaire compiled by the researcher to determine ankle injury history and treatment (History of Ankle Injuries questionnaire) (Appendix I)

According to Simon *et al.* (2014), individuals with CAI are identified by using self-reported questionnaires. The International Ankle Consortium is currently recommending the use of any one of the following three questionnaires in order to confirm ankle instability in CAI: the Ankle Instability Instrument (AII), the Cumberland Ankle Instability Tool (CAIT), or the IdFAI (Gribble *et al.* 2013). See Table 3.1 for a comparison between the AII, CAIT and the IdFAI.

The International Ankle Consortium also currently endorses one of the following two questionnaires to describe the level of self-reported disability associated with CAI:

the FAAM or the Foot and Ankle Outcome Score (FAOS) (Gribble *et al*. 2013). See Table 3.2 for a comparison between the FAAM and the FAOS

Currently only one standardised questionnaire exists which measures the function of the back and lower extremities in ballet or modern dancers. This questionnaire is the DFOS. See Table 3.3 for a description of the DFOS.

Table3.1 Comparison between the AII, CAIT and IdFAI

Instrument	Description of instrument	Psychometric properties	Included in this study	Reason for inclusion/ exclusion
AII	The AII was developed in order to identify patients with ankle instability (Donahue, Simon & Docherty 2011). It is a 16-item questionnaire which includes three different types of questions: Yes/No, Multiple choice and open-ended questions (Donahue *et al.* 2011).	Sensitivity 0.73 (0.59 – 0.83) Specificity 0.86 (0.79 – 0.83) Good test-re-test reliability (Intraclass Correlation Coefficient (ICC)= 0.7 – 0.89) (Simon, Donahue & Docherty 2014; Donahue *et al.* 2011) When used in conjunction with the CAIT, the AII had a predictive value of 84.6% (Simon *et al.* 2014)	No	A 2011 study has shown that the use of the AII alone has low predictive value for ankle instability status and recommends that it should be used in conjunction with the CAIT (Donahue *et al*. 2011).
CAIT	The CAIT was developed in order to identify patients with ankle instability and to grade the severity of the condition (Simon *et al.* 2014). It consists of nine closed-ended questions (Donahue *et al*. 2011).	Sensitivity 0.56 (0.45 – 0.67) Specificity 0.86 (0.79 – 0.9) (Donahue *et al.* 2011). When used in conjunction with the AII, the CAIT had a predictive value of 84.6% (Simon *et al.* 2014).	No	A 2011 study has also shown that the use of the CAIT alone has low predictive value for ankle instability status and it is recommended that it should be used in conjunction with the AII (Donahue *et al.* 2011).

IdFAI	The IdFAI was developed based on a combination of the AII and the CAIT (Simon, Donahue & Docherty 2012). It consists of 10 questions and utilises a Likert scale in nine out of the 10 questions (Simon *et al.* 2012).	Sensitivity 0.83 (0.75 – 0.89) Specificity 0.94 (0.89 – 0.97) (Simon *et al.* 2014) The IdFAI has a predictive value of 87.8% (Simon *et al.* 2014)	Yes	The IdFAI was developed by using a combination of both the AII and CAIT and thus provides a more suitable instrument for identifying ankle instability (Simon *et al.* 2012). It is a short and simple questionnaire which takes less than 5 minutes to complete and is quick and easy to score (Simon *et al.* 2012) The IdFAI has been used in previous studies on dancer populations (Simon *et al.* 2014).

Table 3.2 Comparison between the FAAM and FAOS

Instrument	Description of instrument	Psychometric properties	Included in this study	Reason for inclusion/ exclusion
FAAM	The FAAM was developed in order to assess limitations in function of the foot, ankle or leg in a wide range of musculoskeletal conditions (Martin, Irrgang, Burdett, Conti & Swearingen 2005). It consists of two subscales and contains 29 closed-ended questions (Martin *et al.* 2005). It was developed using the Foot and Ankle Disability Index (FADI) (Donahue *et al*. 2011; Martin *et al.* 2005).	Sensitivity 0.59 (0.48 – 0.74) Specificity 0.78 (0.72 – 0.83) (Simon *et al*. 2014) The FAAM has been found to be both valid and reliable with an ICC of 0.89 for the ADL subscale and 0.87 for the Sport subscale (Eechaute, Vaes, Van Aerschot, Asman & Duquet 2007).	Yes	The FAAM is regarded as providing the most suitable means for assessing functional ability in patients with CAI (Hoch & McKeon 2010). The FAAM was found to be both valid and reliable (Eechaute *et al.* 2007).

FAOS	The FAOS was developed in order to assess limitations in the function of the foot and ankle in general foot and ankle conditions (Simon *et al.* 2014). It contains 42 closed-ended questions, sub-divided into five subscales (Donahue *et al.* 2011).	Sensitivity 0.56 (0.35 – 0.75) Specificity 0.76 (0.69 – 0.81) (Simon *et al.* 2014) Test-retest reliability was demonstrated for the FAOS with an ICC of 0.7 – 0.92 for the subscales (Eechaute *et al.* 2007). The FAOS demonstrated only moderate construct validity (Eechaute *et al*. 2007).	No	The FAOS is not regarded as being the most suitable instrument to be used in patients living with CAI.

Table 3.3 The DFOS

Instrument	Description of instrument	Psychometric properties	Included in this study	Reason for inclusion/ exclusion
DFOS	The DFOS is a dance-specific questionnaire that was developed to be used in ballet and modern dancers (Bronner & Turner 1999). It was developed due to the ceiling effects that were observed when using region-specific measures in dancer populations (Bronner, Novella & Becica 2007). It consists of 14 closed-ended questions divided into two parts.	The DFOS demonstrated acceptable reliability (internal reliability r=0.827; ICC r=0.803) (Bronner, Smith, Brown & Urbano 2016). The DFOS also demonstrated high repeatability and acceptable criterion validity (r=0.77; r=0.64) when compared to two well-known outcome measures (the Cincinnati Knee Rating System and the Olerude and Molander Foot-Ankle Questionnaire)(Urbano & Bronner 2016). A preliminary study done in 2003 also indicated that the DFOS has high reliability, validity and responsiveness to musculoskeletal injuries in dancers (Bronner, Spriggs & Ojefeitimi 2003).	Yes	The DFOS is the only dance-specific self-reported functional questionnaire currently available. The DFOS demonstrated acceptable validity and reliability (Bronner *et al*. 2016; Urbano & Bronner 2016).

3.6.1 Identification of Functional Ankle Instability

The IdFAI (Appendix F) is a short, simple questionnaire consisting of 10 closed-ended questions regarding the history of ankle sprains and signs and symptoms of instability and giving way. A Likert scale is used in nine out of the 10 questions.

The IdFAI questionnaire also has a very simple scoring system, with each option of the Likert scale being allocated a specific numeric score. At the end of the questionnaire the scores are added and any participant scoring 11 or higher is identified as having CAI (Simon *et al*. 2014).

3.6.2 Foot and Ankle Ability Measure

The FAAM (Appendix G) consists of two subscales: “ADL” and “sport”. The “ADL” subscale has 21 closed-ended questions and the “sport” subscale has eight closed-ended questions. Each subscale is scored separately. Each response is scored on a scale from four (4) to zero (0). A response of “No Difficulty” would receive a score of four, “Slight Difficulty” a score of three, etc. “Unable to do” would be scored as zero and “N/A” responses are not assigned any score. All the responses are multiplied by four to calculate the maximum score. The item score is calculated by adding all of the scores of the participant. The item score is then divided by the maximum score and multiplied by 100 in order to calculate a percentage. A higher percentage represents better function. The position statement released by the International Ankle Consortium in 2013 suggests that a score of <90% on the ADL subscale and/or <80% on the sport subscale, indicates a significant level of disability (Gribble *et al*. 2013)

3.6.3 Dance Functional Outcome System

The DFOS (Appendix H) questionnaire consists of 14 dance-specific closed-ended questions, divided into two parts. Part A includes questions regarding general activity while part B includes questions regarding dance technique. A score is assigned to each statement, with the top answer representing the most optimal functional level and thus being assigned the highest number of points. With each question, participants are requested to choose the statement which applies to them best. After completion the scores are calculated and converted to a percentage. Since no literature could be found on what would be considered acceptable scores, the researcher decided to follow the recommendations as set out in the position

statement released by the International Ankle Consortium in 2013 on the FAAM. A score of <80% will thus be considered a significant level of dance-specific disability. The FAAM consists of a different set of constructs and thus the scores below 80% on the DFOS were interpreted with caution.

3.6.4 History of ankle injuries questionnaire

The researcher also compiled a literature-based questionnaire in order to gain information regarding the initial ankle injury history and management thereof, as well as information regarding the most recent ankle sprain (Appendix I). The questionnaire was compiled by utilising information recommended by the International Ankle Consortium (Gribble *et al*. 2013).

The self-compiled questionnaire was subjected to a pilot study to enhance the face validity and reliability thereof. The reliability of the self-compiled questionnaire was further enhanced by standardising the conditions under which the questionnaire was to be administered (See Figure 3.1) and standardising the instructions (Appendix I).

The Faces Pain Scale (FPS) was included in the questionnaire in order to measure pain intensity (Dogan, Ay, Evcik, Kurtalis & Oztuna 2012).

3.7 Data collection procedure

In accordance with the ethics approval by the Health Sciences Research Ethics Committee, UFS (Appendix E), the management of each company was contacted and a suitable time and venue was arranged for the completion of the questionnaires. Informed consent was given by the management of each company, as well as by each dancer participating in the study.

A standard data collection procedure for each session was compiled by the researcher in order to increase the reliability of the study. The data collection procedure was as follows:

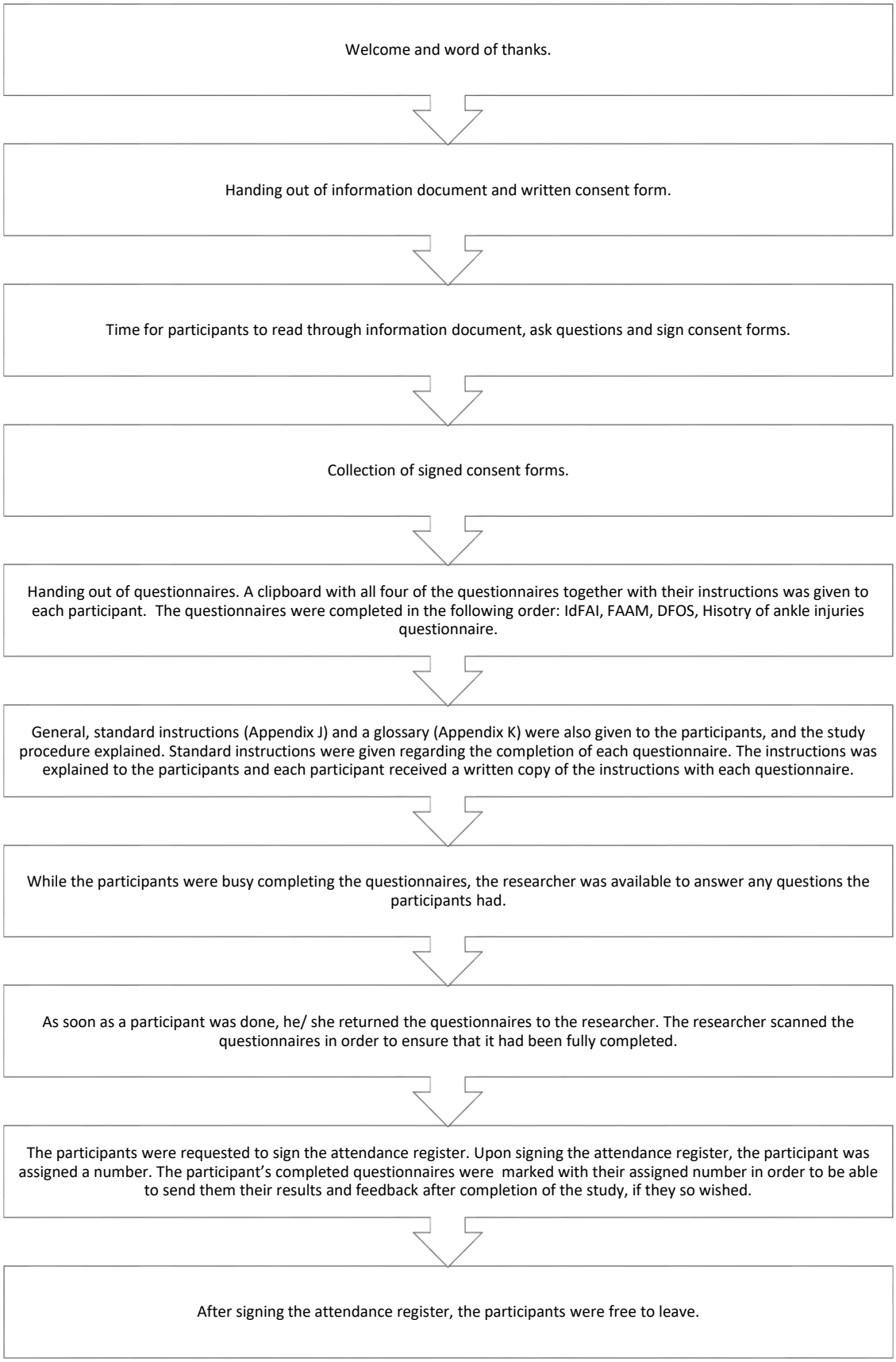

Figure 3.1 Schematic presentation of data collection procedure

Each participant received his/her own questionnaires and all the participants were required to complete the questionnaires during the scheduled time. No discussion of the questionnaires was allowed between participants during the execution of the study.

After collection of the data, the researcher coded all the questionnaires and entered the data into EXCEL spreadsheets. The researcher repeated the data capturing process in order to enhance the integrity of the data. After the data had been captured, the EXCEL spreadsheets were handed to the Department of Biostatistics, UFS, who performed the statistical analysis.

After completion of the study, feedback regarding the results of the study was compiled into a report and e-mailed to the company management (Appendix M), as well as to the individual dancers who requested it.

3.8 Measurement and methodology errors

All three standardised questionnaires used in the study demonstrated acceptable to good levels of reliability and validity (See Tables 3.1 – 3.3). The sensitivity and specificity of the IdFAI and FAAM are also discussed in Tables 3.1 and 3.2.

It is, however, unfortunate that the questionnaires which were used in this study have not undergone cultural validation for use in the South African population.

Since three of the questionnaires were standardised, the questionnaires were only conducted in English. Although this could have potentially excluded some participants, all of the participants who wanted to participate were literate in English. This could be due to the universal nature of the English language and due to English being the main language used in all three of the companies.

The fact that the questionnaires had been completed retrospectively could be a limitation of this study due to the possible effect of recall bias. Recall bias is defined as “a systematic error that occurs when recall of exposure is different between those with and without the outcome” (El-Masri 2013). In this study it could thus indicate that the recall of those participants with CAI of their first significant ankle sprain could have been better than the recall of those participants not affected by CAI. However, as this was one of the first studies on this specific population, time limitations and

budget constraints, the researcher found this to be the best way this specific study could be conducted. Future studies can build and elaborate on this study by, for example, employing a prospective cohort study design and observing the professional dancers over the course of their careers for CAI and the impact this condition has on their function.

By providing standard, detailed instructions before the administration of each questionnaire, the researcher aimed to minimise any misinterpretations that could arise during the completion of the study. Participants were also given a glossary to explain some of the terms that could cause confusion.

By administering the questionnaires in person, the response rate was optimised. This however, posed a risk of the researcher influencing the participants and thus influencing the results. The researcher in this study attempted to minimise these risks by providing standard instructions and following a standard data collection procedure while the data was being collected.

Due to the comprehensive nature of the questionnaires, the researcher anticipated the possibility of the study participants growing tired while completing the questionnaires. The researcher minimised this by handing out all four of the questionnaires at once and allowing the participants who worked quickly to leave as soon as they had finished completing the questionnaires. None of the sessions took more than 60 minutes and the researcher found that losing interest or exhaustion while completing the questionnaires did not seem to be a problem.

Another obstacle anticipated by the researcher was the lack of a suitable venue for questionnaire completion. This proved to be a challenge. At two of the three companies only the dance studios were available in which to conduct the study. These studios did not have desks, or enough tables and chairs, for the participants to use while completing the questionnaires. This challenge was overcome by giving each participant a clipboard to use and spreading the participants out in the studio while they were completing the questionnaires. This solution worked well and the participants were able to complete the questionnaires comfortably without engaging with one another.

The data capturing process was repeated by the researcher, as well as data verification performed by the biostatician in order to minimise any data typing errors. This was done to enhance the integrity of the data.

3.9 Data analysis

The data analysis was done by the Department of Biostatistics, UFS. Descriptive statistics, namely frequencies and percentages for categorical data and medians and percentiles for continuous data were calculated. The prevalence of CAI was calculated and described by means of 95% confidence interval (95% CI) for the prevalence. Dancers with/without injuries and with/without CAI were associated by means of Fisher's exact test for categorical data and Kruskal-Wallis test for continuous data. No 95% CI's could be calculated for the associations due to the small sample size of the subgroups.

3.10 Conclusion

In this chapter the study methodology and research processes were discussed in detail.

In the following chapter the results found in the study will be presented and illustrated by means of tables, graphs and figures.

CHAPTER 4 – RESULTS

4.1 Introduction

In this chapter the results obtained in the study will be presented by means of graphs, figures and tables.

4.2 Study participants

For a schematic overview of the study participants see Figure 4.1.

Fifty-two out of a possible 65 professional ballet dancers completed the four questionnaires. A response rate of 80% was achieved in the study.

Thirteen participants had to be excluded from the results because they had sustained either a fracture of their lower limbs or had undergone lower limb surgery.

The remaining 39 participants were included in the study.

In order for the researcher to interpret the results, it was decided to divide the results into three main groups (See Table 4.1) as set out below:

- Group A – participants who had a previous significant ankle sprain and consequently developed CAI;
- Group B – participants who had a previous significant ankle sprain but did not develop CAI; and
- Group C – participants who did not have a previous significant ankle sprain and did not show any signs of CAI.

Thirty of the questionnaires could be grouped according to the above-mentioned criteria.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

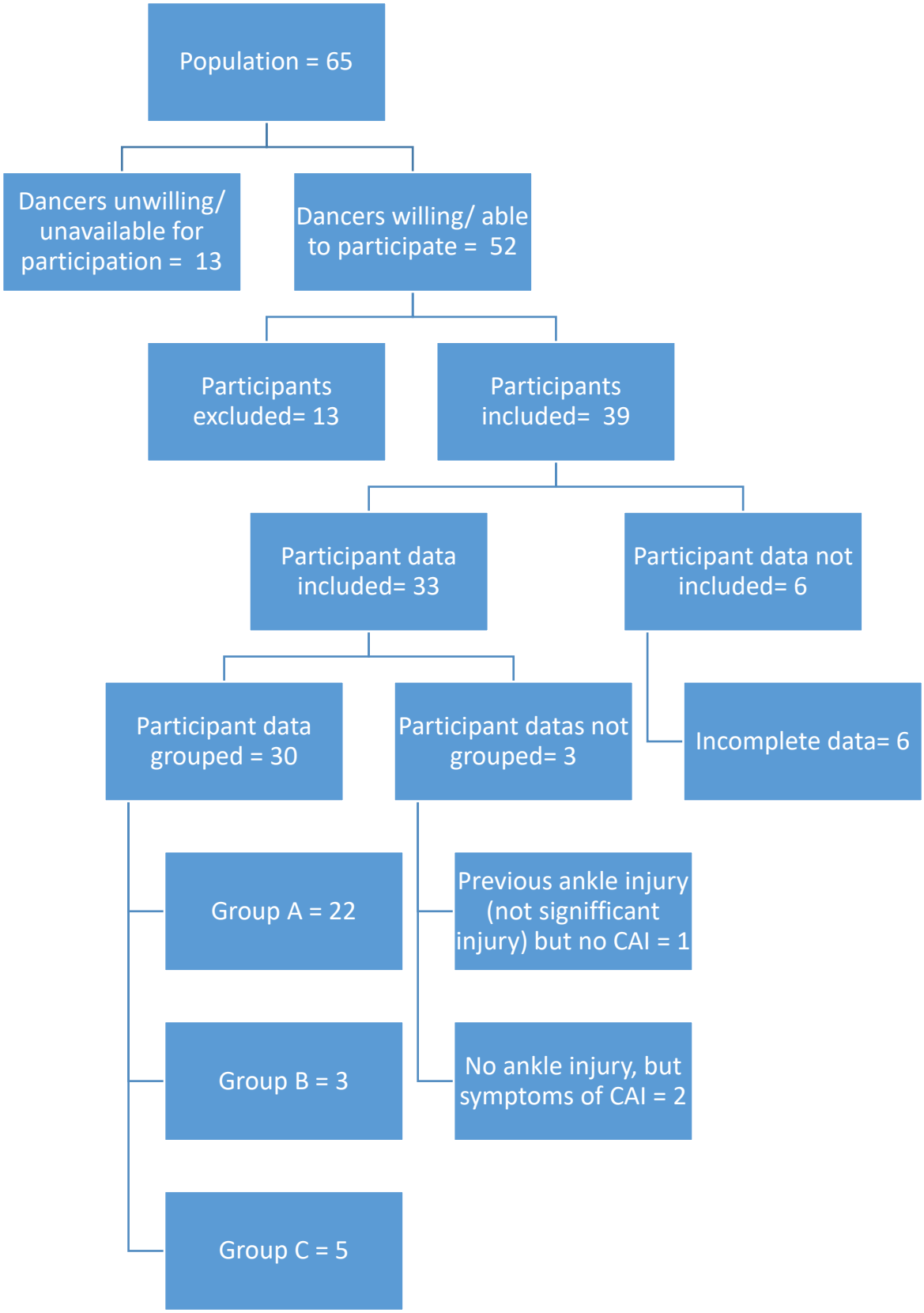

Figure 4.1 Schematic overview of study participants

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

Table 4.1 Grouping of participants

Group	Injury status	CAI classification according to the IdFAI	Number of questionnaires
Group A	Significant ankle sprain unilateral/ bilateral	CAI (unilateral/ bilateral)	22
Group B	Significant ankle sprain unilateral/ bilateral	No CAI	3
Group C	No significant ankle sprain unilateral/ bilateral	No CAI	5

n=30

The data of nine participants could not be included in the above-mentioned groups due to the following reasons:

- Six were excluded as the data was incomplete.
- One participant indicated that he/she had a previous ankle injury, but did not indicate whether the sprain was considered significant. He/ she did not report CAI symptoms. This participant's results will be presented separately.
- Two participants indicated that they did not have a significant ankle injury, but demonstrated the symptoms of CAI. These participants' results will be presented separately.

The main aim of this research study was to determine the prevalence of CAI in professional ballet dancers in South Africa and to describe the level of self-reported function associated with this condition. The results of Group A will thus be presented and compared with the results of Groups B and C, unless indicated otherwise. The results of the three participants who could not be grouped will be presented separately as no comparison between Group A and these participants were made. All the participants' demographic data will be presented together.

4.3 Demographic data

4.3.1 Gender

This study included both male and female participants. Thirteen male and 20 female participants were included.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

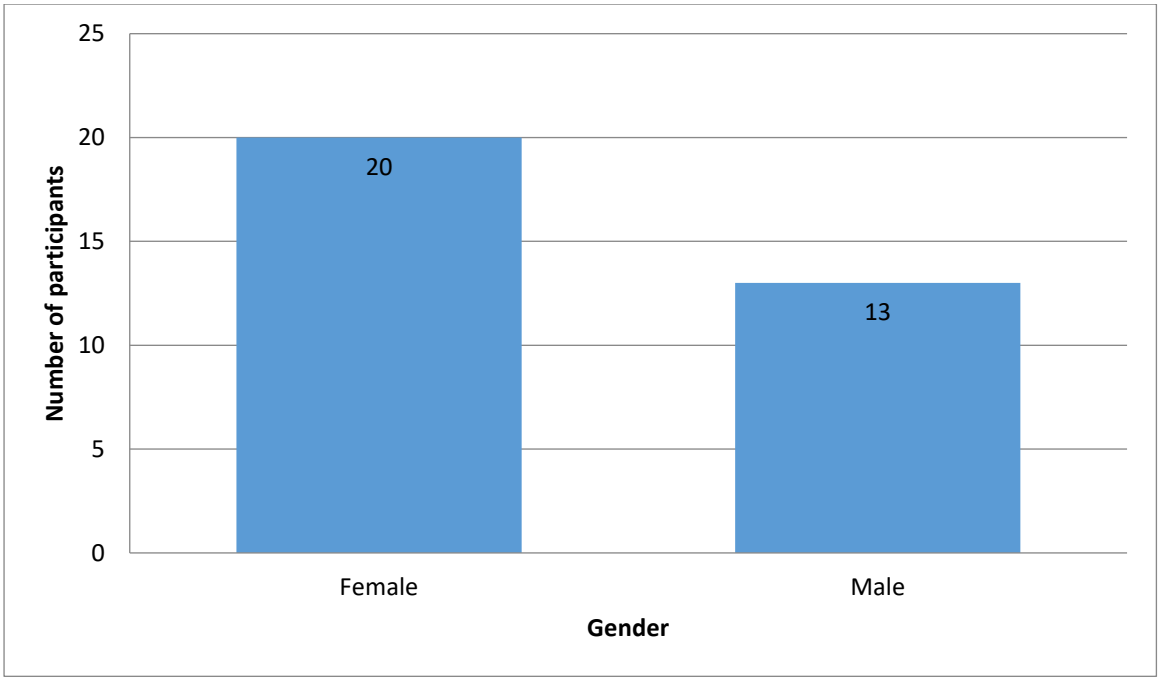

Figure 4.2 Gender (n=33)

4.3.2 Rank in the company

Junior dancers (graduate and corps de ballet members) accounted for 51.2% of the participants, and senior dancers (soloists and principal dancers) accounted for 30.3%. The remaining 18.2% was categorised in the "other" category, for example guest artists dancing with the company for a limited number of performances only.

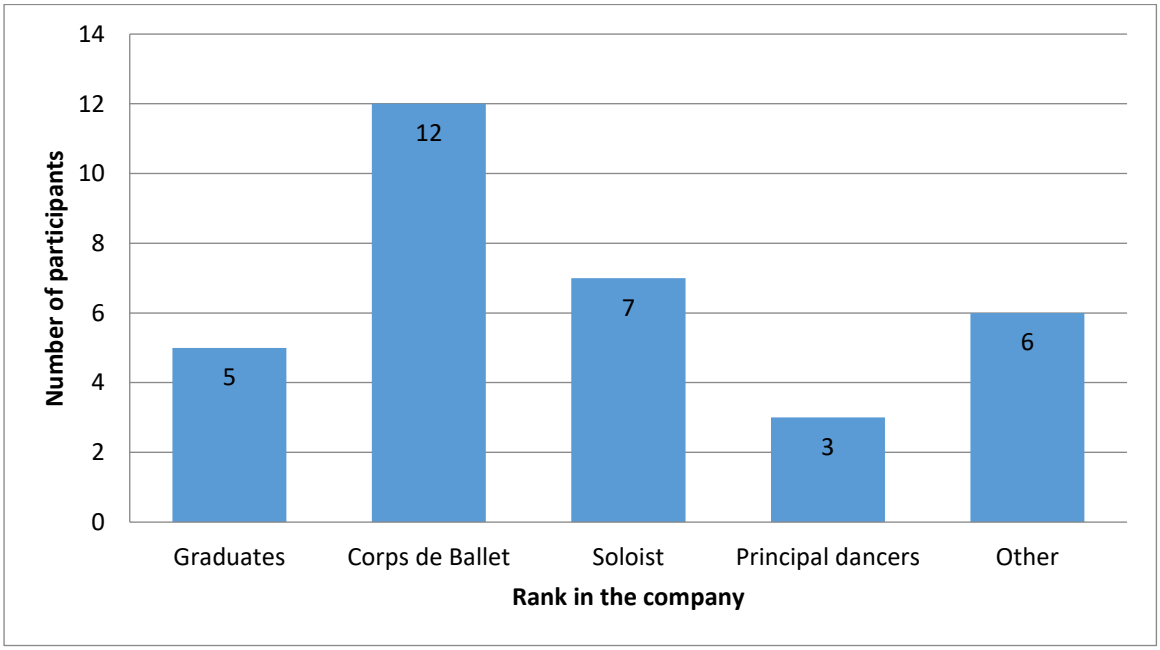

Figure 4.3 Rank in the company (n=33)

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

4.3.3 Age

The median age of participants ranged from 19.2 years to 23.4 years. Due to the small size of the population, the median age and not the mean for the age of participants is presented.

Table 4.2 Median age of participants

Group	Median age (in years)
Group A	23.3
Group B	19.2
Group C	23.4
Other	23

n=33

4.4 Ankle sprain history

4.4.1 Initial ankle sprain

4.4.1.1Ankle sprain history

4.4.1.1.1Ankle sprain history

Twenty-five (n=30) of the participants included in Groups A, B and C indicated that they had had at least one significant ankle sprain. This included the 22 participants from Group A and the three participants from Group B. Of all 33 participants included in the study 75.8% reported sustaining at least one significant ankle sprain.

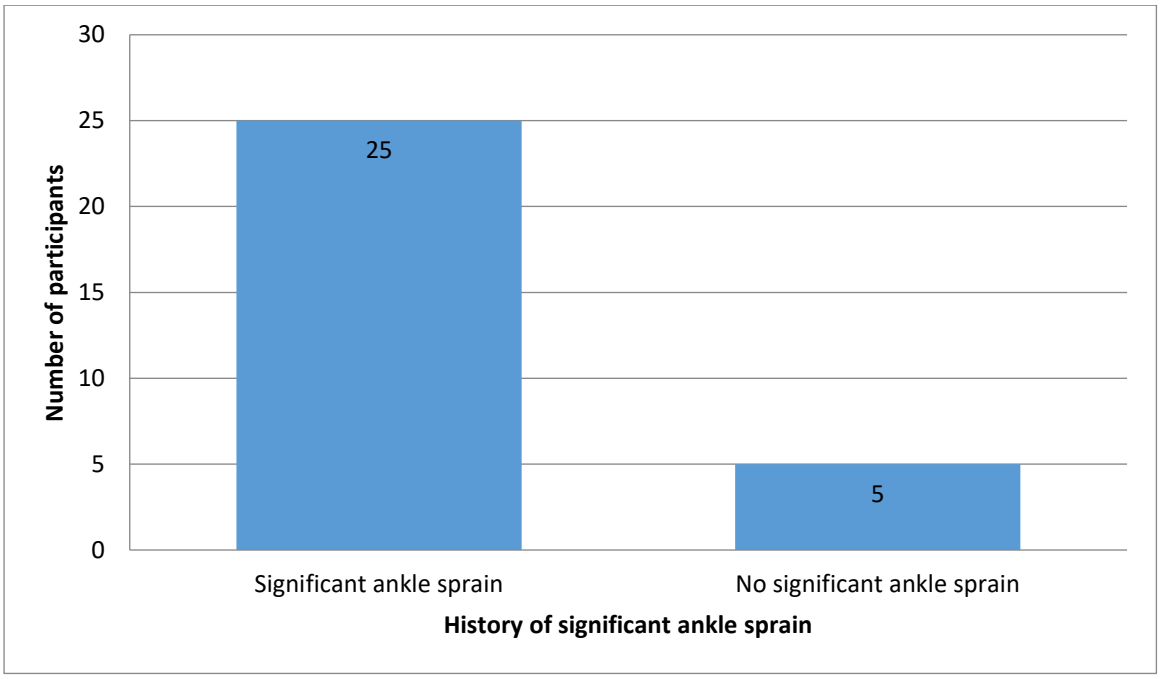

Figure 4.4 History of significant ankle sprain (n=30)

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

Twenty-one of the 25 participants who sustained at least one significant ankle sprain had an initial ankle sprain occurring more than 12 months ago. Only three of the participants' initial ankle sprains had occurred less than 12 months ago. One participant did not complete this question.

4.4.1.1.2 Mechanism of injury

Only three of the 25 participants who sustained at least one significant ankle sprain indicated that their initial ankle sprains had occurred during non-dance related activities. The remaining 22 participants reported sustaining their initial ankle sprains during dance or dance-related activities.

Of the 22 participants, 20 participants could identify specific dance-related activities which had resulted in their initial ankle injuries. The remaining two participants only provided a vague non-specific answer by only stating that the injury occurred during dancing.

Table 4.3 Dance-related activity resulting in ankle sprain

Dance-related activity	**Number of participants**
Jumping/ lifts	13
Allegro	1
Pirouette/ turning	1
Pointe work	1
Partnering work	1
Relevé	1
Cross-training for dance	2

n = 20

4.4.1.1.3 Self-perceived severity of initial injury

Of the 25 participants who had at least one significant ankle sprain, seven indicated that it had been a mild injury, seven mentioned a moderate injury and 11 reported it to be a severe injury.

Table 4.4 Self-perceived severity of initial injury

	Mild	**Moderate**	**Severe**
Group A	5	7	10
Group B	2	0	1
Total	**7**	**7**	**11**

n = 25

No statistical significant difference between Group A and Group B was found in relation to the severity of the initial injury (p=0.4309).

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

4.4.1.2 Management of the initial ankle sprain

Table4.5 Management of initial ankle sprain

		Group A (n=22)	Group B (n=3)
Immobilisation	**Immobilised**	7	1
	Not immobilised	15	2
Weight bearing	**Allowed to weight-bear**	11	2
	Not allowed to weight-bear	10	1
Supervised rehabilitation programme	**Supervised rehabilitation programme**	16	3
	No supervised rehabilitation programme	6	0

Most of the participants in Groups A and B (68%) reported that their ankles were not immobilised after the initial ankle sprain. Half of the participants (n=8) who indicated that their ankle was immobilised, reported that it had been immobilised for longer than seven days. No statistical significant difference between Group A and Group B was found in relation to the length of time immobilised after the initial ankle sprain (p=0.2500).

Thirteen participants (n=24) indicated that they were allowed to put weight on the ankle after the initial ankle sprain. Eleven participants (n=24) indicated that they were not allowed to put weight on the ankle after the initial ankle sprain. One participant did not answer this question. No statistical significant difference between Group A and Group B was found in relation to weight-bearing after the initial ankle sprain (p=1.000).

A total of 19 participants (n=25) indicated that they did participate in a rehabilitation programme supervised by a professional health care practitioner following their initial ankle sprain. No statistical significant difference between Group A and Group B was

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

found in relation to participation in a supervised rehabilitation programme (p=0.5539).

Reports regarding the length of the supervised rehabilitation programme varied from as short as one to seven days to longer than six weeks.

Table 4.6 Length of supervised rehabilitation programme

	Group A	**Group B**	**Total**
One to seven days	3	3	6
Two to four weeks	2	0	2
Four to six weeks	7	0	7
Longer than six weeks	4	0	4

n=19

A tendency for participants in Group A to be involved in longer supervised rehabilitation programmes was found (p=0.0547).

The participants reported on which modalities/ exercises were included in their supervised rehabilitation programmes. Participants could indicate more than one modality/ exercise. The following were included in the various rehabilitation programmes:

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

Table 4.7 Modalities/ exercises included in supervised rehabilitation programmes.

	Group A (n=16)	Group B (n=3)	p-value
Ankle strengthening	1	0	1.0000
Ankle strengthening specifically with a theraband	8	1	1.0000
General ankle mobilisation	3	1	0.5304
Dance-specific exercises	1	1	0.2982
Balance exercises (for example on an aerex mat)	3	0	1.0000
Proprioception exercises (for example on a wobble board)	2	1	0.4221
Calf raises	9	1	0.5820
Ankle stability exercises	1	0	1.0000
Jumping/ plyometric exercises	1	0	1.0000
Foot muscle strengthening exercises (for example doming exercises)	2	0	1.0000
Other treatment modalities such as ultrasound/ electrotherapy/ ice	1	0	1.0000
Other physiotherapeutic modalities such as massage/ cross-frictions/ dry needling	1	1	0.2982
Other medical interventions such as cortisone injections/ medication/ Transact plasters	2	0	1.0000
Other modalities/ interventions not mentioned above	2	0	1.0000

No statistical significant difference between Group A and Group B was found in relation to types of treatment, interventions or modalities and exercises included in the supervised rehabilitation programme.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

4.4.2 Most recent ankle sprain

4.4.2.1 Ankle sprain history

4.4.2.1.1Ankle sprain history

Ten participants (n=25), all in group A, indicated that they had experienced more than one significant ankle sprain. Fifteen participants (n=25) indicated that they only suffered one significant ankle sprain.

Table 4.8 Number of significant ankle sprains

	More than one significant ankle sprain	**Only one significant ankle sprain**
Group A	10	12
Group B	0	3
Total	**10**	**15**

n=25

No statistical significant difference between Group A and Group B was found in relation to the number of significant ankle sprains sustained (p=0.2500).

The results of the ten participants who reported sustaining more than one significant ankle sprain will now be presented.

Three participants (n=9) indicated that their most recent ankle sprain had occurred three to six months previously and six participants indicated that their most recent ankle sprain had occurred more than six months previously. One participant did not complete this question.

4.4.2.1.2 Mechanism of injury

All, but one, of the most recent ankle sprains occurred while the participants were engaged in dance or dance-related activities.

Table 4.9 Activity resulting in ankle sprain

Dance-related activity	**Number of participants**
Jumping/ lifts	4
Pirouette/ turning	1
Partnering work	1
Other dance/ performance-related activities	3
Other activities	1

(n=10)

4.4.2.2.3 Self-perceived severity of most recent ankle sprain

Five (n=10) participants indicated that their most recent ankle sprain had been a mild sprain and the remaining five participants indicated that their most recent ankle sprain had been a moderate sprain.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

4.4.2.2 Management of the most recent ankle sprain

Only two (n=10) participants reported that their ankle had been immobilised in a cast or brace after sustaining the most recent ankle sprain. The remaining eight (n=10) participant's ankles had not been immobilised.

The two participants whose ankles had been immobilised indicated that their ankles had been immobilised for 24 – 72 hours after their most recent ankle sprain.

All ten participants (n=10) indicated that they had been allowed to take weight on their injured foot after their most recent ankle sprain.

A total of eight (n=10) participants indicated that they had not been given a supervised rehabilitation programme by a professional health care practitioner after their most recent ankle sprain. One of the remaining two participants indicated that the supervised rehabilitation programme had lasted one to seven days and the other participant indicated that the supervised rehabilitation programme had lasted two to four weeks.

One participant (n=2) indicated that the supervised rehabilitation had included soft tissue techniques such as cross-frictions/ soft tissue therapy/ dry needling. Another participant indicated that he/she had received strapping as part of the management after his/her most recent ankle sprain. One participant (n=2) added that he/she had received other medical modalities/ interventions such as cortisone injections/ medication/ Transact plasters.

4.4.3 Pain

Fifteen participants, all in Group A, indicated that they were experiencing pain during their daily classes and/or performances in the previously injured ankle. The remaining ten reported that they had not experienced pain in the previously injured ankle. Of the participants in Group A, 68.2% (n=22) reported experiencing pain in the previously injured ankle.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

Table 4.10 Experiencing of pain in the previously injured ankle during daily classes and/or performances

	Pain in the previously injured ankle	No pain in the previously injured ankle
Group A	15	7
Group B	0	3
Total	**15**	**10**

n=25

A tendency for participants in Group A to experience more pain in the previously injured ankle was found (p=0.0522).

Of the 15 participants who reported experiencing pain in the previously injured ankle, the majority of participants (46.7%) reported experiencing 4/10 pain ("nagging, uncomfortable, troublesome pain" according to the FPS).

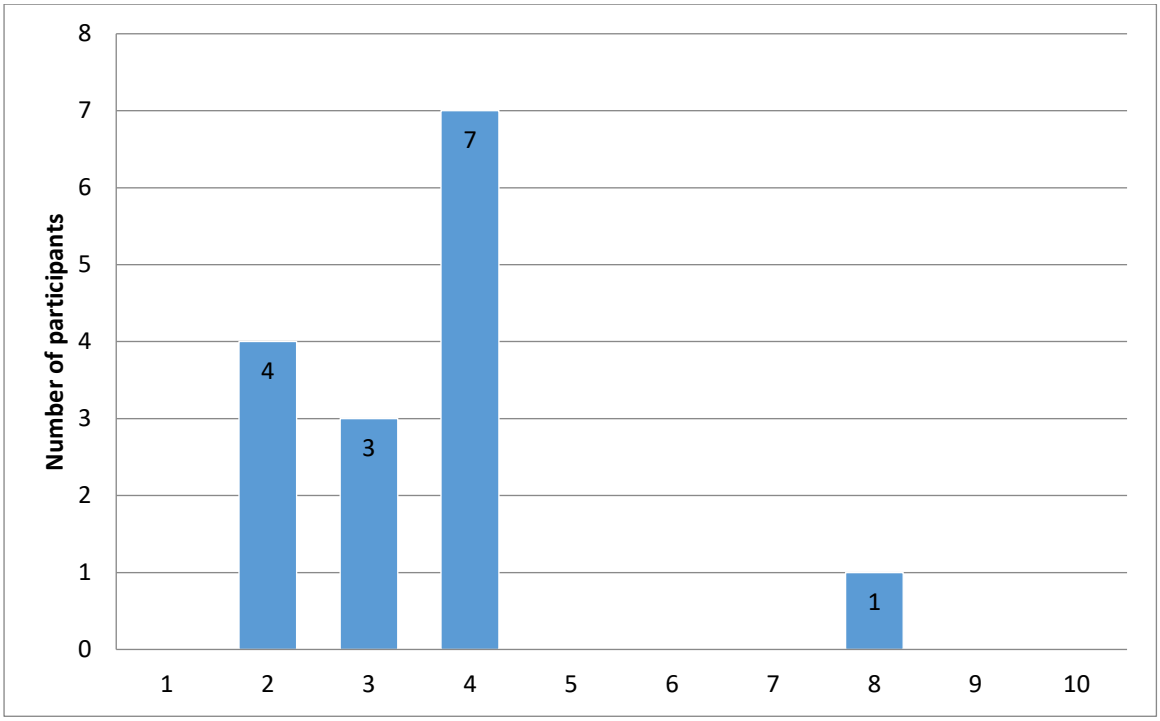

Figure 4.5 Pain experienced by the participants as reported on the Faces Pain Scale (FPS) (n=15)

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

4.5 Prevalence of Chronic Ankle Instability

4.5.1 Symptoms of Chronic Ankle Instability

4.5.1.1 Giving way

Of the participants in Group A, ten had experienced an episode of giving way during the past six months in their right ankle and seven in their left ankle. None of the participants in either Group B or C had experienced an episode of giving way during the past six months.

Table 4.11 Last episode of giving way of the ankle

	Group A (n=22)		**Group B (n=3)**		**Group C (n=5)**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**
Never	3	4	2	2	2	2
>2 years	1	2	0	0	2	2
1 – 2 years	4	6	0	0	0	0
6 – 12 months	4	3	1	1	1	1
1 – 6 months	6	4	0	0	0	0
<1 month	4	3	0	0	0	0

No statistically significant difference was found between Group A, B and C with regard to the time since the last episode of giving way of the right ankle (p=0.1421), or the left ankle (p=0.3843).

Eleven participants in Group A reported experiencing the sensation of giving way once a month or more in their right ankle and seven in their left ankle. None of the participants in Groups B and C experienced giving way sensations more than once a year.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

Table 4.12 Frequency of giving way sensation

	Group A (n=22)		Group B (n=3)		Group C (n=5)	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**
Never	4	5	2	1	3	4
Once a year	7	10	1	2	2	1
Once a month	10	4	0	0	0	0
Once a week	1	3	0	0	0	0

No statistically significant difference was found between Group A, Group B and Group C with regards to frequency of giving way of the right ankle (p=0.1582) or left ankle (p=0.3995).

The majority of participants in Group A reported that they are only sometimes able to stop their right ankle from giving way and that they are only sometimes able to stop or unable to stop their left ankle from giving way.

Table 4.13 Ankle control – How fast can the participant stop it when the ankle starts to roll over/ give way?

	Group A (n=22)		Group B (n=3)		Group C (n=5)	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**
Never rolled over/ given way	1	3	0	0	3	2
Immediately	3	3	2	3	0	1
Sometimes	18	15	1	0	2	2
Unable to stop it	0	1	0	0	0	0

A statistically significant difference was found between Groups A, B and C for the right ankle (p=0.0098) and for the left ankle (p=0.0368). The participants in Group A had less control over their ankles giving way than did those in Groups B and C.

Group A participants reported that their ankle takes at least one day or longer to return to normal after the ankle has given way (12 right ankle, nine left ankle). None

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

of the participants in Group B and C reported that their ankles take more than one day to recover after their ankle has given way.

Table 4.14 Time to return to normal after the ankle has given way

	Group A (n=22)		Group B (n=3)		Group C (n=5)	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**
Never rolled over/ given way	2	4	0	0	3	2
Immediately	3	1	1	2	0	0
<1 day	5	8	2	1	2	3
1 – 2 days	9	7	0	0	0	0
>2 days	3	2	0	0	0	0

A tendency for the participants in Group A to take longer to recover after their right ankles had given way was found (p=0.0585). This tendency was not found for the left ankle (p=0.1344).

4.5.1.2 Feelings of instability

Of the participants in Group A eight participants reported experiencing the feeling of instability during ADL at least once a month or more in their right ankles and six participants in their left ankles.

Table 4.15 Feelings of instability during ADL

	Group A (n=22)		Group B (n=3)		Group C (n=5)	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**
Never	11	10	3	2	3	0
Once a year	3	6	0	1	1	3
Once a month	4	5	0	0	1	2
Once a week	4	1	0	0	0	0
Once a day	0	0	0	0	0	0

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

No statistically significant difference was found between Group A, Group B and Group C with regards to feelings of instability during ADL for the right ankle (p=1.000), or for the left ankle (p=0.3531).

Of the participants in Group A 12 participants reported experiencing a feeling of instability during sport or recreational activities at least once a month or more in their right ankles and ten in their left ankles.

Table 4.16 Feelings of instability during sport or recreational activities

	Group A (n=22)		**Group B (n=3)**		**Group C (n=5)**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**
Never	7	6	2	3	2	0
Once a year	3	6	1	0	1	1
Once a month	8	8	0	0	2	4
Once a week	4	2	0	0	0	0
Once a day	0	0	0	0	0	0

No statistically significant difference was found between Group A, Group B and Group C with regards to feelings of instability during sport or recreational activities for the right ankle (p=0.7633), or the left ankle (p=0.1266).

4.5.2 Chronic Ankle Instability according to the Identification of Functional Ankle Instability questionnaire

Twenty-two participants were classified as having CAI unilaterally or bilaterally. This means that, from the 33 questionnaires included in the study, 22 participants could be classified as having CAI. The prevalence of CAI in professional ballet dancers in SA is thus calculated as being 66.7%, 95% CI [49.6%; 80.2%].

Table 4.17 CAI according to the IdFAI

	Group A (n=22)		**Group B (n=3)**		**Group C (n=5)**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**
CAI	**18**	**14**	**0**	**0**	**0**	**0**
No CAI	**4**	**8**	**3**	**3**	**5**	**5**

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

4.6 Self-reported functional abilities

4.6.1 Self-reported function according to the Foot and Ankle Ability Measure

Table 4.18 Self-reported function according to the FAAM

	Self-reported functioning with regards to ADL		Self-reported functioning with regards to sport	
	Frequency	Percentage	Frequency	Percentage
Less than 80%	4	18.2	6	27.3
80%- 89%	4	18.2	10	45.5
90 – 99%	12	54.6	4	18.2
100%	2	9.1	2	9.1

(n=22)

The International Ankle Consortium considers a score of less than 90% on the ADL subscale as being an indicator of a significant level of disability (Gribble *et al.* 2013).

After calculating the scores of the FAAM for each participant, eight participants in Group A scored less than 90% in the ADL subscale.

The International Ankle Consortium considers a score of less than 80% on the sport subscale as being an indicator of a significant level of disability (Gribble *et al.* 2013).

After calculating the scores for functioning with regards to sport, six participants in Group A scored less than 80%.

The majority of the participants in Group A (13 participants) felt that that their function was normal.

Table 4.19 Self-reported level of function

	Group A (n=22)	
	Frequency	**Percentage**
Normal	13	59.1
Nearly normal	8	36.4
Abnormal	1	4.6
Severely abnormal	0	0

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

4.6.2 Self-reported function according to the Dance Functional Outcome System

Table 4.20 Self-reported function according to the DFOS

	Self-reported function with regards to general activities		Self-reported function with regards to dance technique specific function		Self-reported function with regard to overall function	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Less than 80%	2	9.1	0	0	1	4.6
80%-89%	8	36.4	3	13.6	5	22.7
90 – 99%	9	40.9	12	54.6	12	54.6
100%	3	13.6	7	31.8	4	18.2

(n=22)

As no literature was available on what scores would indicate a significant level of disability, the researcher decided to follow the recommendations as set out in the position statement by the International Ankle Consortium for the FAAM (Gribble *et al.* 2013). A score of less than 80% was thus considered to indicate a significant level of disability.

In Group A, two participants scored less than 80% on the general activities subscale of the DFOS, however, only three participants scored 100%.

None of the participants in Group A scored less than 80% on the dance technique specific subscale of the DFOS.

With regard to overall function, only one participant in Group A scored less than 80% on the DFOS.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

4.6.3 Comparison of self-reported function of Group A, B and C

Table 4.21 Comparison of self-reported function of Group A, B and C

	Group A (Median) n=22	Group B (Median) n=3	Group C (Median) n=5
FAAM -Calculated percentage of functioning with regards to ADL.	95.2%	94.7%	97.5%
FAAM -Calculated percentage of functioning with regards to sport.	87.5%	90%	92.9%
FAAM -Self-reported level of function	Normal	Normal	Nearly normal
DFOS -Calculated percentage of function with regards to general activities	90%	96.7%	83.3%
DFOS -Calculated percentage of function with regards to dance technique specific function	95%	95%	75%
DFOS -Calculated percentage of function with regard to overall function	93.3%	96.7%	88.8%

A statistically significant difference in function between Group A and Group C was found with regards to dance technique function (p=0.0054). A tendency towards a statistically significant difference in function between Group B and Group C with regards to dance technique function was also found (p=0.0550). These statistically significant differences will be discussed in detail in the following chapter, and should be interpreted with caution due to the small size of the subgroups.

No other statistically significant associations were found with regards to the level of functional abilities of the three groups.

4.7 Results of other questionnaires not grouped in Group A, B or C

Two participants (participants A and B) reported that they had not obtained any ankle sprains, but that they were experiencing symptoms of CAI.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

Both participants scored 11 or more on the IdFAI and reported feelings of giving way and feelings of the ankle being unstable. Participants who score 11 or more on the IdFAI can be considered as being affected by CAI.

One participant scored 100% on the ADL subscale of the FAAM, while the other participant scored in the 80 – 89% bracket. One participant scored more than 90% on the sport subscale of the FAAM, and one participant scored less than 80% on this subscale.

Both participants scored more than 80% on the DFOS.

One participant (participant C) reported having had only one ankle sprain, but did not indicate clearly whether the sprain could be considered significant or not. This participant did not show signs of CAI and had good, normal function as measured on the FAAM and DFOS.

Table 4.22 Results of participants not included in Group A, B or C

	Participant A	**Participant B**	**Participant C**
IdFAI	>11	>11	<11
Self-reported function on ADL subscale of the FAAM	100%	80%	90%
Calculated score on the ADL subscale of the FAAM	100%	80 – 89%	100%
Self-reported function on the sport subscale of the FAAM	90 – 99%	Less than 80%	90%
Calculated score on the sport subscale of the FAAM	90 – 99%	Less than 80%	100%
Self-reported function on the DFOS	90 – 99%	85%	No answer
Calculated score on the DFOS	90 – 99%	80 – 89%	90 – 99%

In the next chapter the results reported in this chapter will be discussed in detail.

*Group A: + significant ankle sprain and + CAI
Group B: + significant ankle sprain and – CAI
Group C: - significant ankle sprain and – CAI

CHAPTER 5 - DISCUSSION

5.1 Introduction

In this chapter, the results obtained in the study will be discussed in a similar order to the presentation of the results in Chapter 4. A detailed injury history of the dancers is followed by a discussion of the prevalence of CAI in professional ballet dancers and the dancers' self-reported functional abilities.

The strengths of the study, the challenges experienced and the limitations of the study are identified and discussed. Further clinical and research recommendations are made based on the results, as well as findings from the current literature.

5.2 Population

At the time of the study, 65 professional dancers were employed by the three South African dance companies included in the study. Fifty-two dancers were willing and able to participate on the assigned data collection days, and thus a response rate of 80% was obtained in this study. After the exclusion criteria had been applied and the incomplete data excluded from the result, 33 participants were included in the analysis.

Thirty participants' questionnaires could be divided into the three designated subgroups. For a breakdown of the subgroups, please refer to Table 4.1.

Three participants could not be included in the designated three groups. The results from Group A were not compared to the results from these participants due to the specific aims and objectives of the study identified (See Chapter 3). Those three participants' results will be discussed separately.

It was decided to include only ballet dancers in this study as most current studies in dance medicine concentrate on ballet dancers as opposed to other forms of dance. This would make comparisons between the results in a South African population and other similar populations possible.

5.3 Demographics

Approximately 60% of the participants included in the study were female and 40% male. A recent ten year retrospective study by Ramkumar *et al*. (2016) found that one of the major ballet companies in America had on average 53% female dancers and 47% male dancers. This study had a similar distribution of male and female dancers.

The median age of the participants ranged from 19.2 years to 23.4 years which is somewhat younger than the average age of 27.5 years found by Ramkumar *et al.* (2016). This could be explained by the large number of junior dancers, such as the graduates and corps de ballet dancers, who participated in the study. The junior dancers accounted for 51.2% of the participants, while the senior dancers, such as soloists and principals, accounted for only 30.3% of the participants. Having a high prevalence of CAI in young participants could be problematic. These young dancers are still at the beginning of their dance careers and CAI could thus potentially have a negative impact on their careers as professional dancers.

5. 4 Ankle sprain history

5.4.1 Initial ankle sprain

Of the participants in Groups A, B and C, 83.3% reported that they had had at least one significant ankle sprain. Of all participants included in the study results, 75.8% reported sustaining at least one significant ankle sprain. A significant ankle sprain is considered to be an ankle sprain which had symptoms of pain and swelling and resulted in at least one day of interrupted physical activity (Gribble *et al.* 2013). The initial ankle sprain is considered to be the very first significant ankle sprain (Gribble *et al.* 2013).

The 75.8% of participants who sustained at least one significant ankle sprain correlated well with the results found in previous studies. In the study by Simon *et al*. (2014) 70% of the participants included in the study reported sustaining an ankle sprain. It should be noted, however, that the study by Simon *et al*. (2014) does not only include ankle sprain sustained by ballet dancers, but also modern dancers, and that this study was conducted on collegiate dancers, not professional dancers. The

results found in the aforementioned study can thus not be directly compared to the results obtained in the current study. Ankle sprains are common not only in ballet dancers, but other sporting codes as well. In sporting populations such as field hockey and squash, ankle sprains accounted for up to 100% of ankle injuries (Fong, Hong, Chan, Yung & Chan 2007). Doherty, Delahunt, Caulfield, Hertel, Ryan & Bleakley (2014) also found that ankle sprains were very common injuries and were especially prevalent in those participating in indoor and court sports for example basketball and tennis.

The majority (87.5%) of the participants' initial injury occurred more than 12 months prior to the study. This is in line with the inclusion criteria for studies on CAI as described in the position statement released by the International Ankle Consortium in 2013 (Gribble *et al.* 2013).

Only 12% of the ankle sprains sustained by participants could be attributed to activities outside of dance. The fact that 88% of participants sustained their initial injuries while participating in dance or dance-related activities should prompt researchers to investigate these activities further in an attempt to identify preventative measures. Smith, Davies, De Medici, Hakim, Haddad & Macgregor (2016) suggest studies which should attempt to link specific ballet movements or manoeuvres to certain injuries in order to focus injury prevention programmes (Smith, Davies, De Medici, Hakim, Haddad & Macgregor 2016).

Ankle sprains can be sustained via contact or non-contact mechanisms (Gribble *et al.* 2016). Non-contact mechanisms were found to be more common than contact mechanisms and an ankle in a supinated/ inverted position at initial contact was identified as a distinctive feature in the mechanism of most ankle injuries (Gribble *et al.* 2016). A common non-contact mechanism for ankle sprains in dancers involve landing from a jump (Sammarco & Tablante 1997). Activities related to jumping or landing from lifts were linked to 44% of initial ankle sprains in this study.

A systematic review by Pourkazemi, Hiller, Raymond, Nightingale and Refshauge (2014) found that the severity of the initial ankle sprain might, but does not necessarily predict the development of CAI in patients. Forty-four percent (44%) of the participants included in Groups A and B self-identified their initial ankle sprains as being severe sprains. When comparing the severity of the sprains sustained by

those in Group A to those in Group B, no statistical significant difference could be found. It thus seems that those participants who went on to develop CAI did not necessarily sustain more severe ankle sprains than those who did not develop CAI.

5.4.2 Most recent ankle sprain

In this study, 40% of those who sustained an initial significant ankle sprain, experienced at least one more significant ankle sprain. The recurrence rate of acute lateral ankle ligament injuries is generally estimated to be between 70% and 80% (Webster & Gribble 2010; Hubbard *et al.* 2007; Denegar & Miller 2002). A possible explanation for this discrepancy between the current study and previous studies on the recurrence of ankle sprains could relate to the definitions used to define an ankle sprain. In this study, the 40% includes only dancers whose ankle sprains were severe enough to be considered significant.

None of the most recent significant ankle sprains occurred in the three months prior to the study. This is in line with the inclusion criteria for studies on CAI as described in the position statement released by the International Ankle Consortium in 2013 (Gribble *et al.* 2013).

Dance-related activities were linked to the mechanism of injury in almost all the cases of recurrence of ankle sprains in this population. The mechanism of injury could be linked to jumping/ landing from lifts in 40% of the participants. This correlates well with the 44% of initial ankle sprains in these participants which are also linked to jumping/ landing from lifts as stated earlier (see 5.4.1).

It is interesting to note that the self-perceived severity of the most recent ankle injuries in this population tended to be less than that of the initial injury. Half of most recent ankle sprains were classified as mild injuries and the other half as moderate injuries.

5.5 Management of ankle sprain

5.5.1 Immobilisation

More than half of the participants in this study (68%) indicated that their ankle was not immobilised after the initial ankle sprain. Of those participants whose ankles

were immobilised after the initial injury, 50% reported being immobilised for seven days or less.

Only 20% of the participants reported that their ankle was immobilised after their most recent ankle sprain. Furthermore, if immobilised, the ankles was only immobilised for 24 – 72 hours. It should be noted, however, that the most recent reported ankle sprains were only considered to be mild/ moderate injuries. This could have a significant impact on the choice of treatment techniques used, including the use of a splint or cast to immobilise the ankle.

An evidence-based clinical guideline published in 2012 recommends a more functional treatment approach rather than immobilising the ankle in a plaster cast, but mentions that short periods (10 days) of immobilisation in a rigid support after an acute ankle sprain can be justified (Kerkhoffs, Van Den Bekerom, Elders, Van Beek, Hullegie, Bloemers, De Heus, Loogman, Rosenbrand, Kuipers, Hoogstraten, Dekker, Ten Duis, Van Dijk, Van Tulder, Van Der Wee & De Bie 2012). The reasoning behind immobilising an ankle after the acute injury may be to immobilise the ankle joints in order to keep the ligaments from healing in a lengthened position and thus leading to hypermobility and possible instability of those ligaments (Denegar & Miller 2002).

Hiller and Refshauge in Grieve's modern musculoskeletal physiotherapy (2015) also supported a more functional approach in terms of immobilisation of ankles following a sprain. They recommend the use of elastic bandages, tape or ankle braces instead of more rigid forms of immobilisation (Hiller & Refshauge 2015). The systematic review and meta-analysis by Doherty *et al.* (2017), found that braces and ankle taping could be considered effective in the treatment of acute ankle sprains when considering self-reported function and recurrent sprains.

When comparing Group A and B, no statistically significant difference could be found with regards to immobilisation after injury or with regard to length of immobilisation for either the initial or most recent ankle sprain.

It would thus seem that the health care professionals treating these dancers, or the dancers themselves, also prefer a more functional approach.

5.5.2 Weight-bearing and use of crutches after ankle sprain

In order to allow ligaments to heal after an acute ankle sprain, a patient may be instructed to mobilise non-weight bearing for a period of time (Dubin *et al*. 2011). About half (54.2%) of the participants in this study reported being allowed to fully weight-bear on their injured ankle after their initial ankle sprain and 100% after their most recent ankle sprain. In an American study only 4.8% of participants who sustained a ligament sprain were prescribed crutches (Feger, Glaviano, Donovan, Hart, Saliba, Park & Hertel 2017). Again it is important to note that the most recent ankle sprains were classified as mild or moderate and that this could have a significant impact on choice of treatment techniques. No statistical significant difference could be found between Group A and B relating to the weight-bearing status after sustaining ankle injuries.

5.5.3 Rehabilitation

After their initial ankle sprains 76% of the participants indicated that they received a supervised rehabilitation programme. Doherty *et al*. (2017) found good evidence for the use of exercise therapy as part of the treatment for acute ankle sprains. This systematic review describes good outcomes with exercise therapy when considering self-reported function and the prevention of recurrent sprains (Doherty *et al.* 2017).

In this study a significant difference was found in the length of participation in a supervised rehabilitation programme between Group A and B. The participants in Group A tended to participate in longer rehabilitation programmes than the participants in Group B. This statistical significant difference should be interpreted with caution due to the small size of the subgroups in this study. It can be speculated, however, that the quality of the rehabilitation differed between the participants in Group A and B. Unfortunately, no distinction was made between from which of the three companies the participants in each group were. It could be possible that all three of the participants in Group B received treatment by the same healthcare providers or providers who follow similar protocols.

Only 20% of the participants who reported more than one significant ankle sprain reported attending a supervised rehabilitation programme after their most recent ankle sprain. Again, this could possibly be linked to the severity of the most recent injury and to the attitude of the dancers towards rehabilitation. If the dancer felt that

the previous rehabilitation programme did not meet his/her expectations or if the dancer reasons that he/she already knows the exercise protocols used in the rehabilitation programme, they might decide not to attend such a programme again after subsequent ankle sprains.

The rehabilitation programmes in which the dancers participated included exercises such as strengthening, ankle mobilisation exercises, balance exercises and proprioception exercises. The two most common reported exercises were calf raises (52.6%) and ankle strengthening with a theraband (47.4%). Only 31.58% of the programmes were reported to include elements of proprioception or balance training. It is interesting to note that only such a relatively small percentage of participants reported the inclusion of proprioceptive and balance exercises due to these exercises being described extensively in literature as a means of prevention and treatment of CAI (Doherty *et al*. 2017; Webster & Gribble 2010; Loudon *et al*. 2008; Van der Wees *et al.* 2006).

Dancers are considered to have superior balance skills when compared to non-dancers (Hutt & Redding 2014). Ballet training and choreography contain various movements which challenge the balance skills of the dancers, such as the many multi-directional and rotational activities as well as movements frequently being performed on a small base of support, for example on demi-pointe or *en-pointe* (Hutt & Redding 2014). Dance training itself is also believed to improve balance skills (Hutt & Redding 2014). It may therefore be possible that the participants in this study already had superior balance skills before their injuries and that the retraining of their balance skills after injury was automatically incorporated via them resuming their normal ballet classes.

5.6 Pain

Of the participants in Groups A, B and C, 50% reported experiencing pain with their previously injured ankle. All of the participants who experienced pain in the previously injured ankle were in Group A.

A significant difference was shown between pain experienced in the previously injured ankle between Group A and Group B. The participants in Group A tended to be experiencing more pain in the previously injured ankle than those in Group B.

Almost half (46.7%) of the participants reported experiencing 4/10 pain on the FSP. According to the FPS this pain can be described as a “nagging, uncomfortable/ troublesome pain”. The mean for pain experienced as measured by the FPS was 3.5/10. A recent randomised controlled trial by Plaza-Manzano, Vergara-Vila, Val-Otero, Rivera-Prieto, Pecos-Martin, Gallego-Izquierdo, Ferrugat-Garcias and Romero-Franco (2016) found that participants with CAI experienced pain of 5/10 (±1.7) and 5.2/10 (±2) before their intervention was performed.

The experience of pain by dancers is seen by many as inevitable and unavoidable (Harrison & Ruddock-Hudson 2017). Dancers function within a culture of “no pain, no gain” and they are commended by superiors for dancing through pain and injury (Molnar & Karin 2017; Thomas & Tarr 2009). Harrison & Ruddock-Hudson (2017) found that many dancers do not consider the implications and risks involved when pushing through pain to continue performing. These dancers may in effect be putting their current as well as their future health in jeopardy and increase their risk of sustaining or aggravating their injuries (Harrison & Ruddock-Hudson 2017).

5.7 Symptoms of Chronic Ankle Instability

5.7.1 Giving way/ rolling over of the ankle

Giving way of the ankle is noted to be one of the most commonly reported symptoms experienced by those affected by CAI (Koboyashi & Gamada 2014; Gribble *et al.* 2013; Webster & Gribble 2010).Of the participants in Group A, 50% experienced the sensation of giving way once a month or more in their right ankle and 31.8% in their left ankle. In Group A 45.5% of the participants experienced an episode of giving way during the previous six months in their right ankle and 31.8% in their left ankle. This is somewhat lower than the 56.1% of participants who experienced an episode of their ankle giving way during the previous six months in the study by Simon *et al.* (2014).

The majority of participants in Group A, reported that they were only sometimes able to stop or unable to stop their ankles from giving way. A statistically significant difference was found between Groups A, B and C for both the right ankle and left ankle. The participants in Group A struggled more to stop their ankles from giving way than the participants in Groups B and C. This statistically significant difference

should be interpreted with caution due to the small size of the subgroups. There does, however, seem to be a tendency for those who suffer from CAI to have significantly more difficulty in controlling their ankle when it starts to roll over/ give way.

Group A participants reported that their ankle took at least one day or longer to recover after the ankle has given way (54.6% right ankle, 40.9% left ankle). None of the participants in Group B and C reported that their ankles took more than one day to recover after their ankle has given way. A significant difference was found between Groups A, B and C for the right ankle, but not for the left ankle. Again, this statistically significant difference should be interpreted with caution due to the limited number of participants in each subgroup. The tendency seemed to be that the participants affected by CAI of their right ankles took longer to recover from their ankles giving way than did those in Groups B and C.

It would seem that the right ankles of the participants tended to be more affected by injuries and the consequent residual problems than the left ankles. The symptoms associated with the ankle giving way tended to be more severe on the right than on the left for the participants of the study. A possible explanation for this observation could be related to whether the dancers were right side dominant or left side dominant. This concept was, unfortunately, not explored in the current study.

5.7.2 Feelings of instability

Another common symptom of CAI is the feeling of joint instability (Koboyashi & Gamada 2014; Gribble *et al.* 2013; Webster & Gribble 2010). In Group A, 32.8% of participants experienced feelings of instability during ADL and 50% during sport or recreational activities once a month or more often. No statistical significant difference was found between Group A, Group B and Group C with regards to feelings of instability during ADL or during sport and recreational activities. It could be hypothesised that the feelings of ankle instability in these participants could be masked, for example, by the exceptional balance skills professional ballet dancers demonstrate.

5.8 Prevalence of Chronic Ankle Instability in professional ballet dancers in South Africa

The prevalence of CAI in professional ballet dancers in South Africa was found to be 66.7% in this study. This was higher than the approximately 53% prevalence found amongst collegiate dancers in the study by Simon *et al.* (2014). It should be noted that the study by Simon *et al*. (2014) included both ballet and modern dancers, performing at collegiate level. The prevalence of CAI specifically amongst the ballet dancers was found to be 50% (Simon *et al*. 2014). Due to the differences in the compilation of the population of Simon *et al*. (2014) study compared to this study, the results obtained cannot be directly compared.

In a general sports setting, the prevalence of CAI was found to range between 20% and 47% (Simon *et al*. 2014). The prevalence of CAI in professional ballet dancers in South Africa was thus found to be higher than which is found in general sport settings as well. A possible reason for this could be the greater demands placed on the ankles of dancers when compared to athletes participating in other forms of sport.

5.9 Self-reported functional abilities

In this study, self-reported functional questionnaires were used. Kosik *et al*. (2017) state that it is of great importance to include components of self-reported function in the study of health conditions. According to these authors measures of self-reported function provide valuable insight into how a patient experiences his/her health conditions (Kosik *et al.* 2017). Self-reported questionnaires are considered to be an appropriate measure to evaluate functional limitations experienced by patients (Kosik *et al.* 2017).

Of the participants in Group A, only 36.4% scored less than 90% on the ADL subscale of the FAAM and 27.3% less than 80% on the sport subscale of the FAAM. The median score for participants of Group A was 95.2% on the ADL subscale of the FAAM and 87.5% on the sport subscale of the FAAM. These median scores are higher than the 88% and 76% on the ADL and sport subscales respectively as reported by Carcia, Martin & Drouin (2008) amongst collegiate athletes diagnosed

with CAI. Further exploration into possible explanations for this observation is discussed later in Chapter 5.

Houston *et al.* (2015) found that participants who did not develop CAI after a significant ankle sprain had significantly less disability than those diagnosed with CAI when measured on a patient-reported outcome measure such as the FAAM. In this study, no significant difference in level of function could be found between the participants classified in Groups A, B and C when measured on the FAAM.

The bunching of scores at the higher levels of the FAAM could be an example of the ceiling effect observed in dancer populations which prompted the development of a dance-specific function outcome measure (Bronner *et al.* 2007). The DFOS was developed to be used specifically to assess function in ballet and modern dancers (Bronner & Turner 1999). Although not widely used in research yet, the DFOS is believed to provide a suitable means to assess self-reported function in these populations.

Only 9.09% of the participants in Group A scored less than 80% on the general activities subscale of the DFOS, none less than 80% on the dance technique specific subscale and a mere 4.6% less than 80% for overall function as measured by the DFOS. No other studies could be found which utilized the DFOS in populations with CAI, and the result obtained in this study can thus not be discussed in relation to results found in previous studies.

The median score for dance technique specific function was 95% for Group A, 95% for Group B and 75% for Group C. A significant difference between Groups A and C as well as Groups B and C were found. No statistically significant difference between Groups A and B was found. This statistically significant difference should, however, be interpreted with extreme caution due to the limited size of the subgroups. There seems to be a tendency which suggests that the participants who had a history of a significant ankle sprain actually had better self-reported function than their counterparts who reported never having sustained a significant ankle injury.

The researcher hypothesises that this might be due to the study only looking at ankle sprains and not including other ankle injuries or conditions, especially chronic foot and ankle conditions such as tendinopathies, stress fractures and tenosynovitis. In the study by Ramkumar *et al.* (2016) Achilles tendinopathy, metatarsal stress

fractures and posterior tibialis muscle strain or tear were all found to be common diagnoses amongst dancers. The systematic review by Smith *et al.* (2016) also found tendinopathies and metatarsal stress fractures to be amongst the most widespread conditions affecting the feet and ankles of both pre-professional and professional ballet dancers. These conditions could potentially have an impact on the function of the dancers. In future studies a better distinction can be made in an attempt to exclude those dancers suffering from chronic ankle conditions which might also have an effect on the function of their ankles.

Another possible explanation for these findings could be the small size of the subgroups. This makes associations and the drawing of definite conclusions challenging seeing that outliers in the data set can profoundly influence the results. No conclusion can thus be drawn from these findings and the researcher can only attempt to identify tendencies which could then be further investigated.

The results from this study suggest that, although the prevalence of CAI may be high amongst professional ballet dancers, their self-reported function is not severely affected by this condition.

A possible explanation for this finding could be the automatic inclusion of the rehabilitation of balance components in this population due to their return to dancing. Kosik *et al*. (2017) states that balance training might be the main component to include when targeting self-reported function in CAI-sufferers. Dance training itself is considered to improve balance skills and professional ballet dancers are thought to have superior balance skills to start with (Hutt & Redding, 2014). The author hypothesises that due to the dancers participating in dance after their ankle injuries, the balance component of their rehabilitation was automatically addressed. This could then possibly have led to their high scores in terms of self-reported function.

Future research could look further into this phenomenon and aim to identify specific components of balance which dance training addresses. An attempt to incorporate these principles into other populations affected by CAI could then be made in an attempt to improve their self-reported function scores.

Another element to be considered is the cut-off scores which are regarded as significant on the functional outcome measures. An elite athlete is defined as “a person who is currently or has previously competed as a varsity player (individual or

team), a professional player or a national or international level player" by the Segen's medical dictionary (2012). According to this definition professional ballet dancers can be classified as elite athletes. The question remains whether 80% of normal, pre-injury function is a good enough level of function for these elite athletes.

According to Sataloff, Brandfonbrener and Lederman in Dommerholt (2009), "the difference between 95% recovery of an injured finger and 100% recovery may mean the difference between a world-class performing career as a violinist and obscurity." The same principle may be applicable to other performing artists, for example the function of the ankles in professional ballet dancers. Only 18.2% of the participants in Group A considered their overall function as measured by the DFOS to be 100% that of the pre-injury level.

5.10 Results not included in Group A, B or C

One participant reported sustaining an ankle sprain, but did not indicate whether the sprain was regarded as significant. The participant did not develop any CAI symptoms. This participant was not included in Group B or C due to the uncertainty regarding the severity of the sprain. It could be possible that the participant misread or misunderstood some of the instructions and the results were subsequently not included in one of the groups.

Two participants reported not sustaining a significant ankle sprain, but still reported experiencing the symptoms of CAI. The researcher hypothesises that this could be due to other factors causing the instability, for example hypermobility. Generalised hypermobility is observed to be very common amongst dancers (Briggs, Mc Cormack, Hakin & Grahame 2009). In a 2011 review researchers found that hypermobility amongst the general population was between 6% and 17%, but up to 44% in dancer populations (Day, Koutedakis & Wyon 2011).

The presence of joint hypermobility in dancers, coupled with the extreme range of joint motion required to perform ballet dancing could possibly have an effect on the stability of the ankle joints in ballet dancers. In the review by Day, Koutedakis & Wyon (2011) it was found that dancers who were classified as hypermobile sustained more injuries than the dancers who did not have hypermobility. No

distinction was however made between which structures were injured (Day, Koutedakis & Wyon 2011).

Hypermobility is not only often found in dancers, but can also be present in other sporting codes requiring increased range of motion. Attenborough, Hiller, Smith, Stuelcken, Greene & Sinclair (2014) found a high percentage of gymnasts who continued to experience persistent symptoms after an ankle sprain. Future studies can investigate the effect of joint hypermobility in dancers, especially with regards to the experiencing of CAI symptoms.

5.11 Strengths of the study

This was the first study in South Africa which examined the prevalence of CAI in professional ballet dancers. South African dancers may have unique circumstances due to being employed as professional dancers in a developing country. South African companies do not have all the resources which may be available to bigger international companies, such as a team of healthcare professionals dedicated to the well-being and rehabilitation of their dancers. The pressure to return to dancing after an injury may also be more due to the limited number of dancers being available in these companies.

Due to the small size of the population of professional ballet dancers in South Africa, the whole population was included in the study. Fifty-two out of a possible 65 dancers participated in the study and a high response rate of 80% was thus achieved. Response rate to surveys varies greatly in literature and many measures can be taken in an attempt to improve the response rate for example offering incentives and regulating the length of the questionnaires (Guo, Kopec, Cibere, Li & Goldsmith 2016). In the study by Simon *et al*. (2014) a response rate of 83% was achieved. The current study had a similar, high response rate.

The study was also the first to examine the self-reported function in ballet dancers affected by CAI. Interestingly it was found that these dancers' self-reported function was not severely affected. The researcher hypothesises that this may be due to the automatic inclusion of balance exercises by returning to dance. Another possible explanation could be that the cut-off scores are not applicable for elite athletes such as professional ballet dancers.

5.12 Challenges

Despite giving both written and verbal instructions and the researcher being present to answer questions, some of the questions in the questionnaires still seemed to cause a degree of confusion with the dancers. A few of the questions were clearly misunderstood or simply left unanswered. This lead to the exclusion of six questionnaires which, when considering the size of the population, was very unfortunate.

The size of the population was quite small, which makes generalisation of the study findings difficult. It should be kept in mind that the population of professional ballet dancers in South Africa is very small to start with and every effort was made by the researcher to include as many professional ballet dancers as possible. In the exploratory study by Simon *et al*. (2014) only 34 ballet dancers were included, which correlates well with the 33 dancers' results which were eventually included in this study.

Although the DFOS has only been used in a few case-studies found in peer-reviewed journals, a preliminary study done in 2003 indicated that the DFOS has high reliability, validity and responsiveness to musculoskeletal injuries in dancers (Bronner *et al*. 2007; Smith 2012; Bronner *et al*. 2003). It was decided to include this outcome measure due to a lack of a better validated, more applicable outcome measure.

5.13 Study limitations

The retrospective nature of the study could be regarded as a limitation of the study. Dancers might not have been able to vividly remember their first significant ankle sprain or the subsequent management thereof. The study also relies on self-reported data and it could be possible that the dancers mistook another foot or ankle condition for an acute ankle sprain or symptoms of CAI.

Not including other chronic ankle conditions such as tendinopathies could also be a limitation in this study. Chronic foot and ankle conditions are considered to be a common diagnosis in dancers and could potentially have an effect on the functioning of these dancers (Ramkumar *et al.* 2016; Smith *et al.* 2016). It should, however, be

noted that a relationship between ankle sprains and tendinopathy in dancers has been suggested in literature (Ritter & Moore 2008). The effects of tendinopathy on the function of dancers therefore may be very difficult to isolate and exclude in subsequent research studies.

The study also did not take into account the possible effects of hypermobility on the stability of the ankles of the dancers. It could thus be possible that some of the dancers reported symptoms of CAI after an ankle injury due to hypermobility, or worsened by hypermobility, and not due to the effects if CAI in isolation.

Unfortunately, due to the large number of participants at some of the sessions, the questionnaires were only scanned quickly by the researcher before the participant left. This led to some of the questionnaires not being completed in full. In future studies, the researcher could employ a research assistant who could assist with ensuring that the participants did not omit any section of the questionnaire.

The study also did not explore the experiencing of pain in the subjects further and used only a one-dimensional approach. Other information which could have been interesting includes the frequency of experiencing pain, the duration of the pain and the impact of the pain on the participant.

5.14 Clinical recommendations

Of all dancers included in the study results, 75.8% of dancers experienced at least one significant ankle sprain. Of those dancers who had at least one significant ankle sprain, 40% went on to have more than one significant ankle sprain. The occurrence of acute ankle sprains thus seems to be a problem in this population. Dancers, as well as the healthcare professionals treating these dancers, should be educated concerning the correct course of management of acute ankle sprains. Injury prevention programmes could also be initiated by dance company administration in collaboration with knowledgeable health care providers in an attempt to minimise the occurrence of acute ankle sprains.

The most common mechanism of injury in this population was landing from a jump or lift. When implementing injury prevention programmes in this population, special

consideration should be given to exercises and strategies to ensure safe and effective jump landings.

The prevalence of CAI in this population was found to be 66.7%. Although, the self-reported function of these dancers does not seem to be severely affected, the prevalence of CAI is still a concern. CAI includes symptoms such as the ankle rolling over/ giving way. The dancers affected by CAI reported a tendency to have less control over their ankles giving way and tended to take longer to recover from their ankles giving way than those dancers not affected. The affected dancers also reported more pain in the previously injured ankle. These symptoms could potentially have a negative effect on the dancers. Healthcare professionals and dancers should be educated on the symptoms of CAI, prevention and the correct evidence-based management of CAI.

According to the HPCSA (1976) physiotherapists play a significant role in the prevention and management of all injuries pertaining in sport. Injury prevention programmes can be developed and implemented by physiotherapists at the professional ballet companies. Physiotherapists treating professional ballet dancers also have a responsibility toward their patients to provide them with optimal, evidence-based care. It is thus crucial for physiotherapists involved in the care of these dancers to be educated on the identification and correct management of conditions regularly affecting them, such as CAI.

5.15 Research implications

Further research can be conducted focusing on finding possible explanations for the good self-reported functional levels found amongst professional ballet dancers. The studies could aim to identify specific components of balance which returning to dance training addresses. The components and principles can then be incorporated into the treatment of other populations affected by CAI in an attempt to improve their self-reported function scores.

Another recommendation for future studies includes looking into the cut-off scores on outcome measures for elite athletes. The question remains as to whether 80% or 90% of pre-injury function is a good enough level of function for elite athletes such as professional ballet dancers.

Lastly, the researcher recommends studies and interventions which aim to prevent acute ankle sprains in this population and thus reduce the subsequent development of CAI.

5.16 Conclusion

In this chapter a detailed discussion on the results found in the study was provided.

The following chapter will conclude the dissertation.

CHAPTER 6 – CONCLUSION

In this chapter, the dissertation concludes with a summary of the most important research findings.

Ankle sprains were found to be a significant problem in the South African professional ballet dancer population. Of all dancers included in this study 75.8% reported having sustained at least one significant ankle sprain and most of the dancers reported sustaining their ankle sprains while being involved in dance or dance-related activities. Landing from a jump was identified as one of the most common mechanisms of ankle sprains in this population.

Of the dancers who had sustained at least one significant ankle sprain 40% went on to have at least one more significant ankle sprain and 88% went on to develop symptoms of CAI. The prevalence of CAI in professional ballet dancers in South Africa was found to be 66.7%, which was somewhat higher than what was previously reported in other similar studies.

The dancers affected by CAI reported tendencies to have less control over their ankles from giving way, and to take longer to recover from their ankles giving way than those dancers not affected by CAI. The affected dancers also reported a tendency to experience more pain in the previously injured ankle.

Although the prevalence of CAI was found to be higher than in some other sporting populations, the self-reported function of professional ballet dancers in South Africa was not found to be severely affected.

The findings of this study could stimulate further research to identify possible explanations for the reported level of function despite injury. The researcher hypothesises that this could be attributed to components of balance training being incorporated automatically into the dancer's rehabilitation due to them returning to dancing. Future studies could build on the current study by investigating the rehabilitation protocols followed by the dancers after an ankle sprain, possibly allowing for the identification of an optimal rehabilitation protocol. The researcher also suggests looking into the cut-off scores of self-reported functional measures for elite athletes/ performers to determine its validity in these populations. Lastly, future research can look into possible ankle-sprain prevention strategies to be implemented

by professional ballet company management in collaboration with knowledgeable health care providers, such as physiotherapists.

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APPENDIX A: PARTICIPANT INFORMATION DOCUMENT

Dear Participant

INFORMATION REGARDING THE STUDY: CHRONIC ANKLE INSTABILITY AND ASSOCIATED SELF-REPORTED FUNCTION IN PROFESSIONAL BALLET DANCERS IN SOUTH AFRICA

I am a M.Sc. Physiotherapy student at the University of the Free State (UFS). In fulfilment of my postgraduate degree I have to conduct a research study in my chosen field of interest.

The injury rate amongst dancers is very high with up to 90% of dancers sustaining an injury during their career (Simon, Hall & Docherty 2014). Ankle sprains are considered to be the most common traumatic injury sustained by dancers (Russell 2010).

It is estimated that between 70% and 80% of patients who suffered from an initial ankle sprain, will experience a recurrence of the injury (Denegar & Miller 2002; Hubbard, Kramer, Denegar & Hertel 2007; Webster & Gribble 2010). According to research the recurrence of ankle sprains are believed to lead to a condition called Chronic Ankle Instability (Webster & Gribble 2010).

Chronic Ankle Instability is described as "the development of repetitive ankle sprains and persistent symptoms after injury" (Hubbard *et al*. 2007). This condition is characterised by feelings of instability in the ankle, "giving way" of the ankle and recurrent ankle sprains (Gribble, Delahunt, Bleakley, Caulfield, Docherty, Fourchet, Fong, Hertel, Hiller, Kaminski, McKeon, Refshauge, Van Der Wees, Vincenzino & Wikstrom 201; Koboyashi & Gamada 2014; Webster & Gribble 2010).

Since ankle sprains are such common injuries amongst dancers, it is believed that chronic ankle instability could also be a common occurrence.

This study is one of the first attempts to determine how Chronic Ankle Instability affects the lives of professional ballet dancers.

The researcher hopes to gain a better understanding of the effect this condition has on the lives of professional ballet dancers. In future, this study could possibly be used as motivation to develop better, more dance-specific treatment strategies for this specific population.

The questionnaires aim to provide information on how common Chronic Ankle Instability is amongst professional ballet dancers in South Africa and to which extent it affects their daily lives.

The study consists of four separate questionnaires which will take no more than 60 to 90 minutes to complete. The questionnaires will only be completed once, and no follow-up sessions will be necessary. The questionnaires will be completed at a time which is convenient for the company. The researcher will travel to the company studios to conduct the questionnaires. You will thus not have any expenses to participate in the study and the demands on your time will not be longer than 90 minutes.

Due to participants not being subjected to any form of treatment, the risks involved with participating in this study are minimal. The researcher does not foresee any dangers or harm that could result from participating in this study. All reasonable measures have been taken to ensure your safety during your participation in this study.

Your participation in the study is purely voluntary. You may withdraw at any stage without being penalised in any manner. No remuneration will be provided for participating in the study.

The results obtained from this study, however, could be used to motivate for further studies into the management and prevention of CAI in this population. The results could also be used to promote awareness of this condition in the dancers themselves, the company management and the health professionals responsible for the treatment of these dancers. The dancers participating in the study will thus indirectly benefit from the results obtained through the study.

The results from this part of the study may be published in a peer-reviewed, accredited journal and/or presented at a professional forum or conference. Every care will be taken to protect the confidentiality of the study participants.

The protocol has also been subjected to evaluation committees at the University of the Free State and approval by the Ethics Committee at the Faculty of Health Sciences of the University of the Free State has been obtained. Should you have any further questions regarding the ethical aspects, the Ethics Committee can be contacted on 051 401 7794/5

Should you have any further questions you may contact the researcher on 082 421 1983 or cherezanemarais@yahoo.com

Kind regards

Cherezane Marais

APPENDIX B: PARTICIPANT INFORMEND CONSENT DOCUMENT

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

CONSENT TO PARTICIPATE IN THE RESEARCH STUDY:

CHRONIC ANKLE INSTABILITY AND ASSOCIATED SELF-REPORTED FUNCTION IN PROFESSIONAL BALLET DANCERS IN SOUTH AFRICA

You have been invited to participate in the abovementioned research study.

You have been informed about the study by the primary researcher, Cherezane Marais.

You have received and read the attached information document.

You may contact Cherezane Marais at 082 421 1983, should you have any questions regarding the research study.

You may contact the Secretariat of the Ethics Committee of the Faculty of Health Sciences, UFS at 051 401 7794/5 if you have questions regarding your rights as a research participant.

Your participation in this study is purely voluntary. You may withdraw at any stage without being penalised in any manner.

You will not receive remuneration for your participation in this study.

The results from this part of the study may be published in a peer-reviewed, accredited journal and/or presented at a professional forum or conference. Every care will be taken to protect the confidentiality of the study participants.

If you agree to participate in this study, you will receive a signed copy of this documents as well as the participant information document.

Your participation is highly appreciated!

Hereby I, _____, declare that the abovementioned research study as well as this consent form has been explained to me. I understand what my involvement in this research study will entail. I voluntary agree to participate in this study.

_____ _____

Signature of participant Date

_____ _____

Signature of witness Date

APPENDIX C: COMPANY MANAGEMENT INFORMATION DOCUMENT

Dear Artistic Director/ Company Management

INFORMATION REGARDING THE STUDY: CHRONIC ANKLE INSTABILITY AND ASSOCIATED SELF-REPORTED FUNCTION IN PROFESSIONAL BALLET DANCERS IN SOUTH AFRICA

I am a M.Sc. Physiotherapy student at the University of the Free State (UFS). In fulfilment of my postgraduate degree I have to conduct a research study in my chosen field of interest.

The injury rate amongst dancers is very high with up to 90% of dancers sustaining an injury during their career (Simon, Hall & Docherty 2014). Ankle sprains are considered to be the most common traumatic injury sustained by dancers (Russell 2010).

It is estimated that between 70% and 80% of patients who suffered from an initial ankle sprain, will experience a recurrence of the injury (Denegar & Miller 2002; Hubbard, Kramer, Denegar & Hertel 2007; Webster & Gribble 2010). According to research the recurrence of ankle sprains are believed to lead to a condition called Chronic Ankle Instability (Webster & Gribble 2010).

Chronic Ankle Instability is described as “the development of repetitive ankle sprains and persistent symptoms after injury” (Hubbard *et al.* 2007). This condition is characterised by feelings of instability in the ankle, “giving way” of the ankle and recurrent ankle sprains (Gribble, Delahunt, Bleakley, Caulfield, Docherty, Fourchet, Fong, Hertel, Hiller, Kaminski, McKeon, Refshauge, Van Der Wees, Vincenzino & Wikstrom 2013; Koboyashi & Gamada 2014; Webster & Gribble 2010).

Since ankle sprains are such common injuries amongst dancers, it is believed that chronic ankle instability could also be a common occurrence.

This study is one of the first attempts to determine how Chronic Ankle Instability affects the lives of professional ballet dancers in South Africa.

The researcher hopes to gain a better understanding of the effect this condition has on the lives of professional ballet dancers. In future, this study could possibly be used as motivation to develop better, more dance-specific treatment strategies for this specific population.

The questionnaires aim to provide information on how common Chronic Ankle Instability is amongst professional ballet dancers in South Africa and to which extent it affects their daily lives.

The study consists of four separate questionnaires which will take no more than 60 to 90 minutes to complete. The questionnaires will only be completed once, and no follow-up sessions will be necessary. The questionnaires will be completed at a time which is convenient for the company. The researcher will travel to the company studios to conduct the questionnaires. The dancers will thus not have any expenses to participate in the study and the demands on their time will not be longer than 90 minutes and will be once-off.

Due to the participants not being subjected to any form of intervention, the risks involved with participating in this study are minimal. The researcher does not foresee any dangers or harm that could result from participating in this study. All reasonable measures will be taken to ensure the participants' safety during their participation in this study.

The participants' participation in the study is purely voluntary. They may withdraw at any stage without being penalised in any manner. No remuneration will be provided for participating in the study.

The results obtained from this study, however, could be used to motivate for further studies into the management and prevention of CAI in this population. The results could also be used to promote awareness of this condition amongst the dancers themselves, the company management and the health professionals responsible for the treatment of these dancers. The dancers participating in the study will thus indirectly benefit from the results obtained through the study.

The results from this part of the study may be published in a peer-reviewed, accredited journal and/or presented at a professional forum or conference. Every care will be taken to protect the confidentiality of the study participants.

The protocol has also been subjected to evaluation committees at the University of the Free State and approval by the Ethics Committee at the Faculty of Health Sciences of the University of the Free State has been obtained. Should you have any further questions regarding the ethical aspects, the Ethics Committee can be contacted on 051 401 7794/5

Should you have any further questions you may contact the researcher on 082 421 1983 or cherezanemarais@yahoo.com

Kind regards

Cherezane Marais

APPENDIX D: PERMISSION DOCUMENTS FROM COMPANIES

BOVIM BALLET
BEYOND BALLET

CONFIRMATION OF PERMISSION TO CONDUCT STUDY:

In my capacity as Company Manager of Bovim Ballet, I confirm that permission has been granted to Ms. C. Marais to conduct the study: Chronic Ankle instability and associated self-reported function in professional ballet dancers in South Africa on our dancers whom wish to participate in this study.

Sincerely,

François Arzul

Company Manager

Bovim Ballet

+ 27 21 797 0777

info@bovimballet.com

Hereby I, ELIZABETH TRIEGAARDT in my capacity as EXECUTIVE DIRECTOR grant permission to Cherezane Marais to conduct the study: Chronic Ankle Instability and Associated Self-reported function in Professional Ballet Dancers at Cape Town City Ballet.

E Triegaardt

Elizabeth E Triegaardt

date 19 Feb, 2016

JOBURG BALLET

A WORLD CLASS AFRICAN BALLET COMPANY

20 January 2016

Dear Sir/Madam

This letter serves to confirm that Cherezane Marais has been given permission by Joburg Ballet to conduct her research study at our company at Joburg Theatre, corner Loveday and Hoofd street, Braamfontein, Johannesburg, Gauteng on Thursday 18 February 2016 from 11h00 to 12h30. Cherezane Marais will be conducting said research on 9 professional ballet dancers.

If you have any further queries, please do not hesitate to contact me on (011) 877-6897 or chase@joburgballet.com

Yours sincerely

COMPANY MANAGER

JOBURG THEATRE COMPLEX, HOOFD STREET, BRAAMFONTEIN / PO BOX 291990, MELVILLE 2109, SOUTH AFRICA
TEL +27 (0)11 877 6898, FAX +27 (0)11 877 6864; E-MAIL info@joburgballet.com; WEBSITE www.joburgballet.com
INCORPORATED UNDER S21: 2001/016254/08 NPO 016-403

APPENDIX E: ETHICAL APPROVAL

UNIVERSITY OF THE
FREE STATE
UNIVERSITEIT VAN DIE
VRYSTAAT
YUNIVESITHI YA
FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

IRB nr 00006240
REC Reference nr 230408-011
IORG0005187
FWA00012784

16 March 2016

MISS D MARAIS (A VAN DER MERWE)
DEPARTMENT OF PHYSIOTHERAPY
FACULTY OF HEALTH SCIENCES
UFS

Dear Ms Marais

ECUFS NR 236/2015
MISS D MARAIS (A VANDER MERWE)
DEPARTMENT OF PPHYSIOTHERAPY
PROJECT TITLE: CHRONIC ANKLE INSTABILITY AND ASSOCIATED SELF-REPORTED FUNCTION IN PROFESSIONAL BALLET DANCERS IN SOUTH AFRICA

1. You are hereby kindly informed that, at the meeting held on 15 March 2016, the Health Sciences Research Ethics Committee (HSREC) approved the above project after all conditions were met.

2. The Committee must be informed of any serious adverse event and/or termination of the study.

3. Any amendment, extension or other modifications to the protocol must be submitted to the HSREC for approval.

4. A progress report should be submitted within one year of approval and annually for long term studies.

5. A final report should be submitted at the completion of the study.

6. Kindly use the **ECUFS NR** as reference in correspondence to the HSREC Secretariat.

7. The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

Yours faithfully

.....
DR SM LE GRANGE
CHAIR: HEALTH SCIENCES RESEARCH ETHICS COMMITTEE

Health Sciences Research Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | F: +27 (0)51 444 4359 | E: ethicsfhs@ufs.ac.za
Block D, Dean's Division, Room D104 | P.O. Box/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa
www.ufs.ac.za

APPENDIX F: IDENTIFICATION OF FUNCTIONAL ANKLE INSTABILITY

IDENTIFICATION OF FUNCTIONAL ANKLE INSTABILITY (IdFAI)

Instructions: This form will be used to categorize your ankle stability status. A separate form should be used for the right and left ankles. Please fill out the form completely and if you have any questions, please ask the administrator. Thank you for your participation.

Please carefully read the following statement:

"Giving way" is described as a temporary uncontrollable sensation of instability or rolling over of one's ankle.

I am completing this form for my **RIGHT/LEFT** ankle (circle one).

1.) Approximately how many times have you sprained your ankle? _____

2.) When was the last time you sprained your ankle?

❑Never ❑ > 2 years ❑ 1-2 years ❑ 6-12 months ❑ 1-6 months ❑< 1 month

3.) If you have seen an athletic trainer, physician, or healthcare provider how did he/she categorize your most serious ankle sprain?

❑Have **not** seen someone ❑Mild (Grade I) ❑Moderate (Grade II) ❑Severe (Grade III)

4.) If you have ever used crutches, or other device, due to an ankle sprain how long did you use it?

❑Never used a device ❑1-3 days ❑4-7 days ❑1-2 weeks ❑2-3 weeks ❑>3 weeks

5.) When was the last time you had ***"giving way"*** in your ankle?

❑Never ❑> 2 years ❑1-2 years ❑6-12 months ❑ 1-6 months ❑< 1 month

6.) How often does the ***"giving way"*** sensation occur in your ankle?

❑Never ❑Once a year ❑Once a month ❑Once a week ❑Once a day

7.) Typically when you start to roll over (or 'twist') on your ankle can you stop it?

❑Never rolled over ❑Immediately ❑Sometimes ❑Unable to stop it

8.) Following a typical incident of your ankle rolling over, how soon does it return to 'normal'?

❑Never rolled over ❑Immediately ❑ < 1 day ❑1-2 days ❑> 2 days

9.) During "Activities of daily life" how often does your ankle feel ***UNSTABLE****?*

❑Never ❑Once a year ❑Once a month ❑Once a week ❑Once a day

10.) During "Sport/or recreational activities" how often does your ankle feel ***UNSTABLE****?*

❑Never ❑Once a year ❑Once a month ❑Once a week ❑Once a day

IDENTIFICATION OF FUNCTIONAL ANKLE INSTABILITY (IdFAI)

Instructions: This form will be used to categorize your ankle stability status. A separate form should be used for the right and left ankles. Please fill out the form completely and if you have any questions, please ask the administrator. Thank you for your participation.

Please carefully read the following statement:
"Giving way" is described as a temporary uncontrollable sensation of instability or rolling over of one's ankle.

I am completing this form for my **RIGHT/LEFT** ankle (circle one).

1.) Approximately how many times have you sprained your ankle? _____

2.) When was the last time you sprained your ankle?

❑Never (0) ❑ > 2 years (1) ❑ 1-2 years (2) ❑ 6-12 months (3) ❑ 1-6 months (4) ❑< 1 month (5)

3.) If you have seen an athletic trainer, physician, or healthcare provider how did he/she categorize your most serious ankle sprain?

❑Have **not** seen someone (0) ❑Mild (Grade I) (1) ❑Moderate (Grade II) (2) ❑Severe (Grade III) (3)

4.) If you have ever used crutches, or other device, due to an ankle sprain how long did you use it?

❑Never used a device (0) ❑1-3 days (1) ❑4-7 days (2) ❑1-2 weeks (3) ❑2-3 weeks (4) ❑>3 weeks (5)

5.) When was the last time you had ***"giving way"*** in your ankle?

❑Never (0) ❑> 2 years (1) ❑1-2 years (2) ❑6-12 months (3) ❑ 1-6 months (4) ❑< 1 month (5)

6.) How often does the ***"giving way"*** sensation occur in your ankle?

❑Never (0) ❑Once a year (1) ❑Once a month (2) ❑Once a week (3) ❑Once a day (4)

7.) Typically when you start to roll over (or 'twist') on your ankle can you stop it?

❑Never rolled over (0) ❑Immediately (1) ❑Sometimes (2) ❑Unable to stop it (3)

8.) Following a typical incident of your ankle rolling over, how soon does it return to 'normal'?

❑Never rolled over (0) ❑Immediately (1) ❑ < 1 day (2) ❑1-2 days (3) ❑> 2 days (4)

9.) During "Activities of daily life" how often does your ankle feel ***UNSTABLE****?*

❑Never (0) ❑Once a year (1) ❑Once a month (2) ❑Once a week (3) ❑Once a day (4)

10.) During "Sport/or recreational activities" how often does your ankle feel ***UNSTABLE****?*

❑Never (0) ❑Once a year (1) ❑Once a month (2) ❑Once a week (3) ❑Once a day (4)

Instructions for the “Identification of Functional Ankle Instability” Questionnaire

- Please fill out the questionnaire completely.
- Fill out the questionnaire by writing in the allocated space or by ticking the box that applies to you most. Please tick only one box per question.
- This questionnaire consists of two (2) identical pages.
- One is to be completed for the right ankle and one for the left ankle.
- Please take note that for this questionnaire the term “giving way” will be described as: “ a temporary uncontrolled sensation of instability or rolling over of one’s ankle”.
- If you have any questions, please raise your hand to get the attention of the researcher to ask your questions.

APPENDIX G: FOOT AND ANKLE ABILITY MEASURE

Foot and Ankle Ability Measure (FAAM)
Activities of Daily Living Subscale

Please answer **every question** with **one response** that most closely describes your condition **within the past week**.
If the activity in question is limited by something other than your foot or ankle mark "Not Applicable" (N/A).

	No Difficulty	Slight Difficulty	Moderate Difficulty	Extreme Difficulty	Unable to do	N/A
Standing	□	□	□	□	□	□
Walking on even Ground	□	□	□	□	□	□
Walking on even ground without shoes	□	□	□	□	□	□
Walking up hills	□	□	□	□	□	□
Walking down hills	□	□	□	□	□	□
Going up stairs	□	□	□	□	□	□
Going down stairs	□	□	□	□	□	□
Walking on uneven ground	□	□	□	□	□	□
Stepping up and down curbs	□	□	□	□	□	□
Squatting	□	□	□	□	□	□
Coming up on your toes	□	□	□	□	□	□
Walking initially	□	□	□	□	□	□
Walking 5 minutes or less	□	□	□	□	□	□
Walking approximately 10 minutes	□	□	□	□	□	□
Walking 15 minutes or greater	□	□	□	□	□	□

Foot and Ankle Ability Measure (FAAM)
Activities of Daily Living Subscale
Page 2

Because of your foot and ankle how much difficulty do you have with:

	No Difficulty at all	Slight Difficulty	Moderate Difficulty	Extreme Difficulty	Unable to do	N/A
Home responsibilities	□	□	□	□	□	□
Activities of daily living	□	□	□	□	□	□
Personal care	□	□	□	□	□	□
Light to moderate work (standing, walking)	□	□	□	□	□	□
Heavy work (push/pulling, climbing, carrying)	□	□	□	□	□	□
Recreational activities	□	□	□	□	□	□

How would you rate your current level of function during you usual activities of daily living from 0 to 100 with 100 being your level of function prior to your foot or ankle problem and 0 being the inability to perform any of your usual daily activities.

__ __ __ . 0 %

Foot and Ankle Ability Measure (FAAM)
Sports Subscale

Because of your foot and ankle how much difficulty do you have with:

	No Difficulty at all	Slight Difficulty	Moderate Difficulty	Extreme Difficulty	Unable to do	N/A
Running	□	□	□	□	□	□
Jumping	□	□	□	□	□	□
Landing	□	□	□	□	□	□
Starting and stopping quickly	□	□	□	□	□	□
Cutting/lateral Movements	□	□	□	□	□	□
Ability to perform Activity with your Normal technique	□	□	□	□	□	□
Ability to participate In your desired sport As long as you like	□	□	□	□	□	□

How would you rate your current level of function during your sports related activities from 0 to 100 with 100 being your level of function prior to your foot or ankle problem and 0 being the inability to perform any of your usual daily activities?

__ __ __ . 0%

Overall, how would you rate your current level of function?

□ Normal □ Nearly Normal □ Abnormal □ Severely Abnormal

Instructions for the Foot and Ankle Ability Measure

- This questionnaire consists of three (3) pages.
- Complete the questionnaire by ticking the box that applies to you most. Please tick only one box per question.
- Please complete this questionnaire as it relates to your function during the past week.
- If the activity is limited by something other than your ankle, please tick the “not applicable” (N/A) option.

APPENDIX H: DANCE FUNCTIONAL OUTCOME SYSTEM

DANCE FUNCTIONAL OUTCOME SYSTEM

Please answer every section and mark in each section the one statement which most applies to you. We realize that two statements in any one section may relate to you, but just mark one, which most closely describes your level now. These questions are based only on what you can do at this time. Do not compare yourself to other dancers. If a section is not applicable, please skip it.

GENERAL ACTIVITY

1. Overall Activity Level

_____ I have no limitations. I am able to do everything, including strenuous dancing and exercise.

_____ I can dance, but at a lower level. I must guard myself and limit the amount of heavy dancing.

_____ Light dancing is possible with occasional problems. I must avoid certain movements.

_____ No dancing is possible. Daily activities are possible with occasional problems.

_____ Daily activities cause moderate problems.

_____ Daily activities cause severe problems.

2. Movement Quality

_____ I feel confident that I can perform at the same level and quality as prior to my injury. I am able to articulate my limbs with 100% certainty or clarity.

_____ I feel confident that I am almost at the same level and quality of performance as prior to my injury. I am able to articulate my limbs with 80% certainty or clarity.

_____ I am improving but have a way to go before I am back to the level and quality I was prior to my injury. I am able to articulate my limbs with 60% certainty or clarity.

_____ I am improving but can only control my movement quality some of the time. I am able to articulate my limbs with 40% certainty or clarity.

_____ I am improving but only beginning to focus on movement quality. I am able to articulate my limbs with 20% certainty or clarity.

_____ I am improving but am working on basics and not able to focus on quality at this time.

3. Walking

_____ Normal and unlimited, including hills.

_____ Slight problems, relatively unlimited distances.

_____ Mild problems, most surfaces, up to half a mile (±800m) or 10 blocks.

_____ Moderate problems, flat surfaces, no more than 1/4 mile (±400m) or 5 blocks.

_____ Severe problems, only 1/8 mile (±200m) or 2-3 blocks.

_____ Severe problems, need cane or crutches.

4. Stairs

_____ Normal , unlimited up and down stairs.
_____ Slight problems, need to be careful, particularly (circle one) up/down stairs.
_____ Mild problems, have to go slowly, particularly (circle one) up/down stairs.
_____ Moderate problems, only 10-15 steps possible, particularly (circle one) up/down stairs.
_____ Severe problems, require a banister for support, particularly (circle one) up/down stairs.
_____ Severe problems, only 0-5 steps with support, especially (circle one) up/down stairs.

5. Stability and Symptoms

_____ I can do everything without symptoms of: giving out, locking, catching, grinding, or feeling weak.
_____ I only have symptoms (of giving out, locking, catching, grinding or feeling weak) with strenuous dancing or exercise.
_____ I only have symptoms (of giving out, locking, catching, grinding or feeling weak) with moderate dancing; it limits my vigorous acivities.
_____ Because I have symptoms (of giving out, locking, catching, grinding or feeling weak) with light dancing, it limits almost all of my dancing. I occasionally have symptoms with walking or light household work.
_____ I have symptoms frequently with simple activities such as walking. I must guard my injury at all times.
_____ I have severe problems with symptoms (of giving out, locking, catching, grinding, or feeling weak). I can't do much of anything without having symptoms.

6.Pain

_____ I have no pain.
_____ I have occasional pain with strenuous dance or exercise. I don't think that things are entirely back to normal. Limitations are mild and tolerable, if I am careful.
_____ There is occasional pain with moderate dancing or light exercise.
_____ I have pain with any dancing, exercise, or light recreational activities. Occasional pain is brought on by daily activities.
_____ Pain is a significant problem with activities as simple as walking. The pain is relieved by rest. I can't participate in dancing or exercise.
_____ I have pain at all times, even during walking, standing, or light household work.

DANCE TECHNIQUE SPECIFIC

7. Plié

_____ Able to fully perform grand plié in all positions, including fourth and fifth.
_____ Able to perform grand plié in first and second only.
_____ Able to perform grand plié in second position only.
_____ Cannot grand plié, but can demi-plié in all positions.
_____ Have some difficulty with demi-plié.
_____ Cannot demi-plié.

8. Développé

_____ I am able to fully perform all parts of développé to the front or side without a problem.

_____ I have slight problems performing développé to the front or side.

_____ I have mild problems fully extending my leg in développé to the front or side, and must développé at a lower height.

_____ I have moderate problems fully extending my leg in développé to the front or side and must mark it, but I can fully passé.

_____ I do not développé to the front or side at all, but can do a full passé.

_____ I cannot perform a full passé

9. Relevé Balance (If you do pointe work, indicate whether you can perform the indicated level on pointe.)

_____ Able to attain and maintain my balance in relevé/ pointe on the involved side without a problem.

_____ Able to attain and maintain my balance in relevé/ pointe on the involved side with only slight problems.

_____ Able to attain and maintain my balance in relevé/ pointe on the involved side with moderate difficulty.

_____ Able to relevé but can't maintain the balance on the involved side without barre assistance.

_____ Able to maintain my balance on flat foot, but cannot balance in relevé.

_____ Cannot relevé or maintain my balance on the involved side on flat foot.

10. Rond de jambe

_____ Able to fully perform as much and as often as required, at 90°, grand rond de jambe en l'aire a la seconde (rotational movements of the leg in the air).

_____ Able to perform at reduced speed: rond de jambe en l'aire a la seconde (rotational movements of the leg in the air).

_____ Able to perform with mild problems such as reduced number and speed: rond de jambe en l'aire a la seconde (rotational movements of the leg in the air).

_____ Able to perform with moderate problems such as reduced number, speed, and height (45°): rond de jambe en l'aire a la seconde (rotational movements of the leg in the air).

_____ I mark or avoid all rond de jambe en l'aire type movements (rotational movements of the leg in the air).

_____ I am unable to perform rond de jambe en l'aire a la seconde (rotational movements of the leg in the air) at all.

11. Kneeling/ Floorwork

_____ Able to fully perform floorwork or kneeling activities without limitations.

_____ Able to perform floorwork or kneeling activites with mild limitations.

_____ Able to perform floorwork or kneeling activites with moderate limitations.

_____ Able to perform floorwork or kneeling activites with moderate limitations: may require less repititions or slight modification.

_____ Severe problems, require supports or modification.

_____ Severe problems, unable to do.

12. Turning

_____ Able to fully perform unlimited multiple turns of all kinds, on either leg (to the extent you were able prior to your injury).

_____ Able to perform, but not quite fully, turns of all kinds, on either leg (to the extent you were able prior to your injury).

_____ Able to perform with slight problems, turns of most kinds, on either leg. I have to be careful about placement.

_____ I have moderate problems with turning. I am able to do single inside and outside turns on the involved side.

_____ Severe problems, no turning. I only do turn preparation and balance in relevé on the involved side.

_____ Severe problems, unable to balance on the involved side.

13. Jumping

_____ Able to fully perform everything: All grand and petit allegro (big and small jumping) combinations, including beats (to the extent you were able prior to your injury). Take off power is normal and unlimited. Able to maintain my balance when landing from a jump or hop.

_____ Able to perform, but not quite fully, grand and petit allegro (big and small jumping) combinations (to the extent you were able prior to your injury). Take off power and ability to maintain my balance when landing is pretty good.

_____ Able to perform with slight problems and some guarding: grand and petit allegro, and balance when landing from jumps or hops. I avoid most difficult jumps. Unable to do repeated jumps.

_____ I have moderate problems with jumping. I am only doing simple jumps in the center.

_____ Severe problems, affects all jumping in center floor. Can do simple jumps at the barre.

_____ Severe problems, no jumping activity possible.

14. Grand Allegro/ Across the Floor/ Travelling/ Running

_____ Able to fully perform all travelling combinations (change of direction, pivots, quick stops and starts, or run) at full speed.

_____ Able to perform, but not quite fully, all travelling combinations (change of direction, pivots, quick stops and starts, or run).

_____ Able to perform, with slight problems, travelling combinations (change of direction, pivots, quick stops and starts, or run) at reduced speed.

_____ I have moderate problems, and must move slowly and carefully in travelling combinations (change of direction, pivots, quick stops and starts, or run).

_____ I have severe problems, and must avoid most travelling combinations. I stick to barre and adagio (or center floor).

_____ I avoid all travelling combinations.

Compared to before my injury, if I had to give my dancing performance a grade from 0 to 100, with 0 being the worst and 100 being the best, I would give myself a: ____

Instructions for the Dance Functional Outcome System

- This questionnaire consists of four (4) pages.
- Please complete this questionnaire by ticking the statement that applies to you most. Please tick only one statement per question.
- Please complete this questionnaire as it relates to your current functioning.
- When a question refers to an “injury”, please use your **initial/first significant** ankle sprain as reference.
- If the activity is limited by something other than your ankle, please write “not applicable” or N/A next to the question.

APPENDIX I: ANKLE INJURY HISTORY QUESTIONNAIRE

Instructions
Please read each question carefully.

Mark the appropriate block with a X or write your answer in the space provided.

For Office Use

[ ][ ][ ] 1-3

1. Date questionnaire is completed (dd/mm/yy) …./…../…….

[ ][ ][ ][ ][ ][ ] 4-9
d d m m y y

2. What is your gender?

Male(1)	Female(2)

[ ] 10

3. What is your age?
……..…….years

[ ][ ] 11-12

4. What is your birthdate?(dd/mm/yy)…..…/…..…/……...

[ ][ ][ ][ ][ ][ ] 13-18
d d m m y y

5. What is you current rank in the company?

[ ] 19

1	Principle
2	Soloist
3	Corps de Ballet
4	Graduate
5	Guest artist
6	Other, specify…….……..

6. How long ago did your **initial** ankle sprain occur?

[ ] 20

1	Less than 12 months ago
2	More than 12 months ago

7. Give a short discription of how the **initial** ankle sprain occurred.

_____
_____
_____
_____
_____
_____
_____
_____

[ ][ ] 21-22
[ ][ ] 23-24
[ ][ ] 25-26
[ ][ ] 27-28
[ ][ ] 29-30

8. How would you rate the severity of your **initial** ankle sprain?

[ ] 31

1	Mild
2	Moderate
3	Severe

9. In how many interrupted days of training and/or performing did the **initial** sprain result?

1	None	
2	One day	32
3	Two to three days	
4	A week	
5	More than a week	

10. Was the ankle immobilised (put in a brace or cast) after the **initial** sprain?

Yes(1)	No(2)	
		33

If no, continue at question 12.

11. For how long was the ankle immobilised?

1	Less than 24 hours	34
2	24 to 72 hours	
3	Three to seven days	
4	Longer than seven days (one week)	

12. Were you allowed to take weight on the ankle after the **initial** sprain?

Yes(1)	No(2)	
		35

If yes, continue at question 14.

13. For how long were you not allowed to take weight on the ankle?

1	Less than 24 hours	36
2	24 to 72 hours	
3	Three to seven days	
4	Longer than seven days (one week)	

14.Did you receive supervised rehabilitation from a professional health care practitioner after the **initial** ankle sprain?

Yes(1)	No(2)	
		37

If no, continue at question 17.

15. How long did the rehabilitation program last?

1	One to seven days	38
2	Two to four weeks	
3	Four to six weeks	
4	Longer than six weeks	

16. If you answered yes at question 14, briefly describe the types of exercises which were included in the rehabilitation program.

_____
_____
_____
_____
_____
_____
_____
_____

		39-40
		41-42
		43-44
		45-46
		47-48

17. How long ago did your **most recent** ankle sprain occur?

1	Less than three months ago
2	Three to six months ago
3	More than six months ago

	49

18. Give a short discription of how the **most recent** ankle sprain occurred.

_____
_____
_____
_____
_____
_____
_____
_____

		50-51
		52-53
		54-55
		56-57
		58-59

19. How would you rate the severity of your **most recent** ankle sprain?

1	Mild
2	Moderate
3	Severe

	60

20. In how many interrupted days of training and/or performing did the **most recent** sprain result?

1	None
2	One day
3	Two to three days
4	A week
5	More than a week

	61

21. Was the ankle immobilised (put in a brace or cast) after the **most recent** sprain?

Yes(1)	No(2)

62

If no, continue at question 23.

22. For how long was the ankle immobilised?

1	Less than 24 hours
2	24 to 72 hours
3	Three to seven days
4	Longer than seven days (one week)

63

23. Were you allowed to take weight on the ankle after the **most recent** sprain?

Yes(1)	No(2)

64

If yes, continue at question 25.

24. For how long were you not allowed to take weight on the ankle?

1	Less than 24 hours
2	24 to 72 hours
3	Three to seven days
4	Longer than seven days (one week)

65

25. Did you receive supervised rehabilitation from a professional health care practitioner after the **most recent** ankle sprain?

Yes(1)	No(2)

66

If no, continue at question 28.

26. How long did the rehabilitation program last?

1	One to seven days
2	Two to four weeks
3	Four to six weeks
4	Longer than six weeks

67

27. If you answered yes at question 25, briefly describe the types of exercises which were included in the rehabilitation program.

_____
_____
_____
_____
_____
_____
_____
_____

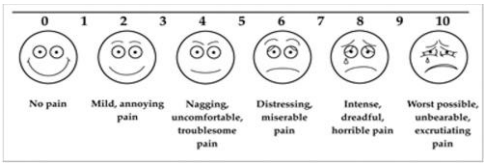
		68-69
		70-71
		72-73
		74-75
		76-77

28. Do you experience any pain in the **previously injured ankle** during your daily class and/or performance?

Yes(1)	No(2)

	78

29. If yes, please rate your **worst** pain on a scale of 0 to 10 (0 being no pain at all and 10 being excruciating pain).



		79-80

30. Have you had any previous fractures (broken bones) in one of your legs?

Yes(1)	No(2)

	81

If no, continue at question 33

31. Where was the fractures? (Mark all applicable)

1	Hip	82
2	Thigh	83
3	Knee	84
4	Lower leg/ Shin	85
5	Ankle	86
6	Foot	87

32. How was the fracture/s treated? (Mark all applicable)

1	External fixation	88
2	Plates/ screws/ etc. inserted during an operation	89
3	Conservative management (no operation)	90

33. Have you had any other operations to any structure in your legs?

Yes(1)	No(2)

☐ 91

If yes, continue at question 34

34. Please give a short discription of the type of operation

_____
_____
_____
_____
_____
_____
_____
_____

☐☐ 92-93
☐☐ 94-95
☐☐ 96-97
☐☐ 98-99
☐☐ 100-101

Thank you for taking the time to complete this questionnaire!
Your participation in this study is highly appreciated!

Instructions for Ankle Injury History Questionnaire

- This questionnaire consists of six (6) pages.
- Answer the questions by marking the appropriate block with an “X” or write your answer in the space provided.
- Do not fill in any information in the blocks on the right side of the vertical line (The column marked “For Office Use”).

APPENDIX J: GENERAL INSTRUCTIONS FOR PARTICIPANTS

General instructions

Thank you for taking part in this study.

This study will consist of the following questionnaires:

- The Identification of Functional Ankle Instability (IdFAI) Questionnaire
- The Foot and Ankle Ability Measure (FAAM)
- The Dance Functional Outcome System (DFOS)
- A questionnaire regarding ankle injury history and the management thereof (History of ankle injuries Questionnaire)

Please take a moment to familiarise yourself with the program that will be followed today:

1. Welcome and word of thanks.
2. Handing out of information document and written consent form.
3. Time for reading through information document and signing consent forms.
4. Collecting of signed consent forms.
5. Handing out of questionnaires. All four of the questionnaires together with their instructions will be handed out.
6. General, standardised instructions given, as well as the program of the day explained. Standardised instructions are given regarding the completion of each questionnaire. Please read the instructions to each questionnaire carefully before completing it.
7. While you are busy completing the questionnaires, the researcher will be available to answer any questions that might arise.
8. As soon as you are done, please hand the questionnaires to the researcher who will be sitting at the researcher's station. The researcher will quickly scan the questionnaires in order to ensure that it is completed.
9. Please make sure to sign the attendance register. You are then free to leave.

Please do not discuss the questionnaires or your responses with your fellow participants during the time of the study.

Should you have any questions while completing the questionnaires, please raise your hand to get the attention of the researcher. The researcher will then come to you to answer your question.

Please take a moment to familiarise yourself with the terms in the glossary provided.

General feedback regarding the results of the study will be e-mailed to the company management after completion of the study. Should you however wish to receive your individual results, please indicate it on the attendance register and provide the researcher with your e-mail address. Please note that individual results will be treated with confidentiality and will not be sent to other dancers or company management.

Thank you very much for your time.

Cherezane Marais

APPENDIX K: GLOSSARY FOR PARTICIPANTS

Glossary

Ankle sprain	"A common musculoskeletal injury in which the ligaments of the ankle partially or completely tear due to sudden stretching. This typically occurs when the ankle is suddenly "twisted" in a sports activity or by stepping off an uneven surface" (*www.medicinenet.com viewed on 18-09-2015).*
Significant ankle sprain	An ankle sprain that had symptoms of pain and swelling and resulted in at least one day of interrupted physical activity (Gribble *et al.* 2013).
Recurrent sprain	"Two or more ankle sprains to the same ankle" (Gribble *et al.* 2013).
Index/ initial ankle sprain	The very first significant ankle sprain (Gribble *et al.* 2013).
Giving way	"The temporary uncontrolled feeling of instability or rolling or twisting over one's ankle which do not result in an actual ankle sprain" (Identification of Functional Ankle Instability Questionnaire). An actual sprain would be one that had symptoms of pain and swelling and resulted in at least one day of interrupted physical activity (Gribble *et al.* 2013).
Activities of daily living	"Routine activities that people tend do every day without needing assistance" (www.investopedia.com *viewed on 18-09-2015).*
Immobilised	"Immobilisation can be obtained through the use of rigid braces, air splints, taping, thermoplastic materials or, most commonly, with the use of a plaster cast" (Brukner & Khan 2006).

Rehabilitation	"Planned, supervised and progressive program to return an individual to their maximum degree of physical and psychological independence" (www.medical-dictionary.thefreedictionary.com viewed on 26-09-2015)
Health care professional	"Any person who has completed a course of study in a field of health" (www.medical-dictionary.thefreedictionary.com viewed on 26-09-2015). For example a medical doctor, physiotherapist or a biokineticist.
Feelings of instability	"The situation whereby during activities of daily living and sporting activities the subject feels that the ankle joint is unstable and is usually associated with the fear of sustaining an acute ankle ligament sprain" (Gribble *et al.* 2013).

APPENDIX L: TURNITIN REPORT

Candidate

ORIGINALITY REPORT

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9	Gribble, P. A., E. Delahunt, C. Bleakley, B. Caulfield, C. Docherty, F. Fourchet, D. T.-P. Fong, J. Hertel, C. Hiller, T. Kaminski, P. McKeon, K. Refshauge, P. van der Wees, B. Vincenzino, and E. Wikstrom. "Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the International Ankle Consortium", British Journal of Sports Medicine, 2013. Publication	<1%
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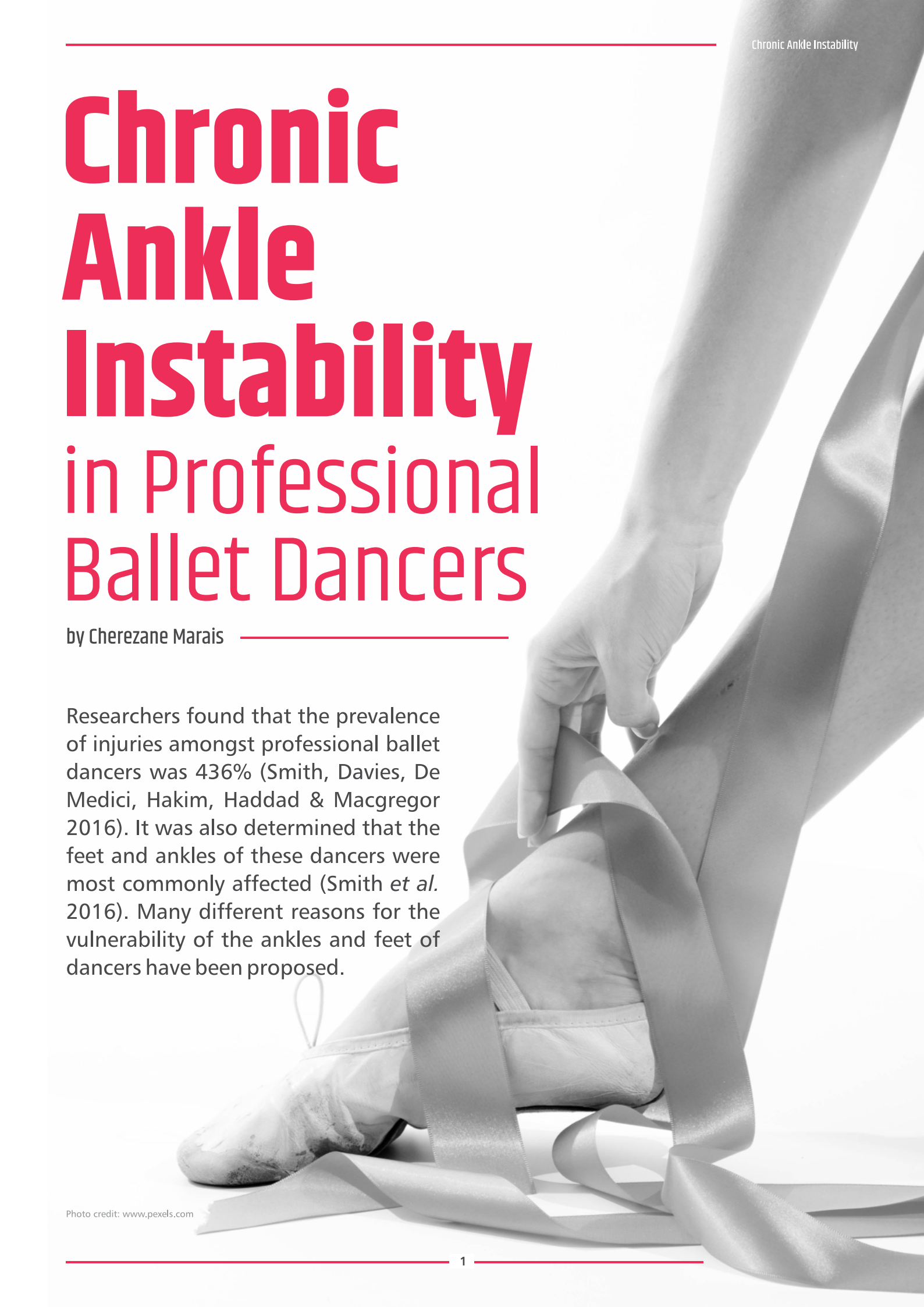
APPENDIX M: REPORT TO PARTICIPANTS

Chronic Ankle Instability in Professional Ballet Dancers

by Cherezane Marais

Researchers found that the prevalence of injuries amongst professional ballet dancers was 436% (Smith, Davies, De Medici, Hakim, Haddad & Macgregor 2016). It was also determined that the feet and ankles of these dancers were most commonly affected (Smith *et al.* 2016). Many different reasons for the vulnerability of the ankles and feet of dancers have been proposed.



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Firstly, ballet dancers require far more movement in their ankles than most people do (Russell, Shave, Kruse, Nevill, Koutedakis & Wyon 2011; Russell, Shave, Kruse, Koutedakis & Wyon 2011). Ballet dancers frequently utilize the *plié* and *en pointe* positions which are at the extremes of ankle movement and they move rapidly and repeatedly between these positions (Russell *et al.* 2011; Russell *et al.* 2011). Ballet dancers are known to go to extreme and sometimes dangerous lengths in order to gain the necessary range of ankle movement required for dancing (Russell *et al.* 2011; Russell *et al.* 2011). The unnatural increased range of movement could possibly have an effect on the stability of the ankle joints in these dancers and could lead to an increased risk of injury.

Secondly, dancing involves a wide variety of movements ranging from fast, complex footwork and rapid, repeated jumps to slow, sustained movements requiring above average balance, co-ordination, flexibility and muscular strength (Potts & Irrgang 2001; Sammarco & Tablante 1997). The demands placed on the feet and ankles of ballet dancers are thus extremely high.

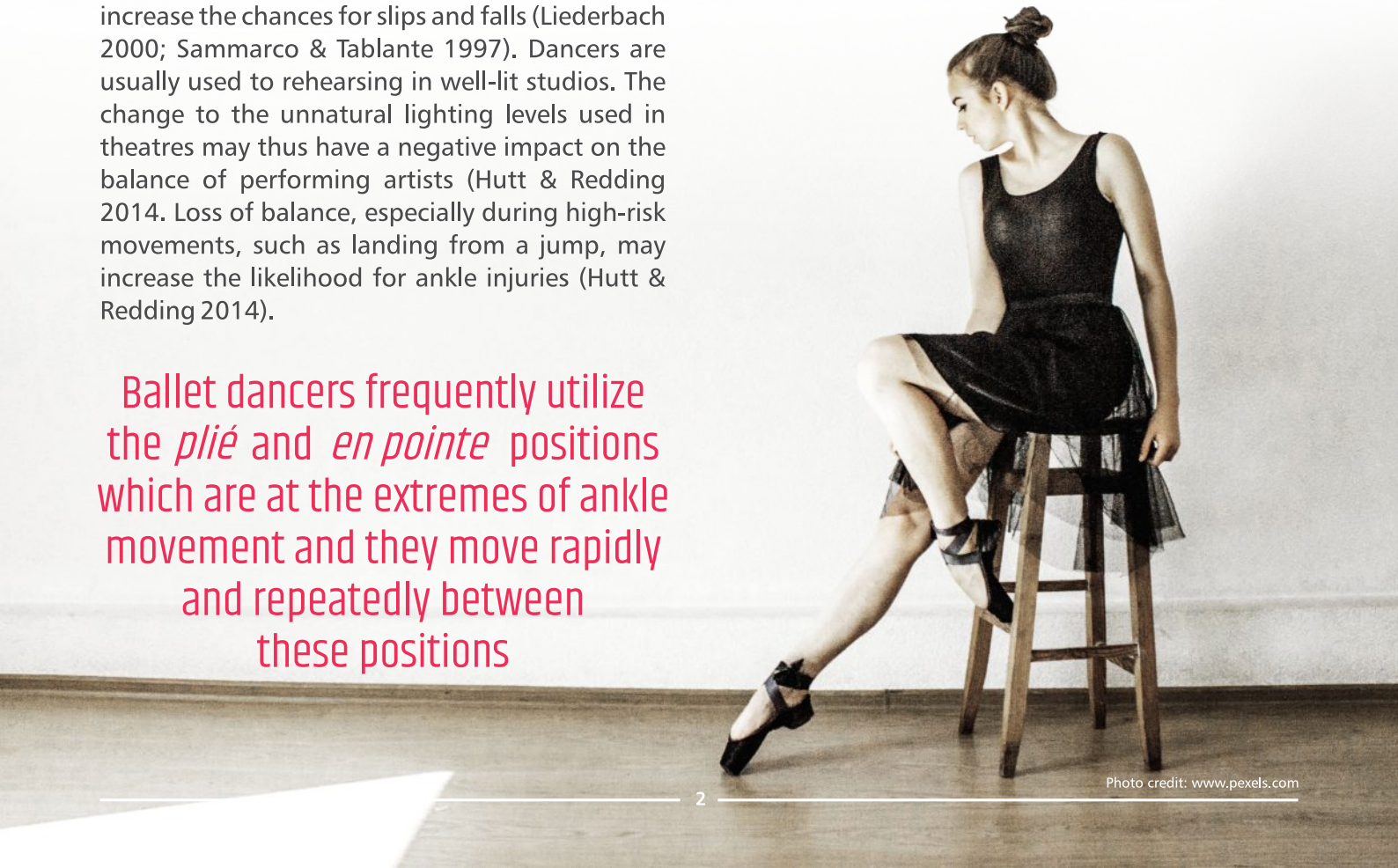
Thirdly, certain environmental factors have been thought to expose dancers to increased risks for injury. Raked stages or slippery surfaces may increase the chances for slips and falls (Liederbach 2000; Sammarco & Tablante 1997). Dancers are usually used to rehearsing in well-lit studios. The change to the unnatural lighting levels used in theatres may thus have a negative impact on the balance of performing artists (Hutt & Redding 2014. Loss of balance, especially during high-risk movements, such as landing from a jump, may increase the likelihood for ankle injuries (Hutt & Redding 2014).

Ballet dancers frequently utilize the *plié* and *en pointe* positions which are at the extremes of ankle movement and they move rapidly and repeatedly between these positions

Lastly, the world of professional ballet is extremely competitive. There is a great deal of pressure on dancers to return to dancing soon after an injury in fear of being replaced by another dancer or being seen as lazy (Simon, Hall & Docherty 2014). This may result in dancers not taking adequate time off after an injury to allow for healing (Simon *et al.* 2014). Many dancers also do not have access to on-site medical care, which in turn may delay the time to receiving medical treatment after an injury (Simon *et al.* 2014).

The most common acute ankle injury sustained by dancers is ankle sprains (Ramkumar, Farber, Arnouk, Varner & McCulloch 2016). Although ankle sprains are seen as minor injuries for which many dancers do not get professional health care advice and treatment for; their consequences can be far reaching.

Researchers found that many people who had sustained one ankle sprain will go on to experience residual problems with their previously injured ankles (Gribble, Delahunt, Bleakley, Caulfield, Docherty, Fourchet, Fong, Hertel, Hiller, Kaminski, Mc Keon, Refshauge, Van Der Wees, Vincenzino & Wikstrom 2013). These residual problems include recurrent sprains, laxity of the ankle ligaments, etc. (Gribble *et al.* 2013).



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According to this theory patients who do not receive medical attention after an acute ankle sprain might be more prone to developing CAI

These residual problems with the stability of the ankle after an ankle sprain are called "Chronic Ankle Instability" (CAI) (Gribble *et al.* 2013).

The most commonly reported symptoms of CAI include a regular sense of giving way and recurring ankle sprains (Gribble *et al.* 2013). "Giving way" refers to those times when one twists one's ankle, but it is not severe enough to be considered an ankle sprain yet (Gribble *et al.* 2013).

Scientists have been scratching their heads trying to figure out why so many patients develop this condition after sustaining an ankle sprain. They still don't have definite answers yet, but they have proposed four theories:

The first proposed theory links CAI to the common belief that lateral ankle sprains are minor injuries that do not require medical attention (Gribble, Bleakley, Caulfield, Docherty, Fourchet, Fong, Hertel, Hiller, Kaminski, McKeon, Refshauge, Verhagen, Vicenzino, Wikstrom & Delahunt 2016). According to this theory patients who do not receive medical attention after an acute ankle sprain might be more prone to developing CAI (Gribble *et al.* 2016).

The second theory proposes that the development of CAI might be linked to the intensity of care a patient receives after an acute ankle sprain (Gribble *et al.* 2016). Health professionals treating patients with acute ankle sprains may sometimes be either too passive or too aggressive in their treatment approaches (Gribble *et al.* 2016). Especially when treating athletes or high-level performing artists, there is usually a lot of pressure to return to activity as soon as possible and the health professionals treating these patients might then be inclined to an overly aggressive approach (Gribble *et al.* 2016).

The third theory states that some malfunctions of the muscles and balance systems in a patient are likely to persist after an ankle sprain (Gribble *et al.* 2016). Combine this with little or no treatment after the sprain and CAI becomes a real possibility (Gribble *et al.* 2016).

The fourth theory investigates the impact genetic factors have on the occurrence of ankle sprains (Gribble *et al.* 2016). One preliminary study found that soldiers who had a specific gene was less prone to sustaining ankle sprains and thus consequently develop CAI (Gribble *et al.* 2016).

All these theories are however, still under investigation and it might be some time until it is known exactly why people develop CAI (Gribble *et al.* 2016).

Seeing that the feet and ankles of dancers are vulnerable to injury and that the rate of ankle injuries in professional ballet dancers is quite significant, some questions arose:

- How common is CAI amongst professional ballet dancers in South Africa?
- How does this condition affect the everyday lives of the dancers, especially their ability to continue dancing?

Three standardised questionnaires and one self-compiled, literature-based questionnaire were used in an attempt to find some answers for the above mentioned questions. One of the standardised questionnaires was used to identify the dancers who had the symptoms of CAI and two of the standardised questionnaires were used to evaluate the function of the ankles of the affected dancers. One of these questionnaires focussed on their general function such as walking, navigating stairs and running. The other one focussed on dance-specific function such as performing *relevé's*, landing from jumps and turning. The literature-based questionnaire was used in order to get some information on the ankle injury history in these dancers.

Three professional ballet companies in South Africa were visited and the dancers were asked to complete the questionnaires.

It was found that approximately 76% of the dancers had sustained at least one significant ankle sprain up to that point in time. A significant ankle sprain is defined as "an ankle sprain which had pain and swelling and resulted in at least one day of interrupted activity".

Most of the dancers (88%) reported sustaining their first significant ankle sprain while being involved in dance or dance-related activities. Landing from a jump was identified as one of the main dance movements which dancers were performing when they sustained their ankle sprain.

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It was found that approximately 67% of the dancers in this study could be classified as living with CAI. The prevalence of CAI amongst professional ballet dancers in South Africa was found to be higher than in other sporting populations or in the general population.

The dancers who were affected by CAI tended to report more difficulty in controlling their ankles when it started to give way/ twist and reported to take longer to recover after their ankles had given way than those dancers who did not develop CAI after an ankle sprain or those who never had an ankle sprain before.

Dancers function in a world where pain is usually seen as inevitable and a culture of "no pain no gain" and "the show must go on exist". Of the dancers included in the study 45% reported still experiencing pain in their previously injured ankle. It was interesting to note that all the dancers included in this 45% were also those experiencing CAI.

When looking at how CAI affected the function of these professional ballet dancers some interesting results were found.

The International Ankle Consortium regards 80% and in some cases 90% of function on the standardised questionnaires used in the study as normal (Gribble *et al.* 2013). According to this standard very few of the dancers' function were really affected.

Most of the dancers who were affected by CAI scored more than the 80% or 90% minimum as prescribed by the International Ankle Consortium. The graph below shows the percentage of affected dancers who scored more than the 80% or 90% and whose function can thus be considered to be normal.

Three professional ballet companies in South Africa were visited and the dancers were asked to complete the questionnaires.

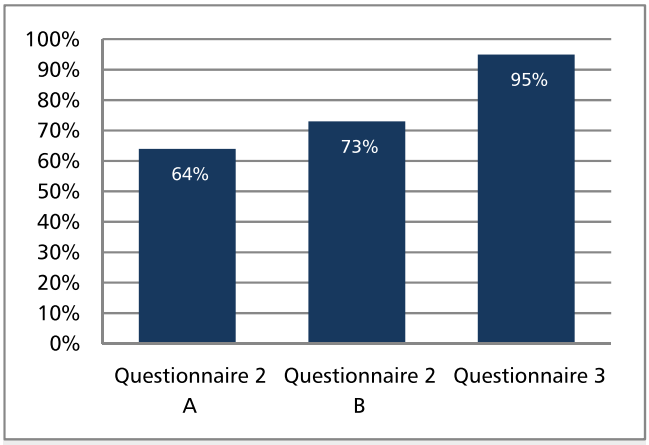

Figure 1. Percentage of dancers with CAI who scored more than the prescribed minimum on the functional scales

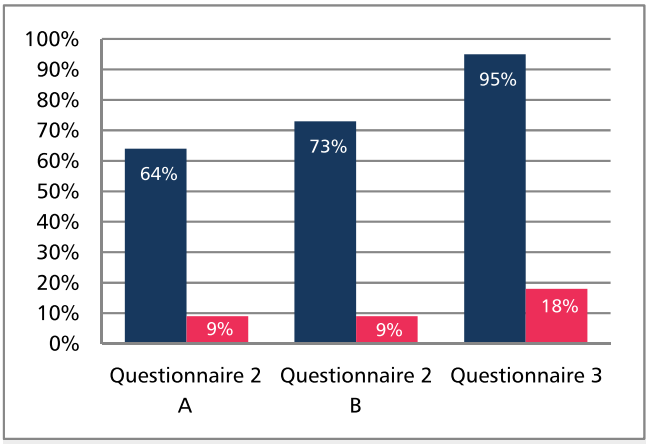

Figure 2. Percentage of dancers with CAI who scored more than the prescribed minimum on the functional scales (blue) vs percentage of dancers with CAI who scored 100% on the functional scales (red)

Two theories for the apparent good self-reported function despite the presence of CAI were proposed:

A big, high quality study found that balance activities might be the most important component to include in rehabilitation of patients affected by CAI (Kosik, McCann, Terada & Gribble 2017). It is also generally believed that dancers, specifically ballet dancers, have superior balance abilities and that ballet dancing can improve balance abilities (Hutt & Redding 2014). The first theory thus is that these dancers actually automatically rehabilitated themselves when they returned to dancing.

The second theory asks if 80% or 90% of normal function is enough for elite athletes such as these professional ballet dancers. Performing arts medicine functions within very narrow margins – as a famous quote by Dr Branfonbrener states (Dommerholt 2009):

"The difference between 95% recovery of an injured finger and 100% recovery may mean the difference between a world-class performing career as a violinist and obscurity"

The same may apply to the ankles of professional ballet dancers. If the same graph as previously is used, but the dancers who scored 100% in the questionnaires are added in red, the graph looks very different.

The question thus remains – is 80/90% of function enough for the demands placed on the ankles of professional ballet dancers?

As with all research, it answers one question and leaves one with three or four new ones. The research team on this study recommends looking further into possible reasons for the apparent good self-reported function found amongst professional ballet dancers despite having the symptoms of CAI. Future studies can aim to investigate the rehabilitation protocols followed by the dancers after an ankle sprain, possibly allowing for the identification of optimal rehabilitation protocol elements. Another recommendation for future studies can be looking into the instruments or scales used to evaluate the function of elite athletes and performers and seeing if these instruments are sensitive enough to detect the small changes in function which can be crucial to these dancers. Future studies can also look into ways to prevent acute ankle sprains form occurring in the first place.

As with all research, it answers one question and leaves one with three or four new ones.

What can you do to prevent developing CAI after an ankle sprain?

It is important to remember that although ankle sprains are not life threatening injuries and most people recover quite well after sustaining one, very few (if any) ankle sprains can be considered a "simple sprain". If you sustained an ankle sprain which resulted in pain, swelling around the ankle and an interruption in your daily activities, it would be advisable to visit a health care professional, preferably one who has experience treating sports injuries. When the health care professional examines you, remember to give truthful and accurate information to them and to follow the prescribed treatment to the "t". It is also extremely important to complete the rehabilitation process as prescribed by the health care provider.

How do you know if you have CAI?

If you had at least one ankle sprain which had pain and swelling of your ankle and resulted in your dancing and daily activities being interrupted for at least one day, the first such ankle sprain having occurred at least 12 months ago and you are experiencing the following symptoms:

- Recurring ankle sprains (more than one ankle sprain to the same ankle)
- If you are experiencing sensations of the ankle giving way/ rolling over/ twisting without sustaining an actual ankle sprain
- If your ankle feels unstable during your everyday activities or during your sport or dancing activities

If you had an ankle sprain and are experiencing these symptoms, you may have CAI.

What should you do if you think you have CAI?

Visit an appropriately qualified health care professional for an assessment and follow-up management if needed. If you are a dancer, it is recommend that you look for a health care professional who has experience working with dancers seeing that the ankles of dancers have some "special considerations" to keep in mind during management.


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Chronic Ankle Instability in Professional Ballet Dancers

APPENDIX N: REPORT FROM LANGUAGE EDITOR

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18 September 2017

To whom it may concern: Certificate of Editing

This letter serves to confirm that **in September 2017** I did the proofreading and the language editing for the thesis of

CHEREZANE MARAIS

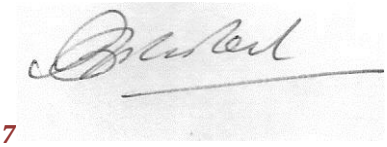
Student Number 2007013564

Titled: ***Chronic ankle instability and associated self-reported function in professional ballet dancers in South Africa***

This document is being submitted in fulfilment of the requirements for the degree

MASTER OF SCIENCE Physiotherapy
In the Department of Physiotherapy
At the UNIVERSITY OF THE FREE STATE

I have proofread and edited the main body of the dissertation but have not been asked to edit the introductory pages or the List of References or any Appendices. This editing principally involves proofreading, language, style and grammar editing; and also checking the text for clarity of meaning, sequence of thought and expression and tenses. I have also noted any inconsistencies in thought, style or logic, and any ambiguities or repetitions of words and phrases, and have corrected those errors which creep into all writing. I have written the corrections on the hard copy and have returned the document to the author, who is responsible for inserting these. Please note that this confirmation refers only to editing of work done up to the date of this letter and does not include any changes which the author or the supervisor may make later.



18 September 2017

Bernice McNeil BA Hons NTSD

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