INJURIES IN GYMNASTICS: THE KNOWLEDGE, ATTITUDES, AND PRACTICES OF SOUTH AFRICAN GYMNASTICS COACHES

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LIST OF ABBREVIATIONS

ABBREVIATION	DEFINITION
ACL	Anterior Cruciate Ligament
FIG	Fédération Internationale de Gymnastique / International Gymnastics Federation
GSA	Gymnastics South Africa
HREC	Human Research Ethics Committee
KAP	Knowledge, Attitudes and Practices
RE-AIM	Reach, Effectiveness, Adoption, Implementation and Maintenance
TRIPP	Translating Research into Injury Prevention Practice
UCT	University of Cape Town

GLOSSARY OF TERMS

TERM	DEFINITION
Accumulated Fatigue	(i.e. during term/semester) fatigue: tiredness resulting from mental or physical exertion or illness, in sport often manifested as failure to maintain the required or expected force (or power output)
Accumulated Fatigue	(i.e. towards end of training/competition) fatigue: tiredness resulting from mental or physical exertion or illness, in sport often manifested as failure to maintain the required or expected force (or power output)
Acute Fatigue	following intense actions during training/competition
Base Role (or Bases)	Bases are taller, heavier and have greater fat percentage, since their role is to support the tops
Extrinsic Risk	External and/or environment risk factors
Flexibility	Flexibility is the ability of soft tissue structures, such as muscle, tendon, and connective tissue, to elongate through the available range of joint motion
Intrinsic Risk	internal personal factors for injury. Intrinsic risk can be divided into modifiable (e.g. fitness level/skill level) and non-modifiable (e.g. age) risk factors
Joint Mobility	Range of Movement (ROM) is how far a joint can move in a given direction. Mobility then, is when we take every ROM of the joint and look at the total movement there is within a joint
Muscle Imbalance	An imbalance in muscular strength between an agonist : antagonist (e.g. biceps : triceps). Agonist - muscle whose contraction is responsible for producing a particular motion. Antagonist – muscle that opposes the action of an antagonist (Biga et al., 2020)
Muscle Imbalance	The muscles on each side of your body should be symmetrical with each other in size and strength. When a muscle (or muscles) on one side of your body is larger, smaller, stronger, or weaker than the corresponding muscle(s) on the other side, you have a muscle imbalance (Frothingham, 2020).

Strength Endurance	Muscular endurance refers to a muscle’s ability to work over a period of time (Edwards, 2023).
Top Role (or Tops)	Tops are the shorter and lighter athletes, and perform various static skills supported by the base in cooperative routines, or big acrobatic jumps after propulsion from the base with landing on them again or on the floor
Training Load	The cumulative amount of stress placed on an individual from a single or multiple training sessions (structured or unstructured) over a period of time

ABSTRACT

Background

Over the last few decades, athlete participation in gymnastics has increased. Injuries occur at all levels of participation in gymnastics from recreational to elite levels. Elite gymnasts may commence training from as early as five years of age and may train consistently for between 20 to 40 hours per week over a full calendar year. Gymnasts are at high risk of injury, and this is associated with longer practice times and increased complexity of routines. Gymnastics coaches are involved in the selection of training programmes for the athlete that may result in both an improvement in athletic performance and decrease in injury risk. Coaches are also typically responsible for promoting injury prevention behaviours in athletes. The aim of this dissertation was to describe the knowledge, attitudes and practices (KAP) of South African-based gymnastics coaches regarding injuries and injury prevention in the sport.

Objectives

The scoping review question and sub-questions were:

- what musculoskeletal injuries occur in recreational and competitive gymnasts;
- what injury definitions are used to identify injuries in recreational and competitive gymnasts;
- what is the incidence and prevalence of musculoskeletal injuries in recreational and competitive gymnasts; and
- how are injuries in recreational and competitive gymnasts classified in terms of injury area, injury type, and injury severity?

The objectives of the survey-based study were to:

- describe the demographic characteristics and coaching characteristics of South African-based gymnastics coaches; and
- describe the KAP of South African-based gymnastics coaches regarding injuries and injury prevention in the sport.

Methods

The dissertation comprised a scoping review and a cross-sectional descriptive study using an online survey to determine the KAP of gymnastics coaches regarding injuries and injury prevention in the sport.

Scoping Review

The scoping review was conducted according to the JBI guidelines. Observational, cohort, and epidemiological studies on injury incidence and prevalence in gymnastics were included in the data charting table of this review. Prospective and retrospective studies of injury incidence in gymnasts were eligible. Review studies were excluded, and a 20-year date limitation was applied to the original data search (i.e., 2003 – 2023).

Survey-based Study

South African-based gymnastics coaches over 18 years of age and from all gymnastics disciplines were eligible for inclusion in the survey-based study. Coaches were recruited through Gymnastics South Africa. An online survey was developed and was assessed for content validity and feasibility, before being accessible to study respondents. Respondents provided informed consent and completed the survey online. The survey collected information on coaches sociodemographic and training characteristics, and coaches KAP regarding injuries and injury prevention in gymnastics.

Results

Scoping Review

Fourteen studies were included on the data charting table for data extraction and synthesis. There was a lack of standardised definition of injury. Injuries were commonly observed during training and competition, with similar injury rates for male and female gymnasts. Athletes from all disciplines of gymnastics were susceptible to musculoskeletal injuries in the upper limbs, lower limbs, head, and trunk. Ligament sprains and muscle/tendon strains were the most commonly reported, with injury severity commonly being mild to moderate.

Survey-based Study

Eighty-five coaches (male: n=28, 32.9%; female: n=57, 67.1%), demonstrating a mean age of 39 years (SD: ±15 years), took part in the survey. Most respondents coached gymnasts aged between five to 20 years, competing from level four to level 10. Coaches demonstrated an inadequate level of knowledge regarding injury prevention (65%), as well as an inadequate level of positive attitude regarding injury prevention (51%). Coaches also highlighted the need for improved injury education to allow them to make informed decisions to support their gymnasts and to assist in enhancing injury prevention efforts.

Conclusion

This dissertation has highlighted the need for more homogenous injury surveillance methods and reporting parameters in gymnastics. While coaches demonstrated inadequate knowledge regarding injuries and injury prevention in gymnastics, coaches understood the importance of improving injury prevention practices. There is an opportunity for rapid translation of these findings in the South African gymnastics context and establishing better working relationships between gymnastics stakeholders (i.e., athletes, guardians/caregivers, and coaches) and health care professionals is an immediate priority.

The baseline of KAP findings from this dissertation will also allow an opportunity for the reassessment of KAP after injury education interventions for gymnastics coaches are implemented. Future research should also include prospective gymnastics injury monitoring and reporting to gain further insights regarding injury burden in South African gymnasts.

CHAPTER ONE: INTRODUCTION AND SCOPE OF DISSERTATION

1.1 Introduction

Gymnastics has long been an established sport at the Olympic Games (Caine et al., 2013). The International Federation of Gymnastics (2014) noted that artistic gymnastics was the second most watched event, during the 2012 London Olympic Games. South African gymnastics, governed by Gymnastics South Africa (GSA), comprises nine disciplines, namely: acrobatic, aerobic, Gym for All, men's artistic, parkour, rhythmic, rope skipping, trampoline, and women's artistic gymnastics (Gymnastics South Africa, 2021).

Gymnastics' Olympic disciplines

Artistic gymnastics is one of the gymnastics Olympic disciplines, alongside rhythmic gymnastics and trampoline (The International Federation of Gymnastics, 2019c, 2019d). Artistic gymnastics is separated into male's artistic gymnastics and women's artistic gymnastics. Males compete on six different apparatus including horizontal bar, parallel bars, pommel horse, rings, vault, and floor. Females compete on four apparatus being vault, floor, uneven bars and beam (Benardot, 2013; Hecht & Burton, 2009; The International Federation of Gymnastics, 2019b, 2019e). Of the five categories included in rhythmic gymnastics (i.e., clubs, ribbon, hoop, rope, and ball), athletes compete in only four events on a rotatory basis (The International Federation of Gymnastics, 2019c). Trampoline has been included as an Olympic discipline since 2000 (Benardot, 2013; Hecht & Burton, 2009; The International Federation of Gymnastics, 2019d). During competition, athletes perform two different routines of 10 consecutive skills each. Synchronised trampoline (or synchro) is a competitive routine that sees two separate gymnasts performing an identical 10-skill routine on two different trampolines simultaneously.

Gymnastics’ non-Olympic disciplines

Tumbling is a competitive, non-Olympic gymnastics discipline. A tumbling pass (or tumbling routine) is a series of consecutive acrobatic manoeuvres. The gymnast performs the tumbling pass on an elevated spring floor strip (The International Federation of Gymnastics, 2019d). Acrobatic gymnastics is also a competitive, non-Olympic discipline. There are five competitive event categories in this discipline, namely men’s pairs, women’s pairs, mixed pairs, women’s group (three members), or men’s group (four members) (The International Federation of Gymnastics, 2019a). The roots of aerobic gymnastics are from group fitness classes of the late 1980’s, with seven basic aerobic movements involving both the arms and legs that, in combination, form the basis of all aerobic gymnastic routines (Western Cape Gymnastics, 2014). The latest addition to the International Federation of Gymnastics’ (FIG) competitive stable of gymnastics disciplines is that of parkour. There are two categories in parkour, namely speed-run and freestyle, completed by the parkour athlete, known as a traceur (Grosprêtre & El Khattabi, 2022; Karmali et al., 2019). The final competitive, non-Olympic gymnastics discipline is rope skipping. As explained by Lucas (2015), the gymnast/jumper can participate in various categories that includes single rope, pairs, double dutch three, and double dutch four. Gym for All is the gymnastics discipline accessible to athletes of all ages and ability levels and is not a competitive gymnastics discipline. Gym for All participants combine various forms of dance and trampoline with elements of artistic, aerobic, and rhythmic gymnastics (Hecht & Burton, 2009).

With an increase in the popularisation of gymnastics, the sport has seen a steady increase in participation over the last few decades (Caine & Harringe, 2013). In turn, the increased participation is associated with an increased injury prevalence (Caine et al., 2013; Daly et al., 2001). Gymnastics injuries occur at recreational, competitive, and elite levels of participation (Albright et al., 2022; Coates et al., 2010; Goulart et al., 2016).

The vast majority of competitive gymnasts are children (Caine & Harringe, 2013; Daly et al., 2001). Since 2000, the minimum age for a gymnast to be able to compete at the Olympics was established as 16 years by the International Federation of Gymnastics (Benardot, 2013). Elite gymnasts may commence training from as early as five years of age and may train consistently for between 20 to 40 hours per week over a full calendar year (Daly et al., 2001; Gram et al., 2021). As adolescents progress through the developmental years, they encounter physical changes associated with the natural growth process. These physical changes result in naturally occurring imbalances between strength and flexibility, predisposing adolescent gymnasts to a high incidence of injury (Daly et al., 2001). Potentially contributing to the diverse injury burden in gymnastics, is the fact that most disciplines in gymnastics require constant change between upper-limb and lower-limb weight-bearing (Farana et al., 2014).

The prevalence of injuries in gymnastics is unclear due to variance in the definition of injury used by researchers. Researchers may report the incidence rate of injury as injuries/1000h of training. A weighted average of three studies of male gymnasts reported an incidence of 1.4 injuries/1000h of training (Bak et al., 1994; Harringe et al., 2007; Kirialanis et al., 2002), while the weighted average of six studies of female gymnasts reported 1.5 injuries/1000h of training (Bak et al., 1994; Caine et al., 1989; Caine et al., 2003; Harringe et al., 2007; Kirialanis et al., 2002; Lindner & Caine, 1990). The difference between injury rates experienced by non-competitive and competitive gymnasts was explored by Thomas and Thomas (2019). The injury rates for competitive and non-competitive male gymnasts were reported as 1.6 vs. 833 injuries/1000 gymnasts per year, and 46 vs. 751 injuries/1000 gymnasts per year for female athletes.

There are widely-held beliefs that to achieve sporting success in elite gymnastics, both training intensity and load must be maintained at extremely high levels over much of the duration of the developmental years, beginning well before puberty (Daly et al., 2001; Kirialanis et al., 2002).

This results in few elite gymnasts passing through adolescence without injury, as they move towards routines with a higher degree of difficulty, developed and refined over longer practice times (Kirialanis et al., 2002). Grapton et al. (2013) highlighted the increased injury risk in gymnasts that have progressed to a higher competitive level, participated in extended training sessions, competed at competitions, and experienced increased life stress. Injury prevention research often aims to reduce the risk of athlete injury while improving sporting performance. While these research-based programmes are best supported by coaches, the most up to date research may not always be accessible, as reported by Saunders et al. (2010). Mawson et al. (2018) stated that the influence of the coach on promoting injury prevention behaviours, along with their influence on injury prevention decision-making, should not be overlooked. Grapton et al. (2013) further highlighted that research provides evidence for promoting training session modification where the coach provides the athlete with an adequate opportunity for rest and recovery.

Mawson et al. (2018) stated that development of optimal injury prevention behaviours in athletes may be most promoted by coaches. When looking to research produced by other sporting disciplines, McKay et al. (2014) highlighted that in soccer, coach knowledge of injuries and of injury prevention programmes is one of the main factors contributing to the use of these programmes with their athletes. McKay et al. (2014) stated that athlete training sessions often failed to incorporate these injury prevention strategies when coaches demonstrated gaps in their own knowledge about injury. Saunders et al. (2010) demonstrated that there was an effective decrease in the likelihood of athletes sustaining injury, where education efforts are directed at improving coach insight concerning injury mechanisms and acute injury management of injury in junior rugby union, netball, and soccer coaches.

1.2 Theoretical Framework

To facilitate the progression from the conceptualisation of implementation strategies into effective real-world outcomes, Finch (2011) developed the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework. The RE-AIM framework was first proposed as a tool to monitor the effectiveness of programmes requiring behaviour change and has since been more broadly applied as a planning tool and a method to review intervention studies. This framework has also been advocated as a suitable model for the delivery and evaluation of sports injury interventions within an ecological sports delivery system. The RE-AIM framework attempts to emphasise to researchers that it is not only the theoretical considerations of injury prevention programmes that should be monitored, but also the factors influencing intervention uptake and effectiveness. These factors may include (Finch, 2011):

- the current behaviours of the group under investigation;
- how previous learned knowledge, attitudes, intentions, and perceptions may influence current behaviours towards injury, and how it may have an effect on desired behaviour change;
- factors that may influence the adoption of potential prevention measures by the sports stakeholders being investigated; and
- how the delivery of interventions may be impacted by setting-specific or cultural factors, and how this may impact how effectively the intervention in sustained beyond the research period.

This framework acknowledges the human behavioural-change component which is necessary for the successful implementation of injury prevention programmes.

1.3 Problem Statement

There is very little information about musculoskeletal injury in recreational and competitive-level gymnastics in South Africa. There is data regarding musculoskeletal injury in recreational and competitive gymnastics in other contexts. A scoping review may be valuable when attempting to identify the types of evidence available in a given field (Peters et al., 2020). Further indications for the use of a scoping review are when attempting to identify the potential knowledge gaps around a topic, or when aiming to provide insight to key characteristics or factors regarding a field of inquiry.

There is also very little information about the knowledge, attitudes, and practices (KAP) of South African-based gymnastics coaches regarding injuries and injury prevention in the sport. Establishing a clear picture of current South African-based gymnastics coaches' understanding of injuries and injury prevention in the sport, will assist to identify gaps in knowledge and practice and facilitate better development of injury prevention and management strategies.

1.4 Aims and Objectives

This dissertation comprises a scoping review (Chapter Two) and a cross-sectional descriptive study using an online survey to determine the KAP of South African-based gymnastics coaches (Chapter Three). The main question asked in the scoping review was "what musculoskeletal injuries occur in recreational and competitive gymnasts?" The sub-questions asked were:

- what injury definitions are used to identify injuries in recreational and competitive gymnasts;
- what is the incidence and prevalence of musculoskeletal injuries in recreational and competitive gymnasts; and
- how are injuries in recreational and competitive gymnasts classified in terms of injury area, injury type, and injury severity?

The aim of the survey-based study was to describe the KAP of South African-based gymnastics coaches regarding injuries and injury prevention in the sport. The specific objectives of the survey-based study were to describe:

- the demographic characteristics and coaching characteristics of South African gymnastics coaches; and
- the KAP of South African gymnastics coaches regarding injuries and injury prevention in the sport.

1.5 Plan of Development of Dissertation Document

A scoping review of the available injury data around musculoskeletal injuries that may occur in recreational and competitive-level gymnastics is presented in Chapter Two.

Chapter Three presents the empirical research component of the dissertation. A summary and conclusion will complete this dissertation in Chapter Four.

CHAPTER TWO: MUSCULOSKELETAL INJURIES IN RECREATIONAL AND COMPETITIVE GYMNASTS – A SCOPING REVIEW

2.1 Introduction

Gymnastics is a sport that caters to athletes at all levels of participation, and as a result creates an opportunity for injury. Gymnasts need to be proficient in the aesthetic and technical aspects of the sport and psychologically able to cope with the demands of the sport (Caine et al., 2013). Specific injury data on injuries in gymnastics is limited, with conflicting reporting formats (Campbell et al., 2019; Hinds et al., 2019; Thomas & Thomas, 2019).

Most gymnasts start participating and training in the sport from a young age, typically increasing the training load as years of participation continue (Campbell et al., 2019; Kirialanis et al., 2002). To achieve higher scores during competition, gymnasts need to increase the intricacy and difficulty of the elements executed – which is typically coupled with an increased training load. The higher training load during the athletes developmental years sees most gymnasts sustaining injury during childhood and adolescence (Desai et al., 2019; Kirialanis et al., 2002). With the demands of gymnastics participation requiring that athletes' from most disciplines perform alternating upper-limb and lower-limb weight bearing (Kirialanis et al., 2002), there is a potential risk of injury present for the upper-limbs and lower-limbs alike (Thomas & Thomas, 2019). Not failing to mention injuries that may occur in the spine and trunk (Thomas & Thomas, 2019). This risk of injury may compound and predispose the gymnastics athlete to developing chronic injuries, as the athlete continues their progression through the sport (Kirialanis et al., 2003).

Peters et al. (2020) indicated that scoping reviews may be conducted when aiming to identify available evidence around a topic and identifying and analysing knowledge gaps. Therefore, the available evidence around musculoskeletal injuries occurring in recreational and competitive-level gymnastics was the focus of this scoping review.

A scoping review of the literature would also aid in identifying and analysing potential knowledge gaps around the topic of musculoskeletal injuries in recreational and competitive-level gymnastics, while facilitating clarification of key concepts and definitions in the literature about musculoskeletal injuries in the sport.

2.2 Scoping Review Questions

The main question asked in the scoping review was "what musculoskeletal injuries occur in recreational and competitive gymnasts?" The sub-questions asked were:

- what injury definitions are used to identify injuries in recreational and competitive gymnasts;
- what is the incidence and prevalence of musculoskeletal injuries in recreational and competitive gymnasts; and
- how are injuries in recreational and competitive gymnasts classified in terms of injury area, injury type, and injury severity?

2.3 Methodology

2.3.1 Eligibility Criteria

Observational, cohort, and epidemiological studies on injury incidence and prevalence in gymnastics were included in the review. Prospective and retrospective studies of injury incidence in gymnasts were eligible. Review studies (e.g., systematic review) and studies that used review information (e.g., patient chart review) were not eligible for inclusion in this scoping review. A 20-year date limitation was applied to the data search (i.e., 2003 – 2023). Studies that reported results from an injury-prevention related intervention were not included; however, where these studies reported injury data pre-intervention, this information was included. In the case of studies that recounted data that was also reported elsewhere (i.e., when both an unpublished thesis and a published journal article were found), the published article was chosen.

The scoping review and components of the evidence searched followed the guidelines of the JBI Manual for Evidence Synthesis (Lockwood et al., 2019; Peters et al., 2020).

2.3.1.1 Participants

The population or participants may further be defined as: all gymnastics disciplines (i.e., artistic, rhythmic, trampoline, tumbling, acrobatic, aerobic, parkour, rope skipping, group gymnastics/Gym for All) and all levels of participation (i.e., recreational, competitive, and elite). There were no specific age limitations, for the age of respondents, in the studies included in this scoping review.

2.3.1.2 Searched Concepts

The concepts searched included: gymnastics participation (i.e., recreational, competitive and elite), exposure to injury, mechanism of injury, risk factors for injury, contributing factors to injury, musculoskeletal injury – area, type, and mechanism, injury severity, surveillance of injuries, and return to competition/return to sport.

2.3.1.3 Context

The context deemed eligible for inclusion included: gymnastics clubs/training/gymnasia and competition.

2.3.2 Information Sources

The following databases were searched: Scopus, EbscoHost (Health Source, CINAHL, AfricaWide), PubMed (Web of Science, PubMed), and Cochrane (Cochrane Review, Cochrane CENTRAL Register of Control Trials). Google Scholar was used to search for grey literature. The reference lists of eligible articles identified during the search were manually searched to identify additional articles that met the inclusion criteria.

2.3.3 Search Strategy

The database search took place on 23 August 2023 with the assistance of a librarian at the University of Cape Town's (UCT) Bongani Mayosi Health Sciences Library. The search for grey literature was carried out on the same date. Databases were searched using the following keywords: (Gymnast* OR tumbling OR trampoline OR "gym for all" OR parkour) AND (injur* OR trauma) AND (risk* OR "risk factor*" OR incidence OR prevalence OR epidemiology OR moi OR "mechanism of injury" OR severity). The search string that was used for the PubMed literature search was: ((((((risk OR risks OR risk factors OR incidence OR prevalence OR epidemiology OR MOI OR "mechanism of injury" OR severity)) OR ("Risk Factors"[Mesh] OR "Risk"[Mesh])) OR ("Incidence"[Mesh])) OR ("Epidemiology"[Mesh] OR "Prevalence"[Mesh])) AND (((injury OR injuries) OR ("Athletic Injuries"[Mesh])) OR ("Wounds and Injuries"[Mesh]))) AND (((gymnast OR gymnasts) OR (gymnastic OR gymnastics)) OR ("Gymnastics"[Mesh])). Additional findings were recorded as per the results of the study. All relevant abstracts and study titles obtained during the search were downloaded to Rayyan (Rayyan Systems Inc., Qatar Computing Research Institute, Doha, Qatar).

2.3.4 Selection Process

From the total number of articles identified in the search above, duplicates were identified and deleted. The titles and abstracts were then screened by two independent reviewers. The two reviewers were given independent access to the platform and rated each article for inclusion or exclusion. Eligibility for inclusion was determined based on the criteria stated above. Each abstract and title was rated and any disagreement between the reviewers was discussed, and a consensus reached. The reviewers then independently assessed the remaining articles by full text to determine final eligibility for inclusion in the review. Articles that were not available in English were also eliminated at this stage. The reviewers discussed and reached consensus on articles where their assessment regarding inclusion initially differed. By this process, the final list of articles was confirmed for the review.

2.3.5 Data Collection Process

A data charting table was used to record the data. This comprised of an Excel spreadsheet with the following categories: study characteristics, study population, training characteristics, injury data, and contributing factors. The data charting table included the following headings: study design, population (including respondents age and sex, type of gymnastics, gymnastics history, and geographical location), training history if applicable, injury reporting method and injury severity reporting method, injury data (including area of injury, injury severity, and injury incidence or prevalence), and additional injury data as reported (including type of injury, mechanism of injury, body part injured, and risk factors discussed or identified).

2.3.6 Synthesis Methods

Descriptive tables of all the included data are presented below. Injury data is reported as an incidence (recorded in the injury reporting style used by the article in question) or as prevalence (recorded as a percentage). A summary table of each study is presented in Table 1, and includes study design, respondents, and context of gymnastics discipline. Included study definitions of injury and injury severity are presented in Table 2. The injury incidence and prevalence of included studies are presented on Table 3. Outcomes are presented as total number of injuries and their classification, area of injury, mechanism, and severity, and may be found on Table 4. A narrative analysis was performed.

2.4 Results

2.4.1 Study Selection

The electronic search yielded 2111 articles for evaluation. Of these, 681 duplicates were identified and deleted. There were three grey literature records identified from Google Scholar citation searching. Of these, none met the eligibility criterion for inclusion in the study. Twenty articles were identified for full-text evaluation. Fourteen studies were included for data extraction. This process is outlined in the PRISMA-ScR Flow Diagram in Figure 1 (Pollock et al., 2023).

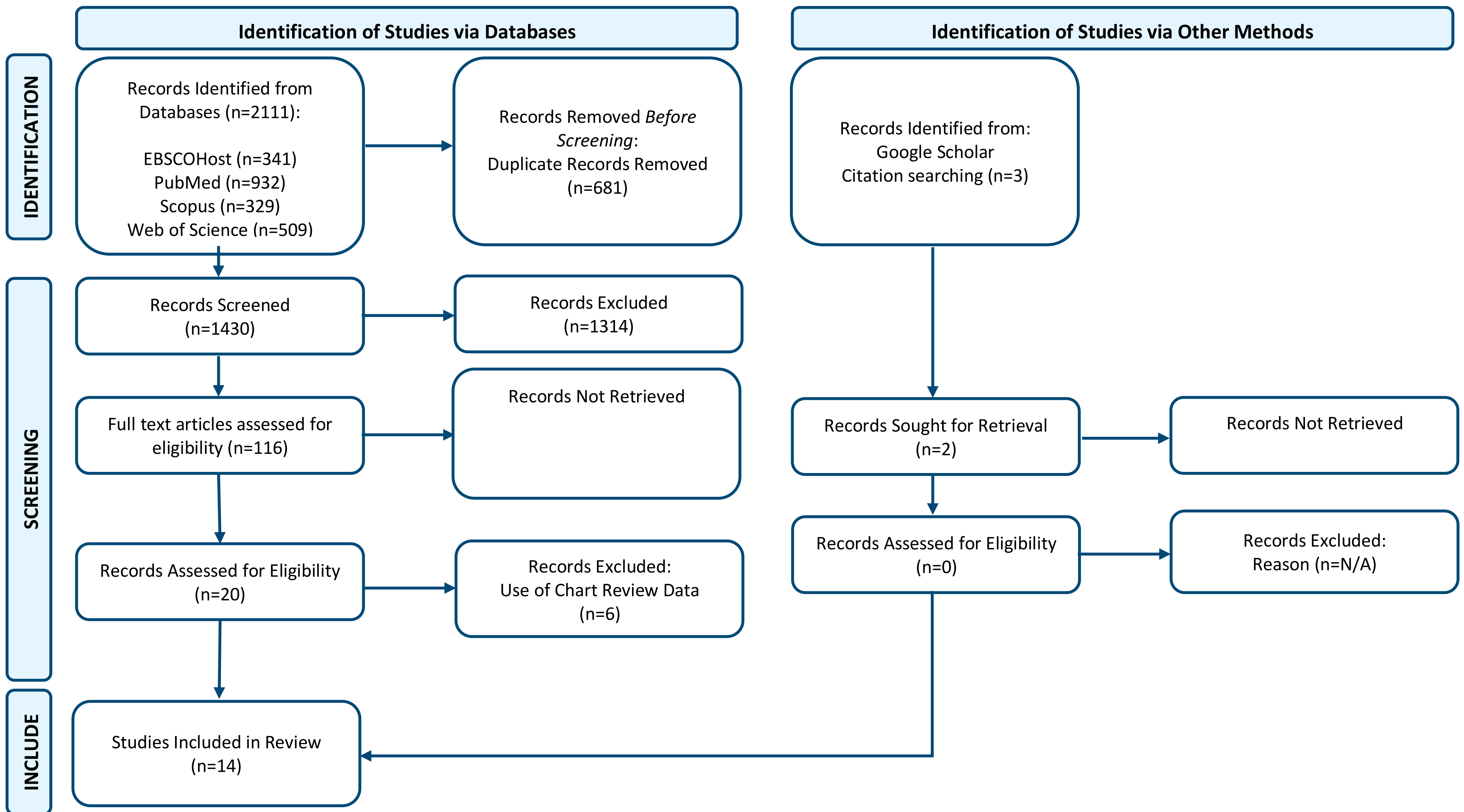

Figure 1. PRISMA-ScR Flow Diagram of Excluded and Included Studies.

2.4.2 Study Characteristics

A summary of the articles included in this scoping review is outlined on the data charting table, presented as Table 1. Fourteen studies were included, representing 2554 respondents. Four studies were prospective (Cupisti et al., 2007; Edouard et al., 2018; Gram et al., 2021; Grapton et al., 2013), and 10 were retrospective (Abalo Núñez et al., 2013; Bonanno et al., 2022; Goulart et al., 2016; Kirialanis et al., 2015; Kolar et al., 2017; O'Kane et al., 2011; Purnell et al., 2010; Sastre-Munar et al., 2022; Vernetta-Santana et al., 2022; Williams et al., 2023). One study was longitudinal, and six studies were cross-sectional, while injury data was obtained using self-report surveys in 12 studies.

Six studies (Bonanno et al., 2022; Edouard et al., 2018; Kirialanis et al., 2015; Kolar et al., 2017; O'Kane et al., 2011; Sastre-Munar et al., 2022) reported on injuries in women's artistic gymnastics and five studies (Edouard et al., 2018; Goulart et al., 2016; Kirialanis et al., 2015; Kolar et al., 2017; Williams et al., 2023) reported on men's artistic gymnastics. Information on injuries in rhythmic gymnastics was reported by five studies (Cupisti et al., 2007; Edouard et al., 2018; Gram et al., 2021; Kolar et al., 2017; Sastre-Munar et al., 2022). Three studies (Grapton et al., 2013; Purnell et al., 2010; Vernetta-Santana et al., 2022) reported on injuries in acrobatic gymnastics, two studies (Edouard et al., 2018; Grapton et al., 2013) reported on injuries in trampoline, with Grapton et al. (2013) reporting on injuries in tumbling, and Abalo Núñez et al. (2013) reporting on injuries in aerobic gymnastics. Williams et al. (2023) reported on injuries in all gymnastics disciplines.

Sample sizes ranged from 20 respondents (Goulart et al., 2016) to 963 respondents (Edouard et al., 2018). Six studies (Edouard et al., 2018; Kirialanis et al., 2015; Kolar et al., 2017; Purnell et al., 2010; Sastre-Munar et al., 2022; Vernetta-Santana et al., 2022) reported on mixed respondents, five studies (Bonanno et al., 2022; Cupisti et al., 2007; Gram et al., 2021; O'Kane et al., 2011; Williams et al., 2023) reported on only female respondents, Goulart et al. (2016) on only male respondents, and two studies (Abalo Núñez et al., 2013; Grapton et al., 2013) did not specify the gender of included respondents.

Of the studies that reported mixed respondents (Edouard et al., 2018; Kirialanis et al., 2015; Kolar et al., 2017; Purnell et al., 2010; Sastre-Munar et al., 2022; Vernetta-Santana et al., 2022), the age range included respondents ranging from nine to 41 years. Studies reporting on only female gymnastics respondents (Bonanno et al., 2022; Cupisti et al., 2007; Gram et al., 2021; O'Kane et al., 2011; Williams et al., 2023) included respondents ranging from six to 30 years of age. The study by Goulart et al. (2016) reporting injuries in only male gymnasts included respondents ranging from 16 to 29 years, where in the studies that did not specify the gender of respondents (Abalo Núñez et al., 2013; Grapton et al., 2013), 12 to 18 years was the age range of the included cohort.

Table 1. Data Charting Form with the Descriptive Information of each of the Included Studies.

AUTHORS	ARTICLE TITLE	STUDY DESIGN	STUDY DURATION	GYMNASTICS DISCIPLINE	NO. OF PARTICIPANTS N (F/M)	PARTICIPANTS AGE (YEARS)
Abalo Núñez et al. (2013)	Analysis of Incidence of Injury in Spanish Elite in Aerobic Gymnastics	Cross-sectional design; data collected through questionnaire of morbidity	Not reported	Aerobic gymnastics	40 (no further gender specification)	9 - 17
Bonanno et al. (2022)	Factors Associated with Achilles Tendon Rupture in Women's Collegiate Gymnastics	Cross-sectional study	4 months	Women's artistic gymnastic	581 (581/0)	18 - 30
Cupisti et al. (2007)	Injury Survey in Competitive Sub-Elite Rhythmic Gymnasts: Results from a Prospective Controlled Study	Prospective and controlled injury survey	8 months	Rhythmic gymnastics	142 (70 female gymnasts; 72 age matched control females)	13 - 19
Edouard et al. (2018)	Gymnastics Injury Incidence during the 2008, 2012 And 2016 Olympic Games: Analysis of Prospectively Collected Surveillance Data from 963 Registered Gymnasts during Olympic Games	Analysis of prospectively collected surveillance data	Not reported	Men's artistic gymnastics, women's artistic gymnastics rhythmic gymnastics, and trampoline	963 (625/338)	16 - 41
Goulart et al. (2016)	Injuries Prevalence in Elite Male Artistic Gymnasts	Cross-sectional survey	Not reported	Men's artistic gymnastics	20 (0/20)	16 - 29
Gram et al. (2021)	Injuries and Illnesses among Competitive Norwegian Rhythmic Gymnasts during Preseason: A Prospective Cohort of Prevalence, Incidence and Risk Factors	Prospective cohort study	3 months	Rhythmic gymnasts	107 (107/0)	12 - 16

Table 1 continued.

AUTHORS	ARTICLE TITLE	STUDY DESIGN	STUDY DURATION	GYMNASTICS DISCIPLINE	NO. OF PARTICIPANTS N (F/M)	PARTICIPANTS AGE (YEARS)
Grapton et al. (2013)	Specific Injuries Induced by the Practice of Trampoline, Tumbling and Acrobatic Gymnastics	Observational, longitudinal study design	5 years	Trampoline, tumbling, and acrobatic gymnastics	Not specified	12 - 18
Kirialanis et al. (2015)	Knee Injuries at Landing and Take-Off Phase in Gymnastics	Cross-sectional study	3 years	Men's artistic gymnastics, women's artistic gymnastics	200 (100/100)	9 – 15
Kolar et al. (2017)	Athletes' Perception of the Causes of Injury in Gymnastics	Retrospective design; data collected through questionnaire	2 years	Men's artistic gymnastics, women's artistic gymnastics, rhythmic gymnastics	63 (43/20)	10 - 35
O'Kane et al. (2011)	Survey of Injuries in Seattle Area Levels 4 to 10 Female Club Gymnasts	Cross-sectional survey	9 months	Women's artistic gymnastic	96 (96/0)	7 - 17
Purnell et al. (2010)	Acrobatic Gymnastics Injury: Occurrence, Site and Training Risk Factors.	Retrospective (injury and training) survey	Not reported	Acrobatic gymnastics	73 (69/4)	9 - 25
Sastre-Munar et al. (2022)	Injuries, Pain, and Catastrophizing Level in Gymnasts: a Retrospective Analysis of a Cohort of Spanish Athletes	Observational, retrospective study design	3 months	Men's artistic gymnastics, women's artistic gymnastics, rhythmic gymnastics	160 (150/10)	13 - 19
Vernetta-Santana et al. (2022)	Injury Profile in Elite Acrobatic Gymnasts Compared by Gender	Epidemiologic, descriptive, cross-sectional study	Not reported	Acrobatic gymnastics	54 (31/13)	14 - 23

Table 1 continued.

AUTHORS	ARTICLE TITLE	STUDY DESIGN	STUDY DURATION	GYMNASTICS DISCIPLINE	NO. OF PARTICIPANTS N (F/M)	PARTICIPANTS AGE (YEARS)
Williams et al. (2023)	Injury Pathology in Young Gymnasts: a Retrospective Analysis	Cross-sectional research design	Not reported	All gymnastics disciplines	55 (55/0)	6 - 17

2.4.3 Injury Definition

Injury definition methods varied between the studies included in this scoping review, with no studies using similar definitions for injury. Goulart et al. (2016) indicated that an incident was considered an injury when it resulted in the need for medical assistance for at least one month. Abalo Núñez et al. (2013) considered an incident an injury when it resulted in time away from training or competition for two days or more, where Sastre-Munar et al. (2022) required a disruption of participation for at least seven days. While four of the included studies defined injury severity, it was only Vernetta-Santana et al. (2022) that provided specification (in days) for minor, moderate and severe injuries. These definitions have been presented in Table 2.

Table 2. Injury Definitions used in the Included Studies.

AUTHORS	INJURY DEFINITION	INJURY SEVERITY DEFINITION
Abalo Núñez et al. (2013)	An incident sustained during competition or training, resulting in a modification of competition or training scheduling for two or more days (i.e. decrease of training load in two or more consecutive sessions)	Not reported
Bonanno et al. (2022)	Any season- or career-ending injury	Not reported
Cupisti et al. (2007)	Not reported	Significant injuries if: school absenteeism, training session modification or time-loss, or medical intervention/management
Edouard et al. (2018)	Any newly incurred concussion or musculoskeletal complaint, due to training during/competing in the Olympic Games. Must have received medical treatment, regardless of consequences thereafter, with respect to absence from further training or competition	Not reported
Goulart et al. (2016)	Any gymnastics-related incident resulting from training and/or competition, causing temporary suspension from, or modification to all or part of training, requiring medical treatment for at least a month	Not reported
Gram et al. (2021)	An incident produced by the transfer of energy, receiving medical attention or not, with modified training or competition, or not. Acute injury - clearly identifiable, single event energy transfer. Overuse injury - multiple cumulative bouts of energy transfer resulting in injury, without a single, clearly identifiable causative event	Moderate (8-28 days) or severe (>28 days) reductions in sports performance or participation, or time loss
Grapton et al. (2013)	Not reported	Not reported
Kirialanis et al. (2015)	Every incident that results in changes to athlete training or competition competence in artistic gymnastics	Not reported

Table 2 continued.

AUTHORS	INJURY DEFINITION	INJURY SEVERITY DEFINITION
Kolar et al. (2017)	Athlete's perception of the role of 1) Internal factors: factors related both the coach and the athletes training preparedness programme; 2) External factors: inappropriate temperatures, inadequate lighting or humidity, poorly prepared tools etc. and how this relates to injuries sustained	Not reported
O'Kane et al. (2011)	Acute injury: a sudden onset injury, preventing practice or competition participation, for 1 or more days. Overuse Injury: pain caused by participating in gymnastics, lasting 2 weeks or more, regardless of time-loss.	Not reported
Purnell et al. (2010)	Injury: Any damaged body part requiring modification to acrobatic gymnastics training or competition. Chronic injury: an injury currently affecting acrobatic gymnastics training or performance, for three months or more	Not reported
Sastre-Munar et al. (2022)	Sustained during sports participation, with a disruption to participation, for at least seven days	Not reported
Vernetta-Santana et al. (2022)	Not reported	Minor (absence from at least one day of training), moderate (absence from training between 8 and 21 days, requiring treatment) or severe injuries (absence from training for more than 21 days, potentially requiring hospitalisation)
Williams et al. (2023)	Not reported	Only reported if gymnast reported absence from sports participation

2.4.4 Injury Incidence and Prevalence

With inconsistent definitions for injury of the included studies, there was also a lack of consistency between the definitions of injury incidence and prevalence, as presented in Table 3. Of the included studies, Cupisti et al. (2007) reported an injury incidence of 1.08 injuries/1000 hours of training, and O'Kane et al. (2011) reported an acute injury incidence of 1.3/1000 hours. Caution should be exercised when comparing these results, as Cupisti et al. (2007) did not provide a definition of injury, while O'Kane et al. (2011) provides a definition for acute and chronic injuries.

Table 3. Injury Incidence and Prevalence of Included Studies.

AUTHORS	INJURY INCIDENCE/ PREVALENCE
Abalo Núñez et al. (2013)	10 injuries in the 2009-2010 season; 17.5% (seven injured) were recurrent
Bonanno et al. (2022)	100 Achilles tendon ruptures for a prevalence rate of 17.2%; of these 6 gymnasts reported 2 or more ruptures
Cupisti et al. (2007)	Incidence: 1.08 injuries per 1000 hours of training; control group: 1.79 events per 1000 hours of physical activity
Edouard et al. (2018)	84.1 ± 17.5 injuries per 1000 registered gymnasts. Injury incidence for men (86.4 ± 22.0) and women (79.9 ± 28.9) injuries per 1000 registered gymnasts
Goulart et al. (2016)	Not reported
Gram et al. (2021)	Incidence rate: 4.2 overuse injuries and 1.0 acute injuries per gymnast per year, with substantial injuries: 2.6 and 0.5 for overuse and acute injuries, respectively; illness incidence rate: 2.6 per gymnast per year, with 1.6 being substantial
Grapton et al. (2013)	226 (63.3%) traumatic events in trampoline, 80 (22.4%) in tumbling and 51 (14.3%) in acrobatic gymnastics, mainly to high level acrobats (n=225, 63.0%), (national or international levels)
Kirialanis et al. (2015)	49.5% of knee injuries in landing and 11.9% in take-off
Kolar et al. (2017)	Incidence: 33.7% - acute injuries; 66.3% - chronic injuries; men's artistic gymnastics: acute injuries - 22 (44.0%), chronic injuries - 28 (56.0%); women's artistic gymnastics: acute injuries - 27 (36.0%), chronic injuries - 48 (64.0%); rhythmic gymnastics: acute injuries - 18 (30.5%), chronic injuries - 41 (69.4%)
O'Kane et al. (2011)	Acute injury rate: 1.3 per 1000 hours (practice rate: 1.0, competition rate: 196.1); overuse injury rate was 1.8 per 1000 hours
Purnell et al. (2010)	Injury occurred in 42 of the participants (57.5%) averaging 2.77 injuries each
Sastre-Munar et al. (2022)	49.5% of rhythmic gymnasts and 50.8% of artistic gymnasts sustained an injury during the 2020 - 2021 competitive season

Table 3 continued.

AUTHORS	INJURY INCIDENCE/ PREVALENCE
Vernetta-Santana et al. (2022)	The highest percentage of injuries was observed in the base role (n=69, 77.5%), compared to the top role (n=20, 22.5%)
Williams et al. (2023)	Not reported

2.4.5 Injury Classification

The injury characteristics are summarised in Table 4. This table includes descriptions of injury including the total number of injuries, type of injury, injured by body area, mechanism of injury, and injury severity. When comparing male and female injury rates, there were two studies (Edouard et al., 2018; Kolar et al., 2017) that reported similar injury rates between male and female participants within the same study, but these results were not comparable to each other.

2.4.5.1 Injury – Area

Injury by body area was reported by 13 of the studies. Two studies made enquiry into specific injuries, and only reported on specifically affected areas of the ankle with Achilles tendon injuries (Bonanno et al., 2022) and the knee (Kirialanis et al., 2015). Grapton et al. (2013) specifically investigated injuries in the acrobatic disciplines of gymnastics. It was reported that separately for trampoline, tumbling, and acrobatic gymnastics, injuries mainly occurred in the lower limbs. Sastre-Munar et al. (2022) reported that injuries were mainly sustained in the lower limbs. Cupisti et al. (2007) and Gram et al. (2021) reported that injuries mainly occurred in the lower limbs and lower back. Abalo Núñez et al. (2013) and Purnell et al. (2010) reported that injuries commonly occurred in both upper limbs and lower limbs. The studies by Edouard et al. (2018), Goulart et al. (2016), Vernetta-Santana et al. (2022), and Williams et al. (2023) reported that injuries occurred in the upper limbs, lower limbs, and the trunk, while only O'Kane et al. (2011) demonstrated that injuries occurred in the upper limb, lower limb, trunk, and head. The study by Kolar et al. (2017) did not report on injury area. While only Williams et al. (2023) determined injuries across all of the gymnastics disciplines, reporting that injuries occurred in the upper limbs, lower limbs, and trunk, it was the studies of rhythmic gymnastics (Cupisti et al., 2007; Gram et al., 2021) that demonstrated comparable results showing that injuries for these athletes mainly occurred in the lower limb and lower back.

2.4.5.2 Injury – Type

Ligament sprain was the most common type of injury, reported by ten studies (Abalo Núñez et al., 2013; Cupisti et al., 2007; Edouard et al., 2018; Goulart et al., 2016; Grapton et al., 2013; Kirialanis et al., 2015; O'Kane et al., 2011; Purnell et al., 2010; Vernetta-Santana et al., 2022; Williams et al., 2023). Contusion or swelling were reported by two studies (Edouard et al., 2018; O'Kane et al., 2011). Muscle or tendon strains, being the second most reported type of injury, were reported by six studies (Abalo Núñez et al., 2013; Cupisti et al., 2007; Edouard et al., 2018; Goulart et al., 2016; Grapton et al., 2013; O'Kane et al., 2011). Tendinopathy/arthritis/impingement were reported by three studies (Edouard et al., 2018; Purnell et al., 2010; Vernetta-Santana et al., 2022), with tendon rupture reported by Bonanno et al. (2022). Purnell et al. (2010) reported growth plate conditions, where bone conditions were reported by Grapton et al. (2013) and Goulart et al. (2016), and fractures were reported by Edouard et al. (2018), O'Kane et al. (2011), and Williams et al. (2023). The involvement of the articular capsule was reported by two studies (Goulart et al., 2016; Purnell et al., 2010), injuries to cartilage was reported by Goulart et al. (2016), and joint dysfunction was reported by Purnell et al. (2010). Concussion symptoms were reported by O'Kane et al. (2011).

2.4.5.3 Injury – Severity

Injury severity was reported by four studies (Edouard et al., 2018; Gram et al., 2021; Vernetta-Santana et al., 2022; Williams et al., 2023). Three of the included studies (Gram et al., 2021; Vernetta-Santana et al., 2022; Williams et al., 2023) provide a definition of injury severity, but injury severity was not comparable between these studies. Gram et al. (2021) defined injury severity as slight (0 days), mild (1-7 days), moderate (8-28 days), or severe (>28 days) time loss or reductions in sports performance or participation. As a result, injury was characterised into three categories: overuse injuries (75%), acute injuries (9%), and illness (16%). Edouard et al. (2018) did not provide a definition for injury severity.

The study by Vernetta-Santana et al. (2022) reported minor (absence from at least 1 day of training), moderate (missed 8-21 days of training and required treatment), and severe (missed more than 21 days of training and required hospitalisation) injury rates for male and female participants. Williams et al. (2023) reported mild (time loss of 4-7 days), moderate (time loss of 8-28 days), and severe (time loss 29+ days) injuries occurring in various age groups. This study also reported the percentage of non-time-loss injuries, as reported on Table 4.

Table 4. Characteristics of Injury of each of the Included Studies.

AUTHORS	TOTAL NUMBER OF INJURIES	CLASSIFICATION OF INJURY	AREA OF INJURY	MECHANISM OF INJURY	INJURY SEVERITY
Abalo Núñez et al. (2013)	10 injuries during the 2009-2010 season	n=4: ligamentous, n=3: tendon, n=3: muscular	N=5: upper limb, n=5: lower limb	Performance of jumps of many types (pike with fall to arm flexion, grouped jumps with twist, and others)	Not reported
Bonanno et al. (2022)	Not reported	Achilles tendon rupture	Achilles tendon / Ankle	Floor exercise (91%) during back-tumbling take-off (85.7%); and vault (9%) during spring board impact (77.8%)	Not reported
Cupisti et al. (2007)	Gymnasts: 49 injuries; controls: 34 injuries	Sprains and strains; gymnasts reported a higher number of vaguely defined painful events	Ankle and foot (38.9%), back (22.2%), lower leg (16.7%)	Not reported	Not reported
Edouard et al. (2018)	81 injuries during 3 Olympic cycles	Sprains (34.6%), tendinopathy/impingement (17.3%), contusions (9.9%), fractures (7.4%);	Lower limb: 62.8% of injuries, trunk: 23.1% upper limb: 14.1%; location: ankle (21.8%), lumbar spine (14.1%), foot (12.8%)	Acute injuries: contact with objects (23.4%), non-contact trauma (22.1%); overuse injuries: sudden onset (15.6%), gradual onset (11.7%); reinjury: (14.3%)	Not reported
Goulart et al. (2016)	111 total injuries	Ligament (28%), bone (26.6%), articular capsule (15.8%), muscle (12.9%), tendon (10%) and cartilage (6.4%)	Forearm (36%), ankle (16.2%), hand and fingers (14.4%), shoulder (12.6%), lower back (9.0%), wrist (8.1%), groin/buttock and heel/toes/foot (6.3%), elbow and knee (5.4%)	Floor (23.4%), pommel horse (11.7%), rings (8.1%), parallel bars and horizontal bars (7.2%), vault (11.7%)	Not reported

Table 4 continued.

AUTHORS	TOTAL NUMBER OF INJURIES	CLASSIFICATION OF INJURY	AREA OF INJURY	MECHANISM OF INJURY	INJURY SEVERITY
Gram et al. (2021)	116 substantial injuries (22 acute and 94 overuse)	Overuse injuries: 75%, acute injuries: 9%, illness: 16%	The knees, lower back and hip/groin were the most common injury locations	Not reported	Slight (0 days), mild (1-7 days), moderate (8-28 days), severe (> 28 days)
Grapton et al. (2013)	357 total injuries reported over the 5-year data collection period	Trampoline – bone damage, muscular damage, ligament damage; tumbling – ligament damage, muscular damage; acrobatic gymnastics –tendon damage, muscular damage, ligament damage	Trampoline, tumbling and acrobatic gymnastics: mostly lower limbs injuries	No specific causal factors for a particular acrobatic sport	Not reported
Kirialanis et al. (2015)	Not reported	Ligament sprains at the knee during landing	Knee	After exercises with back rotation, particularly landing after back somersaults	Not reported
Kolar et al. (2017)	184 total injuries, men's artistic gymnastic: 50 (27.1%), women's artistic gymnastics: 75 (40.7%), rhythmic gymnastics: 59 (32.0%)	Not reported	Not reported	The psychological factors were: poor technique, improper method of teaching, and inadequate load	Not reported
O'Kane et al. (2011)	Not reported	Sprain/strain: 39.6%, bruise/swelling: 30.3%, fracture: 22.6%, concussion symptoms (after a hit to the head): 30.2%, (excluding headache): 15.6%	Acute injuries: lower limbs: 59.6%, upper limbs: 21.6%, spine: 10.6%, head: 8.8%;	Floor: acute injuries (32.1%); landings: 49% of all injuries	Not reported

Table 4 continued.

AUTHORS	TOTAL NUMBER OF INJURIES	CLASSIFICATION OF INJURY	AREA OF INJURY	MECHANISM OF INJURY	INJURY SEVERITY
Purnell et al. (2010)	195 total injuries	Knee: Patellofemoral dysfunction, tendinopathy, Osgood Schlatter's disease; ankle injuries: sprains or Achilles tendinopathy; wrist: ligament/capsule sprains	Knee, ankle and wrist (both acute and chronic)	Dynamic skills: tops (75%), middles (100%); static/balance skill: bases (56.4%); top or middle: acute fractures or sprains; bases: muscle strain or tendinopathy	Not reported
Sastre-Munar et al. (2022)	106 injuries during the 2020 - 2021 season	Not reported	Ankle injuries for both rhythmic gymnastics and artistic gymnastics (23.9% and 28.2% of all injuries respectively)	Not reported	Not reported
Vernetta-Santana et al. (2022)	89 total injuries	Sprains (n=24, 27%), 18 females and 6 males gymnasts; tendonitis (n=15, 15.6%), 28.9% males and 4.5% females	Lower limbs (40, 44.9%), upper limbs (n=25, 28.1%), trunk (n=24, 27%)	Not reported	Moderate injury: n=45 (50.6%), males (n=28) vs. females (n=17); severe injuries: n=15 (16.9%) females (n=12), males (n=3)
Williams et al. (2023)	76 total injuries	Acute injuries: 65%, overuse injuries: 35%; lower limbs - overuse injuries: 25%, sprains: 18.4%; upper limbs – fractures: 10.5%, overuse injuries: 10.5%	Lower limbs: 60.5%, upper limbs: 25.5%, spine: 3.9%	Most injuries occurred during a gymnastics skill (54.7%), landing (20%) and falling (9.3%); training (97.5%) vs. competition (2.5%)	Gymnasts aged 14 to 17: largest proportion of mild, moderate and severe injuries; non-time-loss injuries: 73% of all injuries

2.4.6 Contributing Factors to Injury

Twelve studies considered the contributing factors to gymnastics-related injuries (Abalo Núñez et al., 2013; Bonanno et al., 2022; Edouard et al., 2018; Goulart et al., 2016; Gram et al., 2021; Grapton et al., 2013; Kirialanis et al., 2015; Kolar et al., 2017; O'Kane et al., 2011; Purnell et al., 2010; Vernetta-Santana et al., 2022; Williams et al., 2023). These factors were separated into modifiable and non-modifiable risk factors and are expanded on below.

2.4.6.1 Modifiable Risk Factors

2.4.6.1.1 Sporting Level

The findings of two studies (Bonanno et al., 2022; Edouard et al., 2018) demonstrated that in elite level respondents, the execution of difficult floor and vault skills and competing in all four women's artistic gymnastic events demonstrated an increased risk for Achilles tendon rupture. Further evidence demonstrated that there was a higher proportion of time-loss injury in competition than in training for Olympic level athletes.

2.4.6.1.2 Training Characteristics

Several studies (Abalo Núñez et al., 2013; Grapton et al., 2013; Kirialanis et al., 2015; Kolar et al., 2017; O'Kane et al., 2011; Purnell et al., 2010; Williams et al., 2023) commented on the contribution of training characteristics to injury in gymnastics. Factors included where training time was more than two to four hours per day and the repetition of taking-off’s was more than 30 times in a training day. Abalo Núñez et al. (2013) reinforced this point by stating that the repetitive load during assimilation of specific techniques may lead to a higher risk of injury. Higher level difficulties and more hours of training may increase the risk of injury, further compounded by a lack of physical fitness, inadequate technique, fatigue, and the acquisition of new or difficult skills (Abalo Núñez et al., 2013; Purnell et al., 2010; Williams et al., 2023).

O'Kane et al. (2011) reported that training time exceeding 19 to 25 hours of training per week increases injury risk. Purnell et al. (2010) suggested a slow progression of training load for 11- to 15-year-old gymnasts, from eight hours per week for 11 year olds, to 12.75 hours per week for 15 year olds.

2.4.6.1.3 Landing After Gymnastics Elements

Landings after gymnastics elements may become a contributing injury risk factor when sustained for more than four hours per day during the pre-competition season, and when the repetition of elements on vault result in more than 20 landings (Abalo Núñez et al., 2013; Kirialanis et al., 2015). Landing during the competition season under competition conditions without using thick and soft landing mats and not practicing special landing elements can be a risk factor for knee injuries (Kirialanis et al., 2015). Abalo Núñez et al. (2013) reinforced this point by stating that the repetitive load during assimilation of specific techniques may lead to a higher risk of injury.

2.4.6.1.4 Safety Equipment

Abalo Núñez et al. (2013) stated that the use of safety equipment, as well as specific recommendations, could decrease the incidence of injuries. However, contradicting findings by O'Kane et al. (2011) stated that wearing protective equipment was associated with an increased likelihood of acute and overuse injuries.

2.4.6.1.5 Age-related positions of injury risk

Purnell et al. (2010) stated that the 11- to 15-year-old age group of gymnasts were the most at-risk age group. It was recommended to avoid placing those in the most at-risk age group, in the most at-risk position for chronic injury (i.e., base pair). This was reinforced by Williams et al. (2023) who stated that severe injuries were reported to a greater extent in gymnasts older than 10 years of age.

2.4.6.1.6 Injury and Re-injury

Two studies (Gram et al., 2021; Williams et al., 2023) characterised injury severity by time-loss. In gymnastics, however, training is modified to accommodate injuries while enabling ongoing participation (Williams et al., 2023). This common behaviour by gymnastics coaches to alter training around an injury was reported to increase the risk of severe injury (Gram et al., 2021). Goulart et al. (2016) stated that during rehabilitation, there must be a change in training habits to accommodate the adaptation of skeletal tissue conditioning. Most respondents reported better conditioning after a recovery period. This is linked to the strength exercises used in rehabilitation and to the reduced training load. Further, the decreased risk of injury may also be due to a reduced training load and improved strengthening techniques as reported by Goulart et al. (2016).

2.4.6.2 Non-modifiable Risk Factors

2.4.6.2.1 Falls

A non-modifiable risk factor regarding injury was related to falls (Kirialanis et al., 2015). The risk of sustaining an injury as the result of a fall increases during the transition from the training to competition setting. This may be due to the lack of safety and spotting equipment used (e.g., springboard tumbling foam pits which reduce up to 50% of peak vertical ground reaction forces) during the competition setting, resulting in unfamiliar landmarks.

2.4.6.2.2 Age

Age is another non-modifiable risk factor for injury (Gram et al., 2021; Williams et al., 2023), where competitive level gymnasts may report eight to 10 years of competitive gymnastics. This would expose the athlete to more opportunities of sustaining a gymnastics-related injury. While Gram et al. (2021) report that a younger aged athlete is a risk factor for all injuries, there is no indication of what this ‘younger age’ range may be. Further, they indicate that previous injury and a lack of menarche are potential risk factors in sustaining substantial (mild [1-7 days] to moderate [8-28 days]) injuries.

Williams et al. (2023) report that gymnasts aged six to nine may more commonly experience acute injuries, whereas gymnasts aged 10 to 13 and 14 to 17 may more commonly experience overuse type injuries.

2.5 Discussion

2.5.1 Scoping Review Main Question

The main question asked in this scoping review was "what musculoskeletal injuries occur in recreational and competitive gymnasts?" Men's and women's artistic gymnastics is an Olympic discipline and has the highest number of competitive participants (Hecht & Burton, 2009; The International Federation of Gymnastics, 2019b, 2019e) forming the bulk of research output for competitive gymnastics. No studies that were included investigated recreational gymnastics as the primary focus of the research topic. As a result, most of the research around injuries in gymnastics has been focused on this discipline (i.e.: artistic gymnastics). In total, 11 articles reported injuries in artistic gymnastics (five articles reporting on injuries in men's artistic gymnastics, with six articles reporting on injuries in women's artistic gymnastics, as noted in Section 2.4.2 above). The results of these studies demonstrated that males are more likely to sustain injuries in the upper limbs, while females are more likely to sustain injuries to the lower limbs, as a results of the requirements of each apparatus in these gymnastics disciplines. Rhythmic gymnastics and trampoline are the remaining Olympic disciplines. Five of the studies (Cupisti et al., 2007; Edouard et al., 2018; Gram et al., 2021; Kolar et al., 2017; Sastre-Munar et al., 2022) included in this scoping review reported on injuries in rhythmic gymnastics, with two articles (Edouard et al., 2018; Grapton et al., 2013) reporting injuries occurring in trampoline. When considering gymnastics' non-Olympic competitive disciplines, three (Grapton et al., 2013; Purnell et al., 2010; Vernetta-Santana et al., 2022) of the included scoping review articles report on injuries in acrobatic gymnastics. Both tumbling (Grapton et al., 2013) and aerobic gymnastics (Abalo Núñez et al., 2013) were researched by one of the included studies each.

The remaining competitive non-Olympic disciplines, parkour and rope skipping, were not the primary focus of any of the included scoping review articles. So too, Gym for All, a non-competitive gymnastics discipline, was not the discipline under primary investigation for any of the studies included in this scoping review. While Williams et al. (2023) stated that 'all gymnastics disciplines and competitive levels were eligible to [participate in their study]…', the authors did not specify which gymnastics disciplines reported which injuries. The reporting of musculoskeletal injuries by the included studies mainly focussed on the competitive disciplines of gymnastics, with the exception of parkour and rope skipping. Caution should thus be exercised when attempting to generalise injury results from the included data to the larger gymnastics population.

2.5.2 Scoping Review Sub-questions

2.5.2.1 Injury Definition Used

From the studies included in this scoping review, there were no two studies that used the same injury reporting definition or methodology. To facilitate improved methods for the recording and reporting of epidemiological data, recent consensus statements around injury provide guidelines on how to overcome these challenges (Bahr et al., 2020; Orchard et al., 2020).

2.5.2.2 Incidence and Prevalence

With no consistent definition of injury in gymnastics, the reporting of injury incidence and prevalence is inconsistent. These inconsistencies prevent the comparison of results between studies reporting on musculoskeletal injuries in gymnastics. With consistent standardised injury reporting definitions and methods, clear comparisons would be able to be drawn between studies (Bahr et al., 2020).

2.5.2.3 Injury Classification by Area, Type, and Severity

From the included studies, injuries were reported in the upper limbs, lower limbs, trunk, and head. While the location of these injuries may be more prevalent within each discipline, gymnastics as a whole reports a wide-range of injury loci, with overall injury rates between males and female respondents being relatively similar (Edouard et al., 2018; Kolar et al., 2017; O'Kane et al., 2011).

Ligament sprains and muscle/tendon strains were the most commonly reported types of injury in the sport. From these articles, the classification of gymnastics-related injuries remains unclear. With a standardised definition of injury, results from future research may be comparable. It is evident that there are both acute and overuse injuries being sustained by athletes (Gram et al., 2021; Williams et al., 2023). Injuries were mainly seen to occur during training and in the base acrobat within a pair (Edouard et al., 2018; Purnell et al., 2010).

2.5.3 Contributing Factors to Injury

From the results of this scoping review, there are both modifiable and non-modifiable risk factors associated with musculoskeletal injuries in gymnastics. Grapton et al. (2013) highlighted that injury risk is more readily affected when changes are made to modifiable risk factors. While age itself may be a non-modifiable injury risk factor, it is the fact that competitive level gymnasts may be participating in the sport for eight to 10 years that exposes them to ongoing opportunities to sustain gymnastics-related injuries (Gram et al., 2021; Williams et al., 2023). With the increasing age of the gymnast, often the athlete achieves a higher sporting level. It is this higher competitive level that may be considered a risk factor for injury (Gram et al., 2021; Williams et al., 2023). Elite level athletes need to execute higher level difficulty elements on floor and vault, may compete in all four women's artistic gymnastics events, or all six men's artistic gymnastics events, and may also be exposed to a higher proportion of time-loss injury in competition than in training for Olympic level athletes (Bonanno et al., 2022; Edouard et al., 2018).

Campbell et al. (2019) stated that the menarcheal status of female gymnasts did not demonstrate a significant relationship with injuries, even while training load increased as the athlete progressed through puberty. Falls as a contributing risk factor to musculoskeletal injuries in gymnastics, as identified by Kirialanis et al. (2015), may be associated with the transition between training and competition venues. With less protective equipment used on apparatus in the competition setting, the resultant unfamiliar landmarks may be a predisposition to sustaining injury.

2.5.4 Limitations and Recommendations

While only two non-modifiable risk factors for injury were identified in this scoping review, consideration should be given to how biomechanical factors may be used to modify injury risk. This is evident in several studies, where hand-position has been recommended to change biomechanical loading for a certain skill on a certain apparatus to best minimise injury (Farana et al., 2018; Farana et al., 2015; Farana et al., 2014, 2017a; 2017b). Non-modifiable risk factor research in adolescent female gymnasts may need to be further explored to ensure that risk is adequately identified in this group. Further, information on injuries in the non-competitive discipline of gymnastics is scant. Further limitations such as the vast array of disciplines in gymnastics and the difficulty in obtaining homogenous data should also be considered.

Recommendations that may be drawn from this scoping review is that there is a need for the use of standardised definitions of injury, facilitating homogenous injury surveillance methods and reporting parameters in gymnastics. In addition, further research should include prospective gymnastics injury monitoring and reporting to gain further insights regarding the injury burden in South African gymnastics.

2.6 Conclusion

As is evident in this scoping review, the lack of a standardised definition of injury may result in a wide range of reported injury incidence and prevalence in athletes participating in gymnastics. Injuries were commonly observed during training and competition, with similar injury rates for male and female gymnasts. While certain injuries may be more prevalent in different gymnastics disciplines, athletes from all disciplines of gymnastics are susceptible to musculoskeletal injuries in the upper-limbs, lower-limbs, head, and trunk. Injuries were most commonly reported to be ligament sprains and muscle/tendon strains. The injuries sustained by gymnasts may be mild to moderate. Training characteristics have also been demonstrated to increase the risk of injury. These characteristics include the athlete that is exposed to more than four hours of training per session, where the session may expose the athlete to more than 30 take-offs during a training session, when the athlete exposure is beyond 19 to 25 hours of training per week, or where the athlete perceives a lack of social support from their coach.

In addition, the gap between what coaches perceive to contribute to injuries in their athletes and what the evidence has shown needs to be bridged and discrepancies should be identified. A clearer picture of what coaches know about injuries and what steps they follow when injuries occur needs to be drawn. The next chapter presents a cross-sectional descriptive study using an online survey that describes the KAP of South African-based gymnastics coaches regarding injuries in the sport.

CHAPTER THREE: THE KNOWLEDGE, ATTITUDES AND PRACTICES OF SOUTH AFRICAN-BASED GYMNASTICS COACHES – A SURVEY-BASED STUDY

3.1 Introduction

Gymnasts have been shown to have high injury rates that may disrupt practice and competition (Casey et al., 2023; Kruse et al., 2021; Thomas & Thomas, 2019). A study by Trikha et al. (2023) investigated injury patterns in male and female gymnasts and how these injuries may affect return to sport. There has also been an exploration of factors that gymnasts believe may contribute to injury (Barrette & Harman, 2020; Cavallerio et al., 2022; Fawcett et al., 2020; Kolar et al., 2017). The heterogeneity between study designs demonstrates much variability between study results. The variability between injury definitions, injury reporting methods, participant ages, study periods, and participant skill levels contribute to study result variability (Trikha et al., 2023).

Within South Africa, very little research exists regarding injuries and injury prevention that may occur within the various gymnastics' disciplines. Similarly, there are no known studies investigating the KAP of South African gymnastics coaches' regarding injuries and injury prevention in the sport. For successful injury prevention, the knowledge, attitudes, beliefs, and behaviours of gymnastics coaches regarding injury risk factors and preventive measures as well as barriers and facilitators of good injury prevention behaviours need to be explored (Andersson et al., 2019; Bolling et al., 2018; Finch, 2011). Accordingly, the aim of this survey-based study was to describe the KAP of South African gymnastics coaches regarding injuries and injury prevention in the sport. The specific objectives of this study have been described in Chapter 1, Section 1.4 (page 6) above.

3.2 Methodological Approach

3.2.1 Study Design

This study had a descriptive, cross-sectional design, making use of an online survey to determine South African-based gymnastics coaches' KAP regarding gymnastics injuries (Finch, 2006, 2011; Regmi et al., 2016; Sullivan & Artino, 2013). The study was approved by the Faculty of Health Sciences Human Research Ethics Committee (HREC) at UCT (HREC REF: 516/2021; Appendix A). A quantitative methodological approach was chosen. Descriptive data was gathered through observation without intervention.

3.2.2 Inclusion Criteria

South African-based gymnastics coaches of all genders and from all gymnastics disciplines were eligible for inclusion in this study. Coaches were required to be 18 years or older to prevent minors from participating (Regmi et al., 2016), and were also required to have internet access to complete the online survey. Further, only South African-based gymnastics coaches that were registered with GSA were eligible for inclusion.

3.2.3 Exclusion Criteria

Respondents were excluded if they did not complete the informed consent process. The survey was only available in English, which excluded potential respondents without the proficiency in English literacy required to read and respond to survey questions.

3.2.4 Sample Size

The sample size was calculated using StatCalc (Epi Info 7.2.2.16). The sample size calculation was based on an estimated population size of 500 registered coaches with GSA. Coaches reregister annually and the exact numbers for the 2022-2023 cycle were not known at the time of protocol development. With an expected frequency of adequate knowledge of 50% and an acceptable margin of error of 5%, a sample size of 38, 60, and 81 survey respondents was required for confidence levels of 80%, 90%, and 95% respectively.

3.2.5 Recruitment

The recruitment process began by contacting GSA and asking for their engagement and support with the research process (Appendix B). It was requested that the dissertation advertisement (Appendix C) be placed on GSA's website as well as their social media (i.e., Facebook and Instagram) platforms. Further, the student researcher was provided with an open-access list of the GSA registered clubs. Provincial committees and clubs were contacted via email with the study advertisement and letter of endorsement from GSA (Appendix D). The information document and informed consent form (Appendix E) was also included, which provided potential respondents with additional details about the study, as well as the contact details of the researcher and research supervisors, and it was requested that the information be disseminated to the clubs' coaches.

3.3 Measurement Instruments

3.3.1 Informed Consent

Before gaining access to the survey, respondents were first presented with the information document and informed consent form (Appendix E). This was the first section of the online survey in which the rationale of the study was explained, including the risks and benefits of participation in the survey. Potential responding coaches' that declined consent were automatically exited from the survey and were not able to complete the remaining questions.

3.3.2 Survey

A self-developed survey (Appendix F) was used to determine South African-based gymnastics coaches' knowledge of injuries that may occur with their gymnasts, as well as their attitudes and practices when these injuries occur in their athletes. The KAP survey for this study used the guidelines presented by Andrade et al. (2020) and Kaliyaperumal (2004). The survey included questions on coaches' sociodemographic history, coaching history, and KAP regarding gymnastics injuries. The survey was distributed, and data collected, using an electronic survey tool (Google Forms) that enabled respondents to anonymously complete the electronic survey online.

The survey first presented the informed consent process, during which it identified ineligible participants according to the inclusion and exclusion criteria presented in Chapter 3, Section 3.2.2 (page 39) and Chapter 3, Section 3.2.3 (page 39). Respondents who declined consent were automatically exited from the site and could not complete the survey. The excluded respondents were removed from the study and not given access to the remainder of the survey. Section 1 requested demographic data, including personal details, education information, as well as gymnastics coaching details. Sections 2, 3, and 4 investigated the respondents KAP about injuries in gymnastics. Respondents indicated their choice using a five-point Likert Scale within various categories. These categories included 'level of importance' statements (ranging from 'very important' to 'not sure'), 'level of agreement' statements (ranging from 'strongly agree' to 'strongly disagree'), and a series of true/false questions.

3.3.2.1 The Scoring of Knowledge and Attitudes Regarding Injuries in Gymnastics

In the knowledge and attitudes sections of the survey, responses were determined by using a five-point Likert Scale. There was 'level of importance' statements presented, requiring respondents to indicate how strongly they agreed with each statement, ranging from 'very important' to 'not sure.'

Further, ‘level of agreement’ statements was also presented to respondents in the knowledge and attitude sections. These responses ranged from ‘strongly agree’ to ‘strongly disagree.’ The Likert Scale responses were then weighted, with one point being awarded for the ‘most negative’ answer and five points being awarded for the ‘most positive’ answer (Thorpe et al., 2022). Respondents knowledge was further tested with true/false questions. One mark was awarded for each correct answer and zero marks for each incorrect answer. An average of the knowledge scores was calculated from the sectional scores for the knowledge of non-modifiable risk factors, modifiable risk factors, level of agreement statements, and true/false questions. The knowledge and attitudes were graded using the percentage of correct answers (i.e., 75% and above demonstrated adequate knowledge or positive attitudes, and below 75% demonstrated inadequate knowledge or negative attitudes). A score of 75% had been previously set as a benchmark for adequate/good knowledge and positive attitudes in a KAP study of South African nurses regarding the Road to Health growth charts. A score of less than 75% indicated an inadequate knowledge score and negative attitudes (Cloete et al., 2013).

3.3.3 Validity and Internal Consistency

Once the survey (Appendix F) was designed, it underwent testing for face and content validity by an expert panel comprised of a sports scientist and two sports physiotherapists who had experience and expertise in musculoskeletal injuries and sports medicine. Further, these experts also had collective experience in gymnastics coaching, academic research, and exercise science. The panel was provided with a draft of the survey for review, including a template of the correct responses for the true/false questions included in Section 2 (Knowledge about Injuries). Panel members were requested to review and approve each question (and its respective answer, where applicable) in terms of clarity, coherence, and applicability.

All feedback was considered by the researcher and research supervisor, and changes were applied. Based on this feedback, changes were made to Section 1 (Demographic Information), where questions about respondents tertiary educational level and gymnastics qualifications were added to the survey. It was also recommended that compound questions be separated so that inputs could be appropriately received by the survey software. Suggested changes to Section 2 (Knowledge about Injuries) included adding definitions to terms used in the 'intrinsic risk factor' and 'extrinsic risk factor' sub-sections, as well as defining intrinsic and extrinsic risk factors. The rephrasing of ambiguous and convoluted sentences was suggested for statements in the 'level of agreement' and 'true/false' sections. In Section 4 (Practices around Injuries), redundant terms were deleted, and ambiguous sentences and sentence structure was simplified. A final draft with the recommended changes was sent back to the panel to ensure consensus before finalising the survey for piloting.

Internal consistency was determined via a pilot study. A sample of convenience of five gymnastics coaches were asked to complete the KAP survey twice, within a two-week time frame. All five pilot respondents completed the survey once and only two completed the survey twice. One of the respondents noted the use of complex terms that took extra attention to contextualise that added to the time to the completion of the survey. No further feedback was received from the pilot respondents. The survey was adapted to reduce the readability level and the final survey scored 7.9 on the Flesch-Kincaid Grade Level Test. In addition, as there were no substantive changes to the survey after piloting, these five pilot responses were included in the final analysis. It was only the first responses of all pilot participants that was used in the final analysis.

3.4 Procedure

Ethical approval was obtained from the UCT Faculty of Health Sciences HREC (HREC REF: 516/2021; Appendix A). The survey was assessed for validity and internal consistency through expert panel reviews and a pilot study, as outlined in Chapter 3, Section 3.3.3 (page 42).

The final survey was uploaded to the electronic survey tool (Google Forms) using the validated questions. The researcher and research supervisors then tested the survey to ensure functionality (Creswell & Creswell, 2017).

The online survey was then activated. The recruitment process began by contacting GSA and asking for their engagement and support with the research process (Appendix B). It was requested that the survey advertisement (Appendix C) be placed on GSA's website as well as their social media platforms. Gymnastics South Africa then placed the advertisement on their Facebook (https://www.facebook.com) and Instagram (https://www.instagram.com) platforms. Further, the student researcher was provided with an open-access list of the GSA registered clubs. Provincial committees and clubs were contacted via email with the study advertisement and letter of endorsement from GSA (Appendix D). The information document and informed consent form (Appendix E) was also included, which provided potential respondents with additional details about the study, as well as the contact details of the researcher and research supervisors, and it was requested that the information be disseminated to the clubs coaches.

The survey began with the informed consent process (Creswell & Creswell, 2017). After informed consent was obtained, respondents were required to complete each section of the survey (Appendix F). Respondents were required to respond to each question in the survey to be able to successfully submit their responses. Follow-up attempts, in August and September 2022, for further recruitment included three webinars, conducted on Zoom, and distributed on GSA's Facebook profile. The survey was available from 14 July to 06 December 2022, to ensure that the projected sample size was met. Completed surveys were processed by Google Forms, with all the gathered data exported into Excel.

During this extended data collection period, the researcher provided an open-access series of webinars for gymnastics coaches, with the endorsement of GSA. The webinars attempted to provide information on common gymnastics injuries and information requested by the attending coaches. The first and second webinars provided information about lower-limb and upper-limb injuries, respectively. The final of the three webinars spoke to the importance of injury reporting and injury surveillance efforts, and how this provides insight into the development of injury prevention programmes.

In a final attempt to ensure an adequate response rate, a video advertisement was filmed with the President of GSA, the GSA Development, Education, and Training Manager, and the researcher, requesting that all coaches complete the survey. While the video advertisement was not officially broadcast, the representatives of the federation resonated with the importance of injury prevention efforts as part of their athlete safeguarding efforts.

3.5 Statistical Analysis

Data was exported from Google Forms to an Excel spreadsheet for further data management. Statistical analyses were performed using IBM SPSS software (IBM Corp. 2021, IBM SPSS Statistics for Windows, Version 28.0.1.1 (14) Armonk, NY). Descriptive statistics were used to analyse categorical and numerical data. Categorical variables were assessed using frequency tables. The Shapiro-Wilk test was used to determine normality of the distribution. An independent samples t-test was used for normally distributed data, while a Mann Whitney-U test was used for non-normally distributed data. P-values were recorded to three decimal places (Creswell & Creswell, 2017). Statistical significance was accepted as $p < 0.05$.

3.6 Ethical Considerations

Research ethics approval was obtained from the UCT Faculty of Health Sciences HREC (HREC REF: 516/2021; Appendix A). This study was conducted according to the principles outlined in the Declaration of Helsinki (World Medical Association, 2013).

3.6.1 Autonomy

Informed consent (Appendix E) was obtained from each respondent before being allowed to complete the online survey (Appendix F). Respondents who declined consent were automatically exited from the site and could not complete the survey. The informed consent form described the procedure of the study, as well as the measures taken to ensure the protection of respondents' personal details and confidentiality. The informed consent form stated that participation was voluntary. Withdrawal from the survey could occur at any stage before the submission of a completed survey. However, as responses were anonymous, withdrawal after the submission of responses was not possible. Anonymous participation and confidentiality of data was further reinforced by the informed consent form.

3.6.2 Risks and Benefits to Respondents

There were no risks to the respondents. There were also no direct benefits to individual respondents. However, upon completion of the survey, respondents were provided with a link to an infographic poster (Appendix G). The infographic was self-developed by the student researcher. The infographic contained information about injury location (bias of gymnastics disciplines to specific injuries), injury risk factors (intrinsic and extrinsic risk factors), normal healing times after injury (and how this correlates to changes in strength), and an acute injury management pathway.

3.6.3 Privacy and Confidentiality

Individual privacy was protected as no personal data was collected and survey responses were anonymous. There was no collection of personal identifying information within the survey. The collection of IP addresses by Google Forms was disabled. All survey response data was stored on a password protected computer, further protecting the confidentiality of data and respondents anonymity.

3.6.4 Dissemination of Study Findings

A summarised version of the results will be made available to GSA. The federation would be permitted to distribute this information to all the clubs on their contact list. Upon request, the full version of the study would be provided to GSA or any of their coaches.

3.7 Results

3.7.1 Sample Size

A total of 99 responses were received during the five-month data collection period. Of these, 19 responses were excluded, as they failed to meet the inclusion criteria (Figure 2). Therefore, with the addition of the five pilot responses, data from 85 respondents were included for analysis.

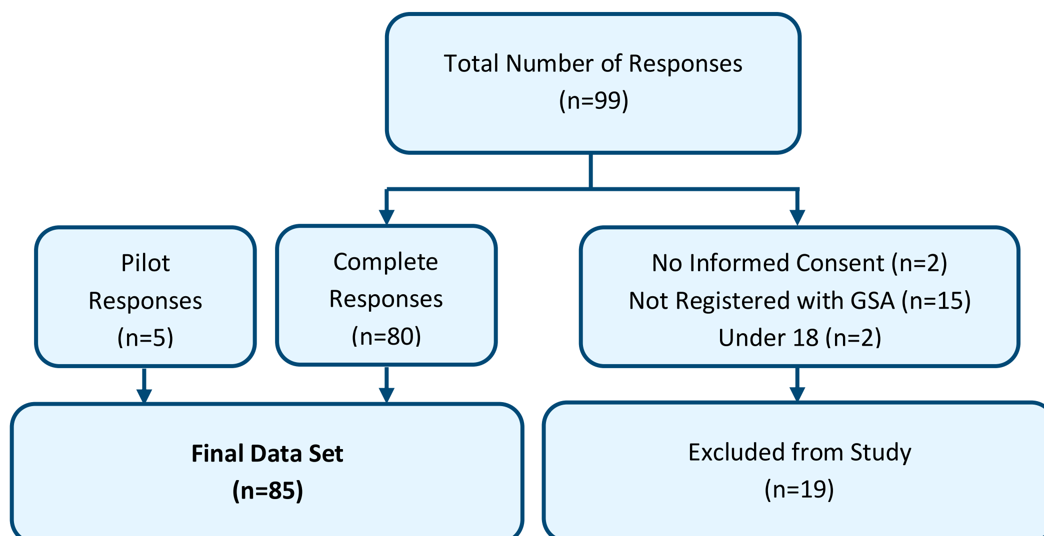

Figure 2. Summary of Study Respondents.

3.7.2 Descriptive Characteristics

There were 28 (32.9%) males and 57 (67.1%) female coach respondents. The mean age of the sample was 39 years (SD: ±15 years; range: 18 to 76 years), with the majority of respondents between 18-34 years old (n=42, 49.4%). Most coaches were from the Western Cape (n=36, 42.4%), followed by Gauteng (n=19, 22.4%). Most coaches (n=74, 87.1%) had obtained a tertiary-level education (i.e., NQF 4 to NQF 9). There were no significant differences between male and female respondents in age, province, or level of education. These findings are summarised in **Error! Reference source not found.**.

Table 5. Sociodemographic Characteristics of Respondents.

	n	%	x^2	p
GENDER				
Male	28	32.9%	N/A	N/A
Female	57	67.1%		
AGE				
18-24 years	19	22.4%	16.08	0.168
25-29 years	12	14.1%		
30-34 years	11	12.9%		
35-39 years	5	5.9%		
40-44 years	5	5.9%		
45-49 years	7	8.2%		
50-54 years	7	8.2%		
55-59 years	9	10.6%		
60-64 years	6	7.1%		
65+ years	4	4.7%		
PROVINCE				
Eastern Cape	5	5.9%	7.154	0.686
Free State	4	4.7%		
Gauteng	19	22.4%		
KwaZulu-Natal	6	7.1%		
Limpopo	3	3.5%		
Mpumalanga	5	5.9%		
Northern Cape	4	4.7%		
North-West	3	3.5%		
Western Cape	36	42.4%		
EDUCATION LEVEL				
Grade 8 – 12	11	12.9%	10.968	0.170
Higher Certificate (NQF 4)	25	29.4%		
Advanced Certificate/National Diploma (NQF 5)	7	8.2%		
Advanced Diploma (NQF 6)	17	20.0%		
Bachelors (NQF 7)	12	14.1%		
Honours (NQF 8)	9	10.6%		
Masters (NQF 9)	4	4.7%		
Doctorate (NQF 10)	0	0%		
Other	0	0%		

3.7.3 Coaching Characteristics

In terms of gymnastics coaching qualifications, the GSA Level 1 Phase A qualification was most commonly reported (n=25, 29.4%), followed by the Fédération Internationale de Gymnastique (FIG) Level 1 (high performance coaching qualification; n=21, 24.7%). While most respondents had up to eight years of gymnastics coaching experience (n=40, 47.1%), 13 (15.3%) respondents had more than 26 years of experience. All gymnastics disciplines were represented, with the primary coaching disciplines being women's artistic gymnastics (n=26, 30.6%), rhythmic gymnastics (n=20, 23.5%), and men's artistic gymnastics (n=13, 15.3%). Only six (7.1%) respondents trained gymnasts participating at levels 11 – 14. Respondents most frequently trained gymnasts between 11 to 15 years old (n=75, 88.2%), with 41 (48.2%) respondents coaching between five to six days per week. There were no significant differences between male and female respondents in coaches' gymnastics qualification or years coaching gymnastics. However, there was a significant difference in the primary discipline of gymnastics coached by respondents, with a significantly higher proportion of male respondents coaching men's artistic gymnastics and females coaching rhythmic gymnastics and women's artistic gymnastics (x^2=56.822; p <0.001). These results are summarised in Table 6.

Table 6. Coaching Characteristics of Respondents (Statistical significance was accepted as $p < 0.05$).

	n	%	x^2	p
COACHES GYMNASTICS QUALIFICATIONS (FOR YEAR 2022)				
Gymnastics Leader	18	21.2		
GSA Level 1 Phase A	25	29.4		
FIG Level 1 (high performance coaching qualification)	21	24.7	3.936	0.415
FIG Level 2 (high performance coaching qualification)	17	20.0		
FIG Level 3 (high performance coaching qualification)	4	4.7		
YEARS COACHING GYMNASTICS (FOR YEAR 2022)				
0 - 2 years	12	14.1		
3 - 5 years	12	14.1		
6 - 8 years	16	18.8		
9 - 10 years	10	11.8		
11 - 15 years	11	12.9	10.897	0.143
16 - 20 years	7	8.2		
21 - 25 years	4	4.7		
26+ years	13	15.3		
PRIMARY DISCIPLINE OF GYMNASTICS COACHED (FOR YEAR 2022)				
Primary Coaching Discipline	n	%		
Acrobatic Gymnastics	5	5.9		
Aerobic Gymnastics	1	1.2		
Gym For All	2	2.4		
Men’s Artistic Gymnastics	13	15.3		
Parkour	2	2.4	56.822	<0.001*
Rhythmic Gymnastics	20	23.5		
Rope Skipping	6	7.1		
Trampoline	5	5.9		
Tumbling	5	5.9		
Women’s Artistic Gymnastics	26	30.6		
LEVEL OF GYMNAST TRAINED (FOR YEAR 2022)				
Level 1 – 3	68	80		
Level 4 – 6	61	71.8		
Level 7 – 10	41	48.2		
Level 11 – 14	6	7.1	N/A	N/A
Age Groups	23	27.1		
Junior Olympic	16	18.8		
Senior Olympic	11	12.9		

Table 6 continued.

	n	%	x^2	p
AGE GROUPS OF GYMNASTS COACHED BY CURRENT COHORT OF COACHES (FOR YEAR 2022)				
<5 years old	36	42.4		
5 to 10 years old	66	77.6		
11 to 15 years old	75	88.2		
16 to 20 years old	49	57.6	N/A	N/A
21 to 25 years old	15	17.6		
26 to 30 years old	7	8.2		
>31 years old	10	11.8		
DAYS COACHING PER WEEK (FOR YEAR 2022)				
1 - 2 days	9	10.6		
3 - 4 days	35	41.2	N/A	N/A
5 - 6 days	41	48.2		

3.7.4 Injury Reporting/Monitoring

Sixty-five respondents (76.5%) coached only gymnastics, with 59 (69.4%) respondents reporting that they monitored gymnasts' injuries. The methods of monitoring injuries included keeping track of injuries in the clubs' gymnastics attendance register via verbal communication, check-ins with athletes and parents, and spreadsheets and logbooks. Six (7.1%) respondents reported that they either had direct contact with doctors, physiotherapists, and other rehabilitation professionals and had received instruction on how best to facilitate optimal recovery, or that they facilitated maintenance of gymnasts' programmes' if the athlete was managed privately. Reasons for not monitoring injuries in their gymnasts from 26 (30.6%) respondents included not previously having any serious injuries at their club or in the level of athlete coached at the club, lack of time, gymnastics coaching not being their full-time occupation, or that they had been instructed not to do so by a superior/peer.

3.7.5 Knowledge and Attitudes Survey Response Scores

Respondents knowledge and attitudes regarding injuries in the sport were scored based on their answers, as discussed in Section 3.3.2.1 (page 41). Most respondents demonstrated adequate knowledge of non-modifiable risk factors (n=75, 88%) and modifiable risk factors (n=72, 85%).

There were 55 (65%) respondents that demonstrated adequate knowledge when presented with the level of agreement statements in the knowledge section of the survey. However, when the respondents knowledge was tested with true/false questions, only 20 (24%) respondents managed to achieve an adequate knowledge score. The question specific responses can be found in Appendix H Table 1. There were only 56 (66%) respondents that managed to achieve an overall knowledge score indicating adequate knowledge (i.e., >75%). Further, only 43 (51%) respondents demonstrated adequate attitudes towards injuries when presented with level of agreement statements in the survey. There were no significant differences in knowledge or attitude scores between male and female respondents respectively, as presented in Table 7.

Table 7. Knowledge and Attitudes Scores regarding Injuries in Gymnastics.

	MALE (N=28)	FEMALE (N=57)	TOTAL (N=85)	x^2	p
KNOWLEDGE SCORES – NON-MODIFIABLE RISK FACTORS					
Inadequate Knowledge (<75%)	4 (14%)	6 (11%)	10 (12%)	0.249	0.618
Adequate Knowledge (>75%)	24 (86%)	51 (89%)	75 (88%)		
KNOWLEDGE SCORES – MODIFIABLE RISK FACTORS					
Inadequate Knowledge (<75%)	7 (25%)	6 (11%)	13 (15%)	2.871	0.090
Adequate Knowledge (>75%)	21 (75%)	51 (89%)	72 (85%)		
KNOWLEDGE SCORES – LEVEL OF AGREEMENT STATEMENTS					
Inadequate Knowledge (<75%)	9 (32%)	21 (37%)	30 (35%)	0.182	0.670
Adequate Knowledge (>75%)	19 (68%)	36 (63%)	55 (65%)		
KNOWLEDGE SCORES – TRUE/FALSE STATEMENTS					
Inadequate Knowledge (<75%)	20 (71%)	45 (79%)	65 (76%)	0.590	0.442
Adequate Knowledge (>75%)	8 (29%)	12 (21%)	20 (24%)		
ATTITUDE SCORES – LEVEL OF AGREEMENT STATEMENTS					
Negative Attitudes (<75%)	17 (61%)	25 (44%)	42 (49%)	2.134	0.144
Positive Attitudes (>75%)	11 (39%)	32 (56%)	43 (51%)		

Data expressed as number and percentage of respondents (n, %).

3.7.5.1 Knowledge-specific Responses

Table 8 summarises the level of importance statements for knowledge of intrinsic and extrinsic risk factors. Twelve respondents indicated that frequent travel was not an important risk factor for injury, with two (2.4%) respondents indicating that they were not sure of the impact of frequent travel on the risk of injury.

Table 9 below summarises the level of agreement statements for knowledge of injuries in gymnastics. Three (3.5%) and nine (10.6%) respondents strongly agreed and agreed respectively, that it is common practice for gymnastics training to continue while injuries may be present, as it promotes healing. Respondents also frequently disagreed (n=26, 30.6%) and strongly disagreed (n=1, 1.2%) with the statement that beginner athletes are 'more at risk of injury'.

Table 8. Frequency Tables of Coaches' Knowledge of Intrinsic and Extrinsic Risk Factors (n=85).

	VERY IMPORTANT	IMPORTANT	SOMEWHAT IMPORTANT	NOT IMPORTANT	NOT SURE
INTRINSIC RISK FACTORS					
Age	32 (37.6%)	29 (43.1%)	22 (25.9%)	2 (2.4%)	-
Maximum Muscle Strength	34 (40%)	38 (44.7%)	12 (14.1%)	-	1 (1.2%)
Muscle Endurance	38 (44.7%)	34 (40%)	11 (12.9%)	-	2 (2.4%)
Muscle Imbalance (left to right)	45 (52.9%)	28 (32.9%)	10 (11.8%)	1 (1.2%)	1 (1.2%)
Muscle Imbalance (agonist/antagonist)	42 (49.4%)	27 (31.8%)	13 (15.3%)	1 (1.2%)	2 (2.4%)
Acute Fatigue	43 (50.6%)	29 (34.1%)	10 (11.8%)	2 (2.4%)	1 (1.2%)
Accumulated Fatigue (within training/competition session)	47 (55.3%)	28 (32.9%)	8 (9.4%)	2 (2.4%)	-
Accumulated Fatigue (during term/semester)	53 (62.4%)	20 (23.5%)	10 (11.8%)	2 (2.4%)	-
Sleep	49 (57.6%)	25 (29.4%)	8 (9.4%)	3 (3.5%)	-
Psychological Factors	50 (58.8%)	28 (32.9%)	6 (7.1%)	1 (1.2%)	-
MODIFIABLE RISK FACTORS					
Overcrowded Training Schedule	39 (45.9%)	30 (35.3%)	10 (11.8%)	6 (7.1%)	-
Overcrowded Competition Schedule	34 (40%)	33 (38.8%)	13 (15.3%)	5 (5.9%)	-
Training Load	52 (61.2%)	22 (25.9%)	6 (7.1%)	5 (5.9%)	-
Frequent Travel	13 (15.3%)	32 (37.6%)	26 (30.6%)	12 (14.1%)	2 (2.4%)
Importance Of Competition	30 (35.3%)	32 (37.6%)	18 (21.2%)	5 (5.9%)	-
Coach Education on Injuries	70 (82.4%)	12 (14.1%)	2 (2.4%)	1 (1.2%)	-

Data expressed as number and percentage of respondents (n, %).

Table 9. Frequency Table of Coaches' Knowledge – Level of Agreement Statements (n=85).

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
There is a decrease in strength after injury	32 (37.6%)	41 (48.2%)	10 (11.8%)	2 (2.4%)	-
Injuries in young gymnasts, heal faster than in older gymnasts	17 (20%)	53 (62.4%)	11 (12.9%)	4 (4.7%)	-
Gymnasts with disordered sleep may be at an increased injury risk	32 (37.6%)	41 (48.2%)	11 (12.9%)	1 (1.2%)	-
It is common practice to continue gymnastics training while injured, as it promotes healing	3 (3.5%)	9 (10.6%)	25 (29.4%)	28 (32.9%)	20 (23.5%)
Monitoring of injuries may help decrease the risk of athletes getting injured	40 (47.1%)	40 (47.1%)	3 (3.5%)	2 (2.4%)	-
Previous injury increases the risk of re-injury	27 (31.8%)	34 (40%)	17 (20%)	7 (8.2%)	-
Beginner athletes are more at risk of injury	4 (4.7%)	23 (27.1%)	31 (36.5%)	26 (30.6%)	1 (1.2%)
Elite athletes are more at risk of injury	11 (12.9%)	37 (43.5%)	24 (28.2%)	13 (15.3%)	-
Injury risk cannot be changed	6 (7.1%)	5 (5.9%)	13 (15.3%)	50 (58.8%)	11 (12.9%)

Data expressed as number and percentage of respondents (n, %).

3.7.5.2 Attitude-specific Responses

Table 10 summarises the level of agreement statements for attitudes regarding injuries that may occur. When asked ‘if I start to monitor injuries now, and I haven’t before, others will think that I am a bad coach,’ most respondents disagreed (n=39, 45.9%) and strongly disagreed (n=34, 40%) with this statement. When respondents were presented with the statement ‘with more information about injuries, I will be able to make better decisions that keep my gymnasts safe and minimise injury risk,’ 68 (80%) respondents strongly agreed, 16 (18.8%) agreed, and only one (1.2%) respondent remained neutral.

Table 10. Frequency Table of Coaches' Attitudes – Level of Agreement Statements (n=85).

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
If I start to monitor injuries now, and I haven't before, others will think that I am a bad coach	-	3 (3.5%)	9 (10.6%)	39 (45.9%)	34 (40%)
With more information about injuries, I will be able to make better decisions that keep my gymnasts safe and minimise injury risk	68 (80%)	16 (18.8%)	1 (1.2%)	-	-
I feel embarrassed if a gymnast is injured during training or competition	4 (4.7%)	11 (12.9%)	28 (32.9%)	31 (36.5%)	11 (12.9%)
If a gymnast gets injured, it's because they weren't listening to me/following my instructions	2 (2.4%)	11 (12.9%)	40 (47.1%)	23 (27.1%)	9 (10.6%)
Injuries are mainly the result of the gymnasts' lack of focus/paying attention	2 (2.4%)	19 (22.4%)	32 (37.6%)	28 (32.9%)	4 (4.7%)
Injuries are mainly the result of the coach's lack of focus/paying attention	-	9 (10.6%)	29 (34.1%)	42 (49.4%)	5 (5.9%)

Data expressed as number and percentage of respondents (n, %).

3.7.6 Practices

Table 11 summarises the level of agreement statements for practices regarding current practices when injuries occur to gymnasts. When presented with the statement 'I have previously pushed gymnasts to train while injured,' the majority of respondents strongly disagreed (n=37, 43.5%) and disagreed (n=31, 36.5%). However, it was noted that 12 (14.1%) respondents agreed with this statement. Similarly, nine (10.6%) respondents also agreed with the statement that 'I have witnessed injuries, and allowed gymnasts to continue training, because they didn't say anything.' There was also strong agreement (n=81, 94.8%) with the statement that 'I would like more information on injuries and their risk factors, to help me make better decisions moving forward.'

Respondents were presented with various statements, requesting an indication of the level of perceived importance to various tests identifying potential injury risk, as summarised in Table 12. 'Subjectively rated muscle soreness' was the test most frequently identified as being very important (n=40, 47.1%). 'Recovery of muscle force' was the test most frequently identified as being important (n=39, 45.9%). 'Subjectively rated recovery status' had the highest cumulative frequency (n=72, 84.7%) when combining the responses for very important (n=37, 43.5%) and important (n=35, 41.2%). Respondents were frequently not sure (n=8, 9.4%) about the importance of heart rate variability as a test identifying injury risk for their athletes, and most frequently interpreted objective measures of sleep as not important (n=7, 8.2%).

An open-ended question probed for insight into injury prevention information delivery methods. Coaches identified that on-going interactive education should be directed at the coach, gymnast, and caregiver to learn together and from each other. An initial course or workshop about injury prevention should be followed-up with regular refresher courses that could include information about skill-specific training precautions. This may also facilitate that coaches have access to the latest research – the result of their ongoing commitment to injury monitoring with their athletes.

Respondents also highlighted the need for different forms of information delivery methods, as not everyone has similar learning styles. These methods may include in-person learning opportunities (that may include interaction with healthcare providers), virtual sessions that may take on a webinar-type format, small group sessions (both within clubs and between clubs), and the availability of smaller snippets of information via social media platforms.

Table 11. Frequency Table of Coaches' Practices – Level of Agreement Statements (n=85).

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
I have previously pushed gymnasts to train while injured	-	12 (14.1%)	5 (5.9%)	31 (36.5%)	37 (43.5%)
I have witnessed injuries, and allowed gymnasts to continue training, because they didn't say anything	1 (1.2%)	8 (9.4%)	9 (10.6%)	42 (49.4%)	25 (29.4%)
I promote rest after injuries	40 (47.1%)	42 (49.4%)	2 (2.4%)	1 (1.2%)	-
I monitor injuries with all my gymnasts	33 (38.8%)	37 (43.5%)	10 (11.8%)	4 (4.7%)	1 (1.2%)
I would like more information on injuries and their risk factors, to help me make better decisions moving forward	48 (56.5%)	33 (38.8%)	3 (3.5%)	1 (1.2%)	-
With some guidance, I would consider monitoring injuries with all my athletes	41 (48.2%)	34 (40%)	9 (10.6%)	-	1 (1.2%)
I encourage all my athletes to let me know about all their injuries	63 (74.1%)	20 (23.5%)	-	2 (2.4%)	-

Data expressed as number and percentage of respondents (n, %).

Table 12. Frequency Table of Coaches' Practices - Level of Importance Statements (n=85).

	VERY IMPORTANT	IMPORTANT	SOMEWHAT IMPORTANT	NOT IMPORTANT	NOT SURE
Rating of perceived exertion (RPE)	35 (41.2%)	31 (36.5%)	13 (15.3%)	-	6 (7.1%)
Heart rate (during training)	21 (24.7%)	26 (30.6%)	30 (35.3%)	3 (3.5%)	5 (5.9%)
Heart rate variability	16 (18.8%)	32 (37.6%)	25 (29.4%)	4 (4.7%)	8 (9.4%)
Subjectively rated fatigue	35 (41.2%)	33 (38.8%)	10 (11.8%)	3 (3.5%)	4 (4.7%)
Subjectively rated sleep	32 (37.6%)	30 (35.3%)	14 (16.5%)	3 (3.5%)	6 (7.1%)
Subjectively rated muscle soreness	40 (47.1%)	29 (34.1%)	10 (11.8%)	2 (2.4%)	4 (4.7%)
Subjectively rated recovery status	37 (43.5%)	35 (41.2%)	8 (9.4%)	1 (1.2%)	4 (4.7%)
Objective measure of sleep (e.g.: sleep watches)	20 (23.5%)	28 (32.9%)	23 (27.1%)	7 (8.2%)	7 (8.2%)
Recovery of muscle force	29 (34.1%)	39 (45.9%)	9 (10.6%)	1 (1.2%)	7 (8.2%)
General medical screen	34 (40%)	31 (36.5%)	12 (14.1%)	3 (3.5%)	5 (5.9%)

Data expressed as number and percentage of respondents (n, %).

3.8 Summary of Results

There were 85 respondents that took part in the survey, made up of 67.1% females and 32.9% males. All South African provinces were represented by the sample of respondents, as well as all of the gymnastics disciplines. Most respondents coached gymnasts between levels 4 and 10, and these gymnasts were predominantly between 5 to 20 years of age. The majority of respondents coached up to four days per week, for up to 12 hours per week, coaching more than 40 athletes per year. There was a significantly higher proportion of male respondents coaching men's artistic gymnastics, and female respondents coaching rhythmic gymnastics and women's artistic gymnastics. There were no other significant differences between males and females for sociodemographic or coaching characteristics. From the results of the knowledge and attitudes section of the survey, respondents demonstrated an inadequate level of knowledge regarding injury prevention (66%). Further, respondents demonstrated an inadequate level of positive attitude regarding injury prevention (51%). From the results of the practices section of the survey, we see that respondents have previously witnessed injuries in their athletes but would like more information about injuries and their risk factors to make better decisions in the future.

3.9 Discussion

3.9.1 Sample Size

The sample was adequately powered, with included responses received from 85 respondents. The number of responses included met a confidence level of 95%. However, with this relatively small sample size, caution should still be exercised when generalising the results of this study to the South African-based gymnastics coaches' population. Mawson et al. (2018), in their study on coaches knowledge of injury prevention programmes in soccer, had 101 respondents, with a response rate of 24.2%. In the current study, with an estimated population size of at least 500 South African-based gymnastics coaches, the inclusion of 85 respondents produced a response rate of 17%.

The response rate may have been this low because of the length of time it took to complete the questionnaire (i.e.: ± 40 minutes). With research in South African gymnastics being relatively scant, coaches may have been hesitant to complete the questionnaire because of unfamiliarity.

3.9.2 Descriptive Characteristics

In the current study, 49.4% of respondents were between the ages of 18 and 34 years, resulting in a younger cohort of currently studied coaches. This is in contrast to Mawson et al. (2018) who reported that 49.5% of their respondents were between the ages of 41 and 50 years. Mawson et al. (2018) included respondents coaching premier, elite, and higher-level soccer teams, as well as in 'house league' athletes, with 65% of respondents having done some level of coaching course. They further reported that coaching courses were completed by 54.3% of house league coaches, and all coaches of premier, elite, and higher-level teams had completed some level of coaching course. Contrasting this, the findings of the current study demonstrated that, even though the included respondents were younger, 100% of the gymnastics coach respondents had obtained some level of gymnastics coaching qualification.

3.9.3 Coaching Characteristics

In the current study, where 85 (100%) gymnastics coaches had attained a gymnastics coaching qualification, Whatman et al. (2018) reported that 70% of youth sport coaches included in their study, have a coaching qualification. This may be a positive reflection of GSA, where most coaches interacting with athletes have obtained an appropriate level of coaching qualification for the sport.

3.9.4 Injury reporting/Monitoring

In the current study, respondents indicated how they were currently monitoring injuries and the medical and rehabilitation professionals with which they exchanged information. Comparative information is scant but Post et al. (2020) reported that the majority of youth sport coaches do not monitor the cumulative amount of time that an athlete may be participating in all sports.

3.9.5 Knowledge, Attitudes, and Practices around Injuries

Previous research into South African nursing staff's knowledge and perception regarding the Road to Health growth chart rated adequate knowledge as a score above 75% (Cloete et al., 2013). This study used the 75% score as an indication for adequate knowledge and attitudes for the scores obtained by the respondent coaches.

3.9.5.1 Knowledge about Injury Prevention

From the knowledge results of the current study's KAP survey, respondents demonstrated an inadequate level of knowledge regarding injury prevention (65%). There is limited research on the KAP of gymnastics coaches regarding injury prevention in the sport. From soccer research, coach knowledge about injury prevention programmes and the level of effectiveness of these programmes has been found to be a primary factor contributing towards soccer coaches' implementation of injury prevention programmes (McKay et al., 2014). Similarly, there was a lower level of incorporation of injury prevention strategies into athlete training sessions when coaches demonstrated gaps in knowledge regarding injury (McKay et al., 2014). Saunders et al. (2010) highlighted the need to improve education in junior rugby union, netball, and soccer. With an improved knowledge of injury mechanisms and early injury management, there was an effective decrease in the likelihood of community players sustaining injury.

However, behaviour change is not guaranteed with the knowledge of the benefits of injury prevention (Andersson et al., 2019). This concept of the translation of knowledge to practice was further explored by Norcross et al. (2016). While investigating the adoption of injury prevention strategies by high school coaches and the factors influencing these decisions, it was discovered that providing coaches with detailed information about the ramifications of injury (to highlight the need for prevention intervention) was the most successful means to encourage adoption of the strategies. This strategy was used in combination with highlighting the advantage of the strategy over current practice. Joy et al. (2013) in their investigation into factors influencing the implementation of anterior cruciate ligament (ACL) injury prevention strategies by coaches, reported that a lack of knowledge about both implementing the programme and educating their athletes was the coaches' primary deterrent in adopting the strategies.

A higher level of education, a higher level of personal playing experience, and a higher level of ACL injuries sustained in their team were similar between the coaches that did implement injury prevention strategies, compared to coaches that did not portray these factors. Similarly, the injury-prevention learning process of the dancers and staff interviewed by Bolling et al. (2021) was affected by their dance experience, their previous injuries, and their own knowledge about their body.

The present study investigated respondents KAP about training factors to facilitate injury prevention, but further exploration should investigate the depth of the gymnasts' knowledge about the aetiology and ramifications of injury, to more fully address this 'implementation gap' (Finch, 2006). Additionally, the sociodemographic background of the gymnast, their level of training and skill, years of practice, as well as injury history needs to be thoroughly explored to ascertain the degree to which a 'learning process' has taken place in the individual – if the statement by Andersson et al. (2019) that the experiences of each individual affect adoption and implementation is considered to be correct.

3.9.5.2 Attitudes towards Injury Prevention

From the attitudes results of the current study's KAP survey, respondents demonstrate an inadequate level of positive attitudes regarding injury prevention (51%). The uptake of injury prevention programmes by high-school coaches was investigated by Norcross et al. (2016). Where coaches had negative attitudes towards injury prevention, with the concomitant lack of belief that the injury prevention programme would work, did not impair the adoption of the programme. It was, however, more likely that coaches would adopt an injury prevention measure if they perceived it to be better than their current practice and aligned with the needs and values of their sport. While attempting to bridge this implementation gap identified by Norcross et al. (2016), the attitudes of gymnasts regarding injury prevention needs to be explored, and their personal values regarding the practice and competition of gymnastics determined.

Athletes, coaches, and physiotherapists have previously acknowledged that sustaining an injury is an inherent risk of elite sports participation (Bolling et al., 2020). Subsequently, a paradigm shift has been suggested to a 'risk-injury management strategy,' where rather than altogether avoiding risk, accepting, and balancing the concept is attempted (Bolling et al., 2020). In the current study, respondents identified several factors they believed to be linked to injury. Factors consistent with previous research include competitive level and training characteristics of the athlete (Abalo Núñez et al., 2013; Bonanno et al., 2022; Edouard et al., 2018; Grapton et al., 2013; Kirialanis et al., 2015; Kolar et al., 2017; O'Kane et al., 2011; Purnell et al., 2010; Williams et al., 2023), landings, falls, and the use of safety equipment (Abalo Núñez et al., 2013; Kirialanis et al., 2015), and the role of injury and re-injury risk (Goulart et al., 2016; Gram et al., 2021; Williams et al., 2023).

To positively influence the perceptions of coaches' beliefs in an injury prevention programmes' viability, further exploration of factors influencing intervention uptake and effectiveness needs to be pursued. Finch (2011) provided the RE-AIM framework to facilitate this process. This model provides insight into the ecological sports delivery system, in which the evaluation of sports injury interventions may take place. Factors for exploration may include the current behaviour practices of the target group, the precursors to those behaviours that may impact behaviour change, factors that may influence the adoption of injury prevention methods by the sports-group as a whole, and the setting-specific and cultural factors that may guide how stakeholders want to receive this information and continue to sustain the programme beyond the extent of the research period (Finch, 2011).

3.9.5.3 Practices around Injury Prevention

From the results obtained in the practices section of the KAP survey, respondents indicated that they had previously witnessed injury in their athletes and would like to receive additional information about injuries and their risk factors to make better decisions in the future. The successful implementation of injury prevention programmes, however, will ultimately depend on an athlete's compliance with the recommended measure (Van Tiggelen et al., 2008). Finch (2006, 2011) explored facilitators to the adoption of safety measures in sport. It was reported that measures are more likely to be implemented if they are: closely aligned to a sport's inherent culture (such as headgear in American football), easy to adopt, do not contradict the culture of the sport, are promoted in a way that is relevant to the sport, and are used by peers and role models. Furthermore, adoption and compliance of the measure is more likely if the benefits of the measure are explained with an 'insistence of excellence' (Finch, 2006). Acknowledging the influence of coaches on athlete injury prevention highlights their responsibility in injury prevention decision-making as well as promoting injury prevention behaviours (Mawson et al., 2018).

There is limited research on the KAP of gymnastics coaches. McKay et al. (2014) reported the inconsistent incorporation of injury prevention strategies, when soccer coaches demonstrated gaps in their injury knowledge. In a study by Wilke et al. (2018), the authors reported that without the guidance of a doctor, physiotherapist, or strength and conditioning coach, injury risk screening were only carried out by 32.5% of coaches. If these members of the support staff were part of injury risk screening implementation, with increasing consistency, 47.9% implemented screening when one member of the team was present, further increasing to 91.7% with the presence of all three support staff members. Contrasting this is the 100% screening rate demonstrated in elite-level football and rugby (Wilke et al., 2018). Where these elite sports may include the previously mentioned healthcare professionals, the onus of injury screening and implementation is not solely the responsibility of the coach. If the sentiment by Saunders et al. (2010) is considered correct, that education concerning injury mechanisms and early management may result in a decreased likelihood of sustaining injury, the majority of respondents wanting more information about injuries in gymnastics may also see a change in the number of injuries sustained by gymnasts.

Feedback was provided by respondents on how to deliver injury prevention information. To facilitate effective behaviour change, researchers should lower the barriers to change (Berger, 2020). If injury prevention programmes are built using the guidelines of the respondents from the current study, researchers may observe improved adoption, leading to sustained maintenance of the injury prevention programme beyond the research period (Finch, 2011).

3.10 Limitations and Recommendations

As the survey was only available in English, caution should be exercised when generalising the results to the full population of South African-based gymnastics coaches. This is acknowledged as a potential limitation as GSA has recently started providing coach education courses in native South African languages. This, along with the relatively small sample size, should prevent overconfidence in the ability to generalise these results. With the survey only being available online, consideration should also be given to the fact that potential respondents may have been self-limited by a lack of access to a stable internet connection, or those from lower socio-economic groups that may have had limited to no access to internet connectivity.

Further caution of should applied to the interpretation of the results, because of the webinars series. Information provided during these interactions may have skewed respondents feedback, as they may have received information that improved their knowledge and affected their attitudes.

Where Finch (2006) provided the TRIPP framework for research leading to real-world sports injury prevention, and where KAP studies are seen as an adequate exercise preceding the TRIPP frameworks' Step 1: Injury Surveillance, the recommendation for future research would be to initiate gymnastics injury surveillance efforts with the assistance of the information provided by the current cohort of respondent coaches. This may facilitate improved adoption and sustained maintenance of injury prevention programmes, beyond the research period (Finch, 2011). Gymnastics coaches are an under-researched cohort – and to improve sports and exercise medicine in gymnastics, more engagement and education with coaches needs to happen at a grassroots level to build understanding and participation in research. As the concept of injury context is still developing, a qualitative approach to data collection and analysis should be pursued.

Methodologies using an emergent design (Bolling et al., 2021; Braun & Clarke, 2006), or quantitative explorations similar to the KAP design of this dissertation (Creswell & Creswell, 2017; Kaliyaperumal, 2004; Regmi et al., 2016; Sullivan & Artino, 2013) could explore gymnasts perspectives on injury and insight into their KAP around sustained injuries. A qualitative approach allows for more flexibility, as the data collection and analysis processes evolve over time. This may be necessary while engaging with younger gymnastics athletes receiving their first exposure to sports injury research. A study design of this nature may enable a more natural transition from broad to more specific questioning, as may be required by the investigators. A quantitative design would facilitate inferential investigation into the KAP of gymnasts. Both design methodologies fit into the structure of the TRIPP framework and simultaneously move gymnastics-specific injury research towards real-life injury prevention programmes. With the respondents in this study reporting a strong interest in receiving additional knowledge regarding injury prevention strategies, and with future research seeking insight from the context of the athlete, investigators can determine where to aim further education.

3.11 Conclusion

In conclusion, to the knowledge of the researcher, this is the first study that describes the KAP of South African-based gymnastics coaches regarding injuries that occur in the sport. From the results of the survey responses, respondents demonstrated an inadequate level of knowledge regarding injury prevention. Further, respondents demonstrated an inadequate level of positive attitudes regarding injury prevention. From the results of the practices section of the survey, respondents had previously witnessed injuries in their athletes but would like more information about injuries and their risk factors to make better decisions in the future. Further investigation is also warranted to explore the gymnasts' perspectives of injury prevention, as interventions are designed and implemented for the safety of the athlete.

CHAPTER FOUR: CONCLUSION

The risk of sustaining a gymnastics-related injury is high across all levels of participation in the sport. In a sport that is dominated by the participation of younger athletes, it may typically be the gymnastics coach involved in disseminating injury information to the athlete. Successful injury prevention requires a comprehensive and detailed understanding of the context of the athletic population including personal, environmental, societal, and sports delivery components.

A scoping review is indicated when attempting to identify the types of evidence available in a given field, when attempting to identify the potential knowledge gaps around a topic, or when aiming to provide insight to key characteristics or factors regarding a field of inquiry. The main question asked in the scoping review (Chapter 1, Section 1.4 (page 6)) was "what musculoskeletal injuries occur in recreational and competitive gymnasts?"

The sub-questions of the scoping review were answered as follows:

- *What injury definitions are used to identify injuries in recreational and competitive gymnasts?*

Injury definition methods varied between the studies included in this scoping review, with no studies using similar definitions for injury.

- *What is the incidence and prevalence of musculoskeletal injuries in recreational and competitive gymnasts?*

With inconsistent definitions for injury of the included studies, there was also a lack of consistency between the definitions of injury incidence and prevalence, resulting in a wide range of reported injury incidence and prevalence in the gymnastics athlete.

- *How are injuries in recreational and competitive gymnasts classified in terms of injury area, injury type, and injury severity?*

From the included studies, injuries were reported in the upper limbs, lower limbs, trunk, and head. Ligament sprains and muscle/tendon strains were the most commonly reported types of injury in the sport. It is evident that there are both acute and overuse injuries being sustained by athletes. The injuries sustained by gymnasts may be mild to moderate.

The RE-AIM framework was the theoretical framework used in this survey-based study. This framework acknowledges the human behavioural-change component which is necessary for the successful implementation of injury prevention programmes. This framework highlights the importance of understanding factors influencing intervention uptake and effectiveness of injury prevention programmes. These factors for exploration may include the current behaviour practices of the target group, the precursors to those behaviours that may impact behaviour change, factors that may influence the adoption of injury prevention methods by the sports-group as a whole, and the setting-specific and cultural factors that may guide how stakeholders want to receive this information and continue to sustain the programme beyond the extent of the research period.

The objectives of the survey-based study (as stated in Chapter 1, Section 1.4 (page 6) were answered as follows:

- *Describe the demographic characteristics and coaching characteristics of South African gymnastics coaches.*

The majority of the study respondents were female coaches, representing all South African provinces, and all of the gymnastics disciplines. The majority of respondents were between 18-34 years of age, with 87.1% of respondents' engaging with some form of tertiary education or beyond. Most respondents (95.3%) have a gymnastics coaching qualification.

Most respondents coached gymnasts between levels 4 and 10, predominantly between the ages of 5 to 20 years old, coaching more than 40 athletes per year, with most coaches currently having coached for 6 to 8 years.

- *Establish the KAP of South African-based gymnastics coaches regarding injuries in the sport.*

From the results of the knowledge and attitudes section of the survey, respondents demonstrated an inadequate level of knowledge regarding injury prevention. Further, respondents demonstrated an inadequate level of positive attitude regarding injury prevention. The majority of respondents (69.4%) indicated that they are currently monitoring injuries in their athletes. From the results of the practices section of the survey, we see that respondents have previously witnessed injuries in their athletes but would like more information about injuries and their risk factors to make better decisions in the future.

Based on the findings of this dissertation, there is a need for an improved understanding of the context of the gymnastics coach (as well as the participating gymnastics athlete) in South Africa, as well as more homogenous injury surveillance methods and reporting parameters. Immediate implementation should include establishing better working relationships between gymnastics stakeholders (i.e., athletes, guardians/caregivers, and coaches) and medical professionals for optimal refinement of education methods. The improvement in relationship may lead to injury prevention strategies being maintained beyond the extent of the investigation period. The KAP results from this study provides an opportunity for the reassessment of baseline KABP after injury information and education efforts have been provided to the coaches. Future research should also include prospective gymnastics injury monitoring and reporting to gain further insights regarding the injury burden in South African gymnasts.

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APPENDICES

Appendix A: HREC Study Approval Letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room G50- Old Main Building
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Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

12 August 2021

HREC REF: 516/2021

A/Prof T Burgess
Division of Physiotherapy
F-45 OMB
Email: theresa.burgess@uct.ac.za
Student: dominicalexanderrhodes@gmail.com

Dear A/Prof Burgess

PROJECT TITLE: THE KNOWLEDGE, ATTITUDES AND PRACTICES (KAP) OF GYMNASTICS COACHES REGARDING INJURIES IN THE SPORT-MSC CANDIDATE-MR DOMINIC A RHODES

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020; 06 July 2020 & 01 July 2021.

Approval is granted for one year until the 30 August 2022.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Mr Dominic Rhodes will also be involved in this study.

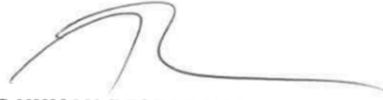
Please quote the HREC REF 516/2021 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

HREC/REF 516/2021sa

Yours sincerely



PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

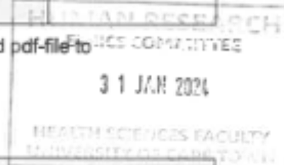
HREC/REF 516/2021sa

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA · UNIVERSITEIT VAN KAAPSTAD

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938)			
This serves as notification of annual approval, including any documentation described below.			
☑ Approved	Annual progress report	Approved until/next renewal date	28.02.2025
☐ Not approved	See attached comments		
Signature Chairperson of the HREC/ Designee	[signature]	Date Signed	4/2/2024



Note: Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za.
Please clarify your plan for research-related activities during COVID-19 lockdown.
Please use the latest form found on our website:
http://www.health.uct.ac.za/fhs/research/humanethics/forms

Comments to PI from the HREC

Principal Investigator to complete the following:

1. Protocol information

Date (when submitting this form)	31 January 2024		
HREC REF Number	516/2021	Current Ethics Approval was granted until	28/02/2024
Protocol title	Injuries in Gymnastics: The Knowledge, Attitudes and Practices of South African Gymnastics Coaches		
Protocol number (if applicable)			
Are there any sub-studies linked to this study?	☐ Yes	✓ No	
If yes, could you please provide the HREC Reference number for all sub-studies? **Note:** A separate FHS016 must be submitted for each sub-study.			

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

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FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

Principal Investigator	A/Prof Theresa Burgess
Department / Office Internal Mail Address	Division of Physiotherapy Department of Health and Rehabilitation University of Cape Town Groote Schuur Hospital Anzio Road Observatory 7725

1.1 Does this protocol receive US Federal funding?	☐ Yes	✓ No
1.2 If the study receives US Federal Funding, does the annual report require full committee approval? **Note:** Any annual approvals for **Full Committee** review MUST be submitted on the monthly HREC submission dates. (Please send electronic copy for full committee review to hrec-submission@uct.ac.za)	☐ Yes	☐ No
If yes in 1.2 please complete section 1.3 below for invoicing purposes		

1.3 Ethics Renewal Fee

Please **(tick ✓)**appropriate box for billing purposes:

Submission Type	*Description*	*New fee (Vat Incl.)*	*tick ✓*
Research funded solely from UCT departmental/ divisional/group budget	Annual evaluation of research progress report for re-certification	**R0,00**	✓
Non-sponsored student research for degree purposes at UCT/Other Universities & Colleges	Annual evaluation of research progress report for re-certification	**R0,00**	☐
Annual re-certification / Progress report (FHS016 Form)	Clinical Trial & International Grant Funded Research - Annual evaluation of research progress report for re-certification for Full Committee Approval	**R7000,00**	☐
Annual re-certification / Progress report (FHS016 Form)	Clinical Trial & International Grant Funded Research - Annual evaluation of research progress report for re-certification for Expedited review	**R3 710.00**	☐
Annual re-certification / Progress report (FHS016 Form)	National grant funded research - Annual evaluation of research progress report for re-certification for Full Committee Approval	**R6000.00**	☐
Annual re-certification / Progress report (FHS016 Form)	National Grant funded research for Annual evaluation of research progress report for re-certification for Expedited review	**R1 500,00**	☐

NB: Protocols funded by UCT (e.g. departmental funding / student research) and by certain grant funding organizations (e.g. MRC, NRF, CANSA,) are exempt from these charges.

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

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FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

Please provide details for Invoicing, either complete section 1 or 2 :	
1. Invoice billing – Directly to Sponsor	
Sponsor's name	
Billing Address of Sponsor:	
Vat Number:	
Contact person	
Telephone number	
Email Address	
2. Internal Journal Billing:	
Fund Number:	
Cost Centre Number:	
Account Holder Name:	
Division of Account Holder:	

2. List of documentation for approval

FHS016 – Request to review an annual approval

3. Protocol status (tick ✓)

☐	Open Enrolment
☐	Closed to enrolment (tick ✓)
☐	Research-related activities are ongoing
☐	Research-related activities are complete, long-term follow-up only
☑	Research-related activities are complete, data analysis only
☐	Main study is complete but sub-study research-related activities are ongoing
☐	Study is closed → Please submit a Study Closure Form (FHS010)

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

4. Enrolment

Number of participants enrolled to date	85
Number of participants enrolled, since last HREC Progress report (continuing review)	0
Additional number of participants still required	0

5. Refusals

Total number of refusals (participants invited to join the study, but refused to take part)	0

6. Cumulative summary of participants

Total number of participants who provided consent	104
Number of participants determined to be ineligible (i.e. after screening)	19
Number of participants currently active on the study	0
Number of participants completed study (without events leading to withdrawal)	85
Number of participants withdrawn at participants' request (i.e. changed their mind)	0
Number of participants withdrawn by PI due to toxicity or adverse events	0
Number of participants withdrawn by PI for other reasons (e.g. pregnancy, poor compliance)	0
Number of participants lost to follow-up. Please comment below on reasons for loss of follow-up.	0
Number of participants no longer taking part for reasons not listed above. Please provide reasons below:	N/A

7. Progress of study

Please provide a brief summary of the research to date including the overall progress and the progress since the last annual report as well as any relevant comments/issues you would like to report to the HREC:
This study is complete. Results, discussion and summary chapters are complete – and awaiting final review by research supervisors, before the dissertation's submission for examination.

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

8. Protocol violations and exceptions (tick ✓ all that apply)

☑	No prior violations or exceptions have occurred since the original approval
☐	Prior violations or exceptions have been reported since the last review and have already been acknowledged or approved
☐	Unreported minor violations that have occurred since the last review, as well as significant deviations not yet reported, are attached for review

9. Amendments (tick ✓ all that apply)

☑	No Prior amendments have been made since the original approval
☐	Prior amendments have been reported since the last review and have already been approved
☐	New protocol changes/ amendments are requested as part of this continuing review (See note below)

Note: If new protocol changes are being requested in this review, please complete an amendment form (FHS006).
Specific changes in the amended protocol and consent/assent forms must be **bolded**, *italicised* or tracked and all changes must include a rationale.

10. Adverse events

10.1 Please provide below or attach a narrative summary of serious adverse events and/ or unanticipated problems since the last progress report. Please indicate changes made to the protocol and informed consent document(s) as a result (if not already reported to the HREC). Please comment on whether causality to any study procedure or intervention could be established.
N/A

10.2 Have participants received appropriate treatment/ follow-up/ referral when indicated (e.g. in the case of abnormal or incidental clinical findings, distress or anxiety)?		
☐ Yes	☐ No	✓ Not applicable
If yes, please describe:		

11. Summary of Monitoring and Audit Activities (tick ✓)

11.1 Was this study monitored or audited by an external agency (e.g. SAHPRA, FDA)?		
☐ Yes	☐ No	✓ Not applicable

11.2 Did a Data and Safety Monitoring Board publish a report?

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

☐ Yes	☐ No	✓ Not applicable

11.3 If yes, please identify the agency and attach a summary of the findings.					
Agency Name		Report attached	☐ Yes	☐ No	☐ Not applicable
		DSMB report attached	☐ Yes	☐ No	☐ Not applicable

11.4 Has there been any agency, institutional or other inquiry into non-compliance in this study, or any finding of non-compliance concerning a member of the research team?	
☐ Yes	✓ No
If yes, please explain:	

12. Level of risk (tick ✓)

12.1 In light of your experience of this research, please indicate whether the level of risk to participants has:	
☐	Increased
☐	Decreased
✓	Shown no change
If there has been a change, please explain:	

12.2 Please provide a narrative summary of recent relevant literature that may have a bearing on the level of risk.

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

13. Insurance

Please confirm that valid no fault insurance is still in place? **(tick ✓)**		
☐ Yes	☐ No	✓ Not applicable – N/A
If yes, please complete the following:		

Insurer's name:			
Policy no.		*Coverage Period:	

For UCT sponsored studies please liaise the Insurance office via fhs.sponsorship@uct.ac.za regarding the required documentation and information required obtain a renewed UCT No-fault Insurance Certificate.

14. Statement of conflict of interest

Has there been any change in the conflict of interest status of this protocol since the original approval? (tick ✓)	
☐ Yes	✓ No
If yes, please explain and if necessary, attach a revised conflict of interest statement (Section #7 in the New Protocol Application Form FHS013):	

15. Signature

My signature certifies that the above is complete and correct.			
Signature of PI	TBurgess	Date	31/01/2024

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

Appendix B: Letter to Gymnastics South Africa

To whom it may concern

I am a Physiotherapist currently studying towards my Masters' of Science in Exercise and Sports Physiotherapy at the University of Cape Town. As part of my Masters' degree, I am required to conduct a research study.

I have chosen to conduct my research in the field of gymnastics and I am appealing to you and your organisation for your assistance in recruiting participants for the study. The study will be investigating gymnastics coaches' knowledge, attitudes and practices around injuries in the sport. The study will help us assess coaches general knowledge of various injury contributing factors. The information gained will allow us to see if there is a need for education regarding injuries in the sport.

This study has received ethical approval from the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town (HREC Reference: 516/2021).

The study will be conducted through an anonymous online survey and we would like to distribute the survey throughout the South African gymnastics coaches' community. The study will require a large number of participants for it to have any significance. Therefore, it would be greatly appreciated if you would assist us by forwarding the attached recruitment advert to all of your organisations coaches. The advert will inform your members of the study and request their voluntary participation.

Participants will be anonymous, as there are no personal identifiers on the questionnaire, and all information will be kept confidential. Any information gained from this questionnaire will be used for the purposes of this study alone, and will remain anonymous and confidential should the findings of the study be published.

There are no risks involved in participating in this study, as there will be no physical testing or intervention.

As a benefit for participating in the study, all participants will receive an infographic poster about injuries in gymnastics. This will be accompanied by an algorithm that reinforces the information given by the poster, while also providing means to monitor the injured athlete. There will be no remuneration for taking part in this study.

Professor Theresa Burgess and Professor Nirmala Naidoo will supervise this study.

Thanking you in advance for your support in assisting with our research. Please do not hesitate to contact me should you have any queries.

Your sincerely

Dominic Rhodes
BSc Physiotherapy (UCT)

A/Prof Theresa Burgess (Research Supervisor)
Tel: 021 406 6171
E-Mail: theresa.burgess@uct.ac.za

A/Prof Niri Naidoo (Research Supervisor)
Tel: 021 406 6314
E-Mail: niri.naidoo@uct.ac.za

If you have any questions about the ethics of this study, please feel free to contact Professor Marc Blockman if you still aren't satisfied with the answers that the researchers have given you.

Professor Marc Blockman
Chair: The Research and Ethical Committee
Faculty of Health Sciences
University of Cape Town
Floor E52 Room 23
Old Main Building
Groote Schuur Hospital
Observatory
Tel: 021 406 6492

Appendix C: Study Flyer (Advertisement)

Coaches Protecting Gymnasts

Please join in and motivate all South African Gymnastics coaches to be part of this MSc Exercise and Sports Physiotherapy, injury survey study

Open: **To all SA Gymnastics Coaches**

Closed: **If you are younger than 18 years**

For further study information, follow the survey link below.

https://forms.gle/Pui9enqNQTNCLY4H6

Or call Dominic Rhodes 0730488078

Appendix D: GSA Endorsement Letter

Suite E11 Clareview Business Park
236 Imam Haron Road
Claremont, Cape Town
7708
Tel: +27 (021) 671 4818
info@sagf.co.za
www.gymnasticssa.co.za
NPO Registration 011-419 NPO

20 September 2022

To Whom It May Concern,

This letter is to confirm that Dominic Rhodes is working on an injury prevention survey with the endorsement of Gymnastics South Africa. Dominic was recently appointed for the Region 5 Games in Malawi, as part of the SASCOC Team SA Medical Team as a Physiotherapist.

The injury survey project is assisting us to improve our education system and data on preventing injuries to help gymnasts, coaches and parents involved in gymnastics.

Stakeholders involved the project:

Dominic Rhodes, an ex-gymnast- MSc Exercise and Sport Physiotherapy candidate (UCT-Masters research)
Gymnastics South Africa- Coaches' Education and Safeguarding (Marti Heri Development Manager)
UCT Medical Research Council (Warren Lucas, Gymnastics SA High Performance Coach and consultant
SASCOC Physiotherapy Commission (Dr. Siyabonga Kunene)

SURVEY: Gymnastics Injuries and Preventative measures

Dominic is seeking information on gymnastics coaches' approach to injury prevention in gymnasts. The Google form survey is totally anonymous and will take around 30 -45 minutes to complete.

All you need to do is follow the link: https://forms.gle/Pui9enqNQTNCLY4H6

Please complete the survey and assist us in forwarding this information to all your coaches and gymnasts that are 18 years and older.

The information gathering must cover the full range of our coaches – from GL to FIG qualified coaches.
All coaches must be older than 18 years or older to take part in the survey.

GYMNASTICS SOUTH AFRICA MANAGEMENT COMMITTEE:
Donovan Jurgens (President); Clive Naidoo (1st Vice President); Keolebogile Mokolopo (2nd Vice President)
Lynn Breytenbach (Member); Melvin Edwards (Member); Anne Vermaak (CEO)

Coaches Protecting Gymnasts

GYMNASTICS
South Africa

Please join in and motivate all South African Gymnastics coaches to be part of this MSc Exercise and Sports Physiotherapy, injury survey study

Open: To all SA Gymnastics Coaches

Closed: If you are younger than 18 years

For further study information, follow the survey link below.

https://forms.gle/Pui9enqNQTNCLY4H6

Or call Dominic Rhodes 0730488078

Those who complete the google form will also have access to a free bonus material.

Many thanks in advance for your role in assisting us with the research and in improving safe coaching in South Africa.

Yours sincerely,

Anne Vermaak
CEO- Gymnastics SA

Marti Heri
National Development and Education Manager-Gymnastics SA

NB: For further information and reference don't hesitate to contact marti@sagf.co.za

Appendix E: Informed Consent Form

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD
HEALTH SCIENCES

Divisions of Communication Sciences & Disorders • Disability Studies • Nursing & Midwifery • Occupational Therapy • Physiotherapy

F45 Old Main Building, Groote Schuur Hospital
Observatory, Cape Town, South Africa, 7925
Telephone: +27 (0) 21 406 6401
Website: www.dhrs.uct.ac.za

Dear participant, thank you for taking the time to read this leaflet.

I am studying toward my Master's of Science in Exercise and Sports Physiotherapy (MSc Exercise and Sports Physiotherapy) at the University of Cape Town. I will be studying the knowledge, attitudes and practices of South African gymnastics coaches regarding injuries in the sport. This study has been given ethical approval by the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 516/2021).

It is well known that injuries in gymnastics happen during both training and competition. Often, coaches do not always witness every injury to every gymnast. At the same time, research shows that gymnasts commonly continue to train, while being injured. However, the knowledge, attitudes and practices of South African gymnastics coaches are not well known when looking at injuries in gymnastics. The results of this study may help to develop guidelines and programmes to inform gymnastics coaches about the ideal management of gymnastics injuries.

If you would like to be part of this study, you will need access to the internet; and be required to fill in an anonymous survey that will take 30-45 minutes to finish. The questionnaire can be found online, by the following link https://forms.gle/Pui9enqNQTNCLY4H6

Before filling in the survey, you will need to give informed consent to complete the questionnaire, by showing that you understood this information sheet and that you are happy to complete the survey. If you do not provide this consent, you will not be able to complete they survey. The questionnaire is completely confidential and there will be no way for any of the information to be linked to you.

The questionnaire will also ask you questions about: your coaching history, your knowledge of injuries, your attitude towards injuries, and your practices when injuries occur.

Being part of this study is voluntary. You may leave the study at any time while completing the survey. Once your survey has been submitted, you will no longer be able to remove your responses, as all responses are anonymous and not linked to an IP address.

Confidentiality and Anonymity

All survey responses will be anonymous and the collection of IP addresses will be actively disabled. All of the responses will be kept on a password-protected computer to protect the confidentiality of the data. The information from this questionnaire will only be used for this study. All the information given during this study is strictly confidential.

Possible Risks

There are no risks that are associated with this type of study and every effort will be made to make sure that the information stays confidential and anonymous.

Anticipated Benefits

Once you have completed your survey, you will be given a link to an infographic poster. You are able to download and print this poster for yourselves and your club. The poster aims to be a source of information that improves coaches and gymnasts understanding of injuries, and facilitate practices that promote optimal recovery after injuries. To reinforce the posters information, coaches will also receive an "Injury Pathway/Algorithm". This may be used to monitor a gymnasts recovery after an injury. You will not be paid for your participation in this study.

Contact Information

If at any time you have any questions about the study, please feel free to contact any of the people listed below. You are assured that all questions will remain confidential.

Dominic Rhodes (Investigator)

Tel: 073 048 8078

E-Mail: dominicalexanderrhodes@gmail.com

A/Prof Theresa Burgess (Research Supervisor)

Tel: 021 406 6171

E-Mail: theresa.burgess@uct.ac.za

A/Prof Niri Naidoo (Research Supervisor)

Tel: 021 406 6314

E-Mail: niri.naidoo@uct.ac.za

If you have any questions about the ethics of this study, please feel free to contact Professor Marc Blockman if you still aren't satisfied with the answers that the researchers have given you.

Professor Marc Blockman

Chair: The Research and Ethical Committee

Faculty of Health Sciences

University of Cape Town

Floor E52 Room 23

Old Main Building

Groote Schuur Hospital

Observatory

Tel: 021 406 6492

Appendix F: The KAP Survey

I confirm that I understand that purposes of this study, and what is required to take part in this study. I understand that I may contact the student researcher or any of the study supervisors with questions at any time during this study. I know that I am free to leave this study without prejudice. I understand that once the survey has been submitted, I will no longer be able to remove my responses, as all responses are anonymous and not linked to an IP address. Finally, I know that the information from the survey is confidential and will be revealed only as a number during statistical analyses.

I have carefully read the information sheet and informed consent form. I understand that nature, purpose and procedure of this study.

Please note that by accepting the option to participate in the study you are providing your informed consent.

☐ I accept the above statement and give my full permission to partake in this study.

☐ I DO NOT accept the above statement and DO NOT wish to partake in this study.

KAP Questionnaire Screening

Are you 18 years or older?	
Yes	No

Are you a qualified gymnastics coach, registered with the SAGF?

Yes	No

Section 1 – Personal History and Coaching Information

Demographic Information

What is your age?
___ Years

What is your gender?
• Male • Female • Other

In which province do you coach gymnastics?
• Eastern Cape • Free State • Gauteng • KwaZulu-Natal • Limpopo • Mpumalanga • Northern Cape • North West • Western Cape

Which gymnastics disciplines do you coach?
• Acrobatic Gymnastics • Aerobic Gymnastics • Gymnastics for All • Men's Artistic Gymnastics • Parkour • Rhythmic Gymnastics • Rope Skipping • Trampoline • Tumbling • Women's Artistic Gymnastics
Multiple selections possible

Please select the highest level of Gymnastics Qualification that you have achieved:
• Gymnastics Leader (GL) • GSA Level 1 Phase A • GSA Level 1 Phase B • FIG Level 1 • FIG Level 2 • FIG Level 3

Please select the highest level of tertiary (after high school) study that you may have achieved:
• Higher Certificate (NQF 4) • Advanced Certificate/National Diploma (NQF 5)

- Advanced Diploma (NQF 6)
- Bachelors (NQF 7)
- Honours (NQF 8)
- Masters (NQF 9)
- PhD (NQF 10)
- Other…

Coaching History

What is your main coaching discipline?
• Acrobatic Gymnastics • Aerobic Gymnastics • Gymnastics for All • Men's Artistic Gymnastics • Parkour • Rhythmic Gymnastics • Rope Skipping • Trampoline • Tumbling • Women's Artistic Gymnastics

What level of gymnast do you train??
• Level 1-3 • Level 4-6 • Level 7-10 • Level 11-14 • Age Groups/Classes (High Performance) • Junior Olympic

- Senior Olympic

Comments/Review:

Multiple selections possible.

What age range of gymnast do you coach?

- < 5 years
- 5 – 10 years
- 11 – 15 years
- 16 – 20 year
- 21 – 25 years
- 26 – 30 years
- > 31 years

Multiple selections possible.

How many years have you been this main coaching discipline?

- 0-11 months
- 1 year
- 2 years
- 3 years
- …
- 45 years
- 46+ years

Multiple selections possible

How many days per week do you coach gymnastics, on average?

- 1
- 2

- 3
- 4
- 5
- 6
- 7

How many hours do you spend coaching, on average, per week?
• 1 • 2 • 3 • 4 • … • 40 • 41+

How many gymnasts do you train, per year?
• 1 • 2 • 3 • 4 • … • 40 • 41+

Please select all gymnastics disciplines that you coach
• Acrobatic Gymnastics • Aerobic Gymnastics • Gymnastics for All • Men’s Artistic Gymnastics • Parkour • Rhythmic Gymnastics • Rope Skipping • Trampoline • Tumbling • Women’s Artistic Gymnastics
Multiple selections possible

Do you coach any other sporting codes? (e.g. basketball, swimming).	
Yes	No

Please insert other coaching qualifications you may have obtained to date.
•
Comments/Review: **Free text input**

Do you keep track of/ monitor injuries in your gymnasts? Do you use IRF; subjectively ask about injury;	
Yes	No

Follow up: Do you keep track of/ monitor injuries in your gymnasts – if yes, how?
• Free text input

Follow up: Do you keep track of/ monitor injuries in your gymnasts – if no, why not?
• Free text input

Coaches Personal Injury History

Were you a gymnast?	
Yes	No

If yes, how many years ago were you a gymnast?
• 0-11 months • 1 year • 2 years • 3 years • … • 45 years • 46+ years

Are you currently a gymnast?	
Yes	No

Please indicate the highest level of gymnastics at which you partake (if yes, from above)
• Level 1-3 • Level 4-6

• Level 7-10 • Level 10-14 • Age Groups/Classes (High Performance) • Junior Olympic • Senior Olympic

Please select all gymnastics disciplines in which you have participated (if you currently are/previously were a gymnast)
• Acrobatic Gymnastics • Aerobic Gymnastics • Gymnastics for All • Men's Artistic Gymnastics • Parkour • Rhythmic Gymnastics • Rope Skipping • Trampoline • Tumbling • Women's Artistic Gymnastics
Comments/Review: **Multiple selections possible**

Have you ever suffered from a gymnastics (or another sporting -) injury?	
Yes	No

Has this injury required treatment, from a healthcare professional?	
Yes	No

Have you hidden/minimised the fact that you were injured and required treatment, from your coaches, to continue training at your sport?	
Yes	No

Did you have a reason for hiding the injury? (What was your motivation for not mentioning your injury?)
• Free text option available

Injury 1

In this section, we would like to find out about your personal history with injuries.

(You will be able to complete an 'injury profile' for a maximum of 4 injuries)

Please indicate if past or current injury:	
Past	Current

Please indicate the area that was injured:
• Head • Neck • Shoulder • Upper arm • Elbow • Forearm • Wrist • Hand

- Chest
- Thoracic Spine
- Lumbosacral
- Abdomen
- Hip/Groin
- Thigh
- Knee
- Lower leg
- Ankle
- Foot
- Region unspecified
- Multiple regions

Please select the type of injury:
• Muscle / Tendon • Nervous • Bone • Cartilage / Synovium / Bursa • Ligament / Joint capsule • Superficial tissues / skin • Vessels • Internal organs • Non-specific • Not sure

- Other…

Please indicate the severity of the injury:
• Pain/symptoms only experienced after exercise • Pain/symptoms during exercise, but that does not affect training/competition • Pain/symptoms during exercise that affects training/competition negatively • Pain/symptoms so severe that I am unable to train or compete

If you were unable to continue training/coaching as a result of your injury, please indicate the time period (i.e.: from the day after your injury, to the day before you were able to resume sporting activity, at the uninjured level) of reduced sports participation.
• 0 days • 1 – 7 days • 8 – 28 days • >29 days

Please select the healthcare provider that may have assisted you for your injury (you may select more than one option)
• No treatment • Self-treated • Doctor • Physiotherapist • Chiropractor • Biokineticist

• Other…
Multiple selections possible

Please select how you were treated for the injury (you may select more than one option)
• Rest (from training/competition/coaching) • Ice / cold compression • Pain medication • Cortisone injection • Stretches • Other…
Multiple selections possible

Are there any other significant injuries that you need to list?	
Yes	No

Injury 2

In this section, we would like to find out about your personal history with injuries.

(You will be able to complete an 'injury profile' for a maximum of 4 injuries)

Please indicate if past or current injury:	
Past	Current

Please indicate the area that was injured:

- Head
- Neck
- Shoulder
- Upper arm
- Elbow
- Forearm
- Wrist
- Hand
- Chest
- Thoracic Spine
- Lumbosacral
- Abdomen
- Hip/Groin
- Thigh
- Knee
- Lower leg
- Ankle
- Foot
- Region unspecified
- Multiple regions

Please select the type of injury:

- Muscle / Tendon
- Nervous

- Bone
- Cartilage / Synovium / Bursa
- Ligament / Joint capsule
- Superficial tissues / skin
- Vessels
- Internal organs
- Non-specific
- Not sure
- Other…

Please indicate the severity of the injury:

- Pain/symptoms only experienced after exercise
- Pain/symptoms during exercise, but that does not affect training/competition
- Pain/symptoms during exercise that affects training/competition negatively
- Pain/symptoms so severe that I am unable to train or compete

If you were unable to continue training/coaching as a result of your injury, please indicate the time period (i.e.: from the day after your injury, to the day before you were able to resume sporting activity, at the uninjured level) of reduced sports participation.

- 0 days
- 1 – 7 days
- 8 – 28 days
- >29 days

Please select the healthcare provider that may have assisted you for your injury (you may select more than one option)
• No treatment • Self-treated • Doctor • Physiotherapist • Chiropractor • Biokineticist • Other…
Multiple selections possible

Please select how you were treated for the injury (you may select more than one option)
• Rest (from training/competition/coaching) • Ice / cold compression • Pain medication • Cortisone injection • Stretches • Other…
Multiple selections possible

Are there any other significant injuries that you need to list?	
Yes	No

Injury 3

In this section, we would like to find out about your personal history with injuries.

(You will be able to complete an ‘injury profile’ for a maximum of 4 injuries)

Please indicate if past or current injury:	
Past	Current

Please indicate the area that was injured:
• Head • Neck • Shoulder • Upper arm • Elbow • Forearm • Wrist • Hand • Chest • Thoracic Spine • Lumbosacral • Abdomen • Hip/Groin • Thigh • Knee • Lower leg • Ankle

- Foot
- Region unspecified
- Multiple regions

Please select the type of injury:
• Muscle / Tendon • Nervous • Bone • Cartilage / Synovium / Bursa • Ligament / Joint capsule • Superficial tissues / skin • Vessels • Internal organs • Non-specific • Not sure • Other…

Please indicate the severity of the injury:
• Pain/symptoms only experienced after exercise • Pain/symptoms during exercise, but that does not affect training/competition • Pain/symptoms during exercise that affects training/competition negatively • Pain/symptoms so severe that I am unable to train or compete

If you were unable to continue training/coaching as a result of your injury, please indicate the time period (i.e.: from the day after your injury, to the day before you were able to resume sporting activity, at the uninjured level) of reduced sports participation.
• 0 days • 1 – 7 days • 8 – 28 days • >29 days

Please select the healthcare provider that may have assisted you for your injury (you may select more than one option)
• No treatment • Self-treated • Doctor • Physiotherapist • Chiropractor • Biokineticist • Other…
Multiple selections possible

Please select how you were treated for the injury (you may select more than one option)
• Rest (from training/competition/coaching) • Ice / cold compression • Pain medication • Cortisone injection

• Stretches • Other…
Multiple selections possible

Are there any other significant injuries that you need to list?	
Yes	No

Injury 4

In this section, we would like to find out about your personal history with injuries.

(You will be able to complete an 'injury profile' for a maximum of 4 injuries)

Please indicate if past or current injury:	
Past	Current

Please indicate the area that was injured:
• Head • Neck • Shoulder • Upper arm • Elbow • Forearm • Wrist • Hand • Chest

- Thoracic Spine
- Lumbosacral
- Abdomen
- Hip/Groin
- Thigh
- Knee
- Lower leg
- Ankle
- Foot
- Region unspecified
- Multiple regions

Please select the type of injury:

- Muscle / Tendon
- Nervous
- Bone
- Cartilage / Synovium / Bursa
- Ligament / Joint capsule
- Superficial tissues / skin
- Vessels
- Internal organs
- Non-specific
- Not sure
- Other…

Please indicate the severity of the injury:
• Pain/symptoms only experienced after exercise • Pain/symptoms during exercise, but that does not affect training/competition • Pain/symptoms during exercise that affects training/competition negatively • Pain/symptoms so severe that I am unable to train or compete

If you were unable to continue training/coaching as a result of your injury, please indicate the time period (i.e.: from the day after your injury, to the day before you were able to resume sporting activity, at the uninjured level) of reduced sports participation.
• 0 days • 1 – 7 days • 8 – 28 days • >29 days

Please select the healthcare provider that may have assisted you for your injury (you may select more than one option)
• No treatment • Self-treated • Doctor • Physiotherapist • Chiropractor • Biokineticist • Other…
Multiple selections possible

Please select how you were treated for the injury (you may select more than one option)
• Rest (from training/competition/coaching) • Ice / cold compression • Pain medication • Cortisone injection • Stretches • Other…
Multiple selections possible

Are there any other significant injuries that you need to list?	
Yes	No

Injury Knowledge Questions

(In this section we aim to discover your knowledge regarding injuries in your gymnasts)

Injury definition

- Intrinsic risk: internal personal factors for injury. Intrinsic risk can be divided into modifiable (e.g. fitness level/skill level) and non-modifiable (e.g. age) risk factors.
- Extrinsic risk: external and/or environment risk factors

Can you please specify the importance of each of the following as **INTRINSIC** risk factors for injury in your gymnasts. (**Intrinsic Risk** – internal personal factors, which can be divided into modifiable risk factors (e.g. fitness level/skill level); and non-modifiable (e.g. age) risk factors.)

	Very Important	Important	Somewhat Important	Not Important	Not sure
Previous Injury					
Age					
Max. muscle strength					
Strength endurance (i.e. resistance to fatigue)					
Muscle imbalance (side to side differences)					
Muscle imbalance (agonist:antagonist e.g. biceps:triceps)					
Acute fatigue (e.g. following intense actions during training/competition)					
Accumulated fatigue (i.e. towards end of training/competition) [fatigue: Tiredness resulting from mental or physical exertion or illness, in sport often manifested as failure to maintain the required or expected force (or power output)]					
Accumulated fatigue (i.e. during term/semester) [Tiredness					

resulting from mental or physical exertion or illness, in sport often manifested as failure to maintain the required or expected force (or power output)]					
Physical fitness (cardio-respiratory/aerobic?)					
Balance/co-ordination					
Joint mobility (ROM is how far a joint can move in a given direction. Mobility then, is when we **take every ROM of** the joint and look at the total movement there is within a joint)					
Flexibility (**flexibility** is the ability of soft tissue structures, such as muscle, tendon, and connective tissue, to elongate through the available range of joint motion)					
Movement efficiency					
Sleep					
Psychological factors (e.g. stress/anxiety; mood; fatigue)					

Are there any other intrinsic risk factors? (Please specify with level of perceived importance)

Yes	No

Can you please specify the importance of the following as **EXTRINSIC** risk factors for injury in your gymnasts. (***Extrinsic Risk*** – *external and/or environmental risk factors*)

	Very Important	Important	Somewhat Important	Not Important	Not sure
Congested training schedule					
Congested competition schedule					
Training load (The cumulative amount of stress placed on an individual from a single or multiple training sessions (structured or unstructured) over a period of time.)					
Frequent travel					
Training facilities					
Recovery facilities					
Importance of competition (e.g. club competition vs. Nationals)					
Internal communication (i.e. between staff)					
Key staff changes (i.e. consistency of athlete's specific coach					
Coach education on injuries					

Are there any other extrinsic risk factors? (Please specify with level of perceived importance)

Yes	No

Please indicate your level of agreement to the following statements:

There is a decrease in strength after injury				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Injuries in young gymnasts, heal faster than in older gymnasts				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Gymnasts with disordered sleep may be at an increased injury risk.				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

It is common practice to continue gymnastics training while injured, as it promotes healing.				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Monitoring of injuries may help decrease the risk of athletes getting injured				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Previous injury increases the risk of re-injury				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Beginner athletes are more at risk of injury				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Elite athletes are more at risk of injury				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Injury risk cannot be changed				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Please indicate if you think the following statements are either True or False. If you are unsure of an answer, please select "Not sure"

Monitoring of injuries & prescription of training ~~should~~ promote the reduction of injuries.		
True	False	Not sure
Comments/Review: • Campbell et al (2019) • Correct answer highlighted • Only part of review process/memo		

Injuries increase re-injury risk		
True	False	Not sure
Comments/Review: • Campbell et al (2019) • Correct answer highlighted • Only part of review process/memo		

Most injuries are associated with floor exercise apparatus (for both males and females)		
True	False	Not sure
Comments/Review: • Campbell et al (2019) • Correct answer highlighted		

• Only part of review process/memo

Tumbling skills are most hazardous, with landing phase being the largest contributor to injuries (closely followed by falls)		
True	False	Not sure
Comments/Review: • Campbell et al (2019) • Correct answer highlighted • Only part of review process/memo		

Elite gymnasts more commonly feel pain when compared to their non-gymnast counterparts. This includes a higher pain rating, experiencing pain for a longer time, and pain in multiple body regions.		
True	False	Not sure
Comments/Review: • Sabati et al (2015) • Correct answer highlighted • Only part of review process/memo		

Females are more prone to injuries in their upper limbs; males are more prone to injuries in their lower limbs.		
True	**False**	Not sure
Comments/Review: • True statement: Females = lower limbs; males = upper limbs • Campbell et al (2019)		

- Correct answer highlighted
- Only part of review process/memo

Sprains and strains are most common in females; rotator cuff injuries are most common in males		
True	False	Not sure
Comments/Review: • Campbell et al (2019) • Correct answer highlighted • Only part of review process/memo		

As the gymnast progresses through the sport, injury risk factors increase, as well as the opportunity for the development of chronic injuries.		
True	False	Not sure
Comments/Review: • Kirialanis et al 2002 • Correct answer highlighted • Only part of review process/memo		

An increased competitive level, longer training sessions, competing at competitions and increased life stress **DECREASE** gymnasts injury risk		
True	**False**	Not sure
Comments/Review: • True statement: risk factors *INCREASE* injury risk • Campbell et al (2019)		

- Correct answer highlighted
- Only part of review process/memo

Increased frequency and intensity of training sessions leading to competition, increases the frequency of injuries sustained at competition		
True	False	Not sure
Comments/Review: • Grapton (2013) • Correct answer highlighted • Only part of review process/memo		

The health and safety of the gymnast should be more important than their sporting success		
True	False	Not sure
Comments/Review: • Grapton (2013) • Correct answer highlighted • Only part of review process/memo		

Intrinsic ('internal') risk factors are more easily changes than extrinsic ('external'). • ***Intrinsic Risk*** *– internal personal factors, which can be divided into modifiable (e.g. fitness level/skill level) and non-modifiable (e.g. age) risk factors.* • ***Extrinsic Risk*** *– external and/or environmental risk factors.*		
True	**False**	Not sure

Comments/Review:

- True statement: external risk is more easily modified than internal risk
- Grapton (2013)
- Correct answer highlighted
- Only part of review process/memo

Training programmes that improve performance and decrease injury risk are best supported by coaches, even though coaches may not always have access to the latest research

True	False	Not sure

Comments/Review:

- Saunders et al (2010)
- Correct answer highlighted
- Only part of review process/memo

Coaches remain the most influential individuals for implementing injury prevention programmes for athletes, because they are responsible for making injury prevention decisions, as well as promoting health behaviours.

True	False	Not sure

Comments/Review:

- Mawson, Creech et al (2018)
- Correct answer highlighted
- Only part of review process/memo

What is your understanding of injury prevention?

- Long answer, free text response available

To facilitate an increase in your injury knowledge, do you have any suggestions for information that you would find valuable for yourself and your gymnasts?
• Long answer, free text response available

Attitudes towards injuries

Please indicate you level of agreement to the following statements:

If I start to monitor injuries now, and I haven't before, others will think that I am a bad coach				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

With more information about injuries, I will be able to make better decisions that keep my gymnasts safe and minimise injury risk:				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

If a gymnast gets injured, it's because they weren't listening to me/following my instructions				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

When gymnasts get injured, it is because I was not pushing them to do their best				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Injuries are mainly the result of the gymnasts lack of focus/paying attention				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Injuries are mainly the result of the coach's lack of focus/paying attention				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

What emotion do you feel most commonly when your gymnast is injured? (e.g. scared, angry, frustrated)
•
Comments/Review: **Free text input**

To reinforce that injury prevention (IP) is not only the responsibility of the gymnastics coach, do you have any suggestions for IP information delivery methods to gymnasts and their parents?
• Long answer, free text response available

To ensure your continued commitment to IP for your gymnasts, what type of support system would you find most beneficial? (eg: regular small groups; monthly phone calls; bi-annual weekend 'refresher' courses etc.)
• Long answer, free text response available

Practices around injuries

Please indicate you level of agreement to the following statements:

I have previously pushed gymnasts to train while injured				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

I have witnessed injuries, and allowed gymnasts to continue training, because they didn't say anything				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

I promote rest after injuries				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

I monitor injuries with all my gymnasts				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

I would like more information on injuries and their risk factors, to help me make better decisions moving forward				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

With some guidance, I would consider monitoring injuries with all my athletes				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

I encourage all my athletes to let me know about all their injuries				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Please indicate which of the following tests you implemented to identify injury risk in your gymnasts, and it's perceived importance.						
	Implemented Yes/No	Very Important	Important	Somewhat Important	Not Important	Not sure
Rating of perceived exertion (RPE)						

Heart rate (during training)						
Heart rate variability						
Subjectively rated fatigue						
Subjectively rated sleep						
Subjectively rated muscle soreness						
Subjectively rated recovery status						
Objective measure of sleep (e.g.: sleep watches)						
Recovery of muscle force						
General medical screen						

In your understanding, what practices may best support injury prevention in the gymnastics athlete? (Please attempt to provide at least 3 factors)
• Long answer, free text response available

An important part of the injury prevention process is the recording and monitoring of gymnastics-related injuries. Please provide any suggestions for factors that would make the adoption and implementation of recording gymnastics injuries, easier.
• Long answer, free text response available

Appendix G: The Infographic

Injuries in Gymnastics

Why they happen & what we can do about them

Injury Location

Gymnasts use both their upper & lower limbs. We see a ± even distribution of upper-limb and lower-limb injuries in both female and male athletes.

Injury Risk Factors

Gymnast Risk Factors
e.g. Bigger body mass with a bigger body size.

Environmental Risk Factors
e.g. Buried trampolines during training; & above ground trampolines during competition.

What Happens During Injury?

When an athlete is injured, there is a decrease in muscle strength.

Muscle Strength

Time

- Injury
- Lag Phase
- Regeneration Phase
- Remodeling Phase

LAG PHASE ; 4-6 days.
The injured tissue is at its weakest.

REGENERATION PHASE; 2-12 weeks.
The injured tissue (e.g. muscle/tendon/ligament) is only about 15% strong.

REMODELING PHASE ; 6-12 months.
The aim here is to strengthen the scar without increasing inflammation; and to restore normal muscle strength, endurance and co-ordination.

Managament After Injury

Acute Management (Immediately after injury)
P.O.L.I.C.E

- **P**rotect (the injured site)
- **O**ptimally **L**oad (knowing that there's a decrease in muscle strength after injury, decreasing weight bearing [upper or lower limbs] is advised for the first 3-5 days after injury).
- **I**ce
- **C**ompress
- **E**levate

- Allow for adequate rest and recovery of the injured site after injury.
- Referral for extra help from health care providers (e.g. physiotherapist, doctor, chiropractor, hospital etc.) depending on the severity of the injury and availability of health services.

Appendix H: Frequency Table of Coaches' Likert Scale Responses.

Table 1. Frequency table of coaches' knowledge –indication of correct/incorrect/not sure to true/false statements (n=85)

	CORRECT	INCORRECT	NOT SURE
Monitoring of injuries & prescription of training promote the reduction of injuries [*True*]	81 (95.3%)	1 (1.2%)	3 (3.5%)
Injuries increase re-injury risk [*True*]	57 (67.1%)	15 (17.6%)	13 (15.3%)
Most injuries are associated with floor exercise apparatus (for both males and females) [*True*]	21 (24.7%)	40 (47.1%)	24 (28.2%)
Tumbling skills are most hazardous, with landing phase being the largest contributor to injuries (closely followed by falls) [*True*]	62 (72.9%)	9 (10.6%)	14 (16.5%)
Elite gymnasts more commonly feel pain when compared to their non-gymnast counterparts. This includes a higher pain rating, experiencing pain for a longer time, and pain in multiple body regions [*True*]	31 (36.5%)	11 (12.9%)	43 (50.6%)
Females are more prone to injuries in their upper limbs; males are more prone to injuries in their lower limbs [*False*]	37 (43.5%)	7 (8.2%)	41 (48.2)
Sprains and strains are most common in females; rotator cuff injuries are most common in males [*True*]	35 (41.2%)	13 (15.3%)	37 (43.5%)
As the gymnast progresses through the sport, injury risk factors increase, as well as the opportunity for the development of chronic injuries [*True*]	66 (77.6%)	7 (8.2%)	12 (14.1%)
An increased competitive level, longer training sessions, competing at competitions and increased life stress **DECREASE** gymnasts injury risk [*False*]	68 (80%)	10 (11.8%)	7 (8.2%)
Increased frequency and intensity of training sessions leading to competition, increases the frequency of injuries sustained at competition [*True*]	45 (52.9%)	18 (21.2%)	22 (25.9%)
The health and safety of the gymnast should be more important than their sporting success [*True*]	85 (100%)	-	-
Intrinsic ('internal') risk factors are more easily changed than extrinsic ('external') [*False*]	19 (22.4%)	42 (49.4%)	24 (28.2%)
Training programmes that improve performance and decrease injury risk are best supported by coaches, even though coaches may not always have access to the latest research [*True*]	80 (94.1%)	1 (1.2%)	4 (4.7%)
Coaches remain the most influential individuals for implementing injury prevention programmes for athletes, because they are responsible for making injury prevention decisions, as well as promoting health behaviours. [*True*]	81 (95.3%)	-	4 (4.7%)

Data expressed as number and percentage of respondents (N, %). The correct response is provided in square *brackets after the statement.*