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The prevalence and characteristics of chronic musculoskeletal pain in adult triathletes in South Africa

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Abstract

Background

Chronic pain, a growing problem globally, affects 11% to 55% of the world's adult population. The prevalence of chronic musculoskeletal pain amongst adult triathletes is unclear due to conflicting prevalence reports. The rise in sport participation at professional, amateur, and recreational levels, has led to an increase in the incidence of sports-related injuries among athletes and suggests that the prevalence of musculoskeletal injuries amongst triathletes, in particular, could also be increasing. However, pain and injury don't always go hand-in-hand. There is consistent support for exercise-induced analgesia and pain perseverance in athletes. The lack of prevalence studies of chronic musculoskeletal pain in adult triathletes does not provide a definitive estimate of prevalence, and therefore leaves a gap in our understanding of chronic pain, and the characteristics thereof, in this population group. Therefore, two studies were conducted: (i) a systematic review of the literature to determine the prevalence of chronic musculoskeletal pain in adult athletes competing in the sports of swimming, cycling and running and adult triathletes and (ii) a cross-sectional survey of South African triathletes to determine the prevalence of chronic musculoskeletal pain in this group.

Methods

Phase 1 : Systematic review

A systematic review was developed according to the Preferred Reporting Items of Systematic Reviews and Meta-Analysis Protocol (PRISMA-P) guidelines (Shamseer et al., 2015) and registered on PROSPERO [ID: CRD42020214094]. A customized search strategy containing relevant words and terms was used to search the following databases: MEDLINE/PubMed (via EBSCOhost), Cochrane Library, SCOPUS, SCIENCEDIRECT and AFRICA-WIDE INFORMATION (via EBSCOhost), Academic Search Premier, CINAHL, PsycArticles and PsycINFO. The risk of bias tool for prevalence studies was used to evaluate risk of bias in eligible studies. Studies were pooled for meta-analysis using the random effects model to determine a summary estimate of the prevalence of chronic musculoskeletal pain in triathletes across included studies. Statistical significance was set at a level of $p < 0.05$.

Phase 2: Cross-sectional survey

A cross-sectional study was conducted online via the social media platforms of Triathlon South Africa (TSA) and all other triathlon and multisport clubs in SA who gave approval. A password protected online survey using Microsoft Forms was created making use of a consent form, demographic questionnaire as well as the Brief Pain Inventory (BPI), Pain Catastrophising Scale (PCS) and the Tampa Scale for Kinesiophobia (TSK).

The sampling frame consisted of adult South African triathletes over the age of 18 years and currently participating in triathlon in SA in either the Sprint, Olympic, Half Iron Man or Iron Man distances. Sample size was calculated based on the estimated number of registered triathletes with TSA and its affiliated clubs. With a confidence level of 95% and a sampling of error of 5%, a sample of 333 would make our findings generalisable to the sampling frame. Ethical approval to conduct this study was granted from University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee.

Results

Phase 1: Systematic review

The initial literature search returned 590 records of which 588 remained after removal of duplicates. Initial screening of titles and abstracts identified 48 studies eligible for full-text review. Chronic musculoskeletal pain is experienced by athletes and triathletes with a pooled prevalence of48.96% and is consistent with global prevalence rates for chronic pain of between 11% and 55%. None of the literature reviewed reported on the effects of gender, culture, and level of income as possible contributing factors for chronic pain and none of the studies reported on whether the participants were disabled by their pain.

Phase 2: Cross-sectional survey

297 triathletes responded to the survey, a sample size sufficient for 89.19% confidence. The prevalence of chronic pain was 29.29%. The association between the presence of chronic pain, socio-demographic characteristics, training and injury history were explored by comparing each variable in those with chronic musculoskeletal pain to those reporting without chronic musculoskeletal pain.

Triathletes reporting chronic pain were significantly older than their counterparts. Apart from swimming, where those with pain were spending significantly longer training, the respondents showed no significant differences in training history or training characteristics. Respondents with chronic pain had sustained significantly fewer triathlon related injuries in the past 6 weeks than those without chronic pain. Conversely, respondents with chronic pain sustained more triathlon related injuries in the past 12 months . Respondents with chronic pain lost fewer training days due to injury in the last 6 months but lost more training days due to injury in the last 12 months.

Conclusion

The aim of this study was to determine the prevalence and characteristics of chronic musculoskeletal pain in adult triathletes in South Africa. The results of the systematic review and the cross-sectional survey offer substantial support for the hypothesis that chronic musculoskeletal pain is prevalent among adult triathletes. Notably, even with our small sample size, the results of the cross-sectional survey show a significant level of chronic pain without disability in this athletic population. We hope that future studies will explore the differences between chronic pain and high impact chronic pain (chronic pain with associated disability) and the effect thereof on participation on meaningful life roles in athletes. The role of physiotherapy in treating people with chronic pain is to minimise disability associated with pain, in both athlete and non-athlete populations.

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List of Abbreviations

BPI	Brief Pain Inventory
CLBP	Chronic low back pain
CI	Confidence interval
HREC	Human Research Ethics Committee
IASP	International Association for the Study of Pain
IQR	Interquartile Range
MSK	Musculoskeletal
PCS	Pain Catastrophising Score
PIS	Pain Interference Score
PRISMA-P	Preferred Reporting Items of Systematic Reviews and Meta-Analysis Protocol
PSS	Pain Severity Score
SA	South Africa
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
TSK	Tampa Scale for Kinesiophobia
TSA	Triathlon South Africa

Chapter 1: Introduction

Triathlon is an endurance sport comprising of swimming, cycling and running in one event (McHardy, Pollard, & Fernandez, 2006; Wicker, Hallmann, Prinz, & Weimar, 2012). Triathlon distances include the sprint event, comprising a 750m swim, a 20km cycle and a 5km run, the Olympic distance event which includes a 1500m swim, a 40km cycle and a 10km run, the long distance event or half Iron Man which is a 1.9km swim, an 80km cycle and a 21.1km run, and the Iron Man or ultradistance event which comprises of a 3.8km swim, a 180km cycle and a 42.2km run (McHardy et al., 2006; Neidel et al., 2019; Wu, Peiffer, Brisswalter, Nosaka, & Abbiss, 2014). The sport of triathlon is well-marketed, growing steadily and increasing in popularity in South Africa (Vlaeyen, Kole-Snijders, Boeren, & Van Eek, 1995). As triathlon is growing in popularity at competitive and recreational levels, so too is the risk of injury (Burns, Keenan, & Redmond, 2003). The rise in participation in sport at professional, as well as at amateur and recreational levels, has led to an increase in the incidence of sports-related injuries among triathletes in general (Ivković, Franić, Bojanić, & Pećina, 2007). The prevalence of painful musculoskeletal injuries amongst triathletes could, therefore, be increasing.

1.1 Pain

Pain forms part of the sensory system and is theorised to serve a protective function in response to potential threat (Moseley, 2017; Vlaeyen & Linton, 2012). It is a normal, conscious construct of the brain, and is defined by the International Association for the Study of Pain as “an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage”(Raja et al., 2020). Pain can be acute or chronic in nature.

Acute pain, is pain of recent onset, playing a protective role by alerting one to actual or potential physical injury, resolving within six weeks of onset and easing with healing (Stanos et al., 2016). Chronic pain, as defined by the IASP, is pain that occurs in one or more anatomical region, persists or recurs for more than three months and causes significant emotional distress and functional disability unaccounted for by any other condition with associated pain (Nicholas, Linton, Watson, & Main, 2011). Chronic musculoskeletal pain, as per the IASP definition, is pain arising from musculoskeletal structures such as bones or joints (Treede et al., 2019).

Nociception, a subconscious, physiological process involves the processing and transmission of noxious stimuli i.e., actual or potential tissue damaging events (Baliki & áVania Apkarian, 2015). The neurons responding to these noxious stimuli are called nociceptors. It is important to note that pain and nociception are not the same and that nociception occurs in the absence of pain perception (Moseley, 2017).

Chronic pain, a growing problem globally, affects 11% to 55% of the world's adult population, placing a strain on healthcare worldwide and occurs in association with many debilitating musculoskeletal disorders such as osteoarthritis and chronic low back pain (Daenen, Varkey, Kellmann, & Nijs, 2015).

Low back pain is the leading cause of disability globally with more than 85% of people with low back pain having no specific structural cause for their pain (Mousavi, van Dieën, & Anderson, 2019). Osteoarthritis, a common painful and often disabling disease, continues to increase in prevalence in high and low income countries, including South Africa (Saw, Kruger-Jakins, Edries, & Parker, 2016). In people living with chronic pain conditions, fear avoidance behaviours, fear of movement or re-injury and fear avoidance beliefs are strongly related with disability (Vlaeyen et al., 1995). This can lead to pain catastrophising as a result of painful experiences which may be exacerbated by movement, leading to more fear of movement and further avoidance behaviours, with resultant disuse atrophy, depression, reduction in pain tolerance and increased disability (Houben, Leeuw, Vlaeyen, Goubert, & Picavet, 2005; Vlaeyen & Linton, 2012). Thus, chronic pain and the disability often accompanying it, are mediated by biopsychosocial factors (Vlaeyen et al., 1995). One of the biopsychosocial factors recognised to influence chronic pain and disability is exercise.

Research provides consistent support for the reduction in pain sensitivity after exercise or the phenomenon of exercise-induced hypoalgesia (Flood, Waddington, Thompson, & Cathcart, 2017). A systematic review and meta-analysis comparing pain sensitivity in athletes against normally active controls, concluded that people who participated in regular vigorous exercise, as performed by athletes, had a higher tolerance for pain when compared to controls (Tesarz, Schuster, Hartmann, Gerhardt, & Eich, 2012).

Further evidence suggests that participating in vigorous physical activity can increase pain tolerance in healthy adults and studies investigating the effect of aerobic exercise on healthy nonathletes, shows increases in pain tolerance with aerobic exercise (Ransdell, Vener, & Huberty, 2009; Umeda, Lee, Marino, & Hilliard, 2016). Regular physical activity and exercise is associated with a reduction in the excitability of central neurons, changes neuroimmune signalling in the central nervous system and causes an increase in the release of endogenous opioids and serotonin levels in the inhibitory pathways for nociception in the brainstem (Law & Sluka, 2017). Exercise clearly affects nociceptive and pain processes, similarly pain affects participation in exercise.

Pain affects everything from sleep, to eating, mood, social interactions and most importantly, activities of daily living, therefore reducing activities and participation in meaningful life roles resulting in disability (Nicholas et al., 2011). Pain can alter the way in which the central nervous system works. Therefore, a person in pain can become hypersensitive and experience an increase in pain with little or no provocation (Daenen et al., 2015; Latremoliere & Woolf, 2009). As a result, incoming afferents from a nociceptor can activate adjacent nociceptive pathways due to overstimulation, causing hyperalgesia and maintenance of pain (Millan, 1999; Woolf, 2011). Central sensitization, plays a pivotal role in chronic pain conditions and is defined as an increase in response, by central neurons to input from unimodal and polymodal receptors (Nijs, Van Houdenhove, & Oostendorp, 2010). Central sensitization, is the outcome of a variety of molecular, cellular and circuit changes in the central nervous system and is responsible for maintaining pain even after the initial injury has healed (Woolf, 2011). Pain can modify the way the central nervous system works. Thus, one can become more sensitive to a painful stimulus. This hypersensitivity can lead to an increase in pain levels with a decrease in pain provocation (Millan, 1999). It is clear that the experience of pain is complex and affected by biopsychosocial factors that make it unique to each individual.

The brain plays a central role in pain and stress responses, with the limbic system pivotal in integrating incoming nociceptive and stress signals (Vlaeyen & Linton, 2012). One of the mechanisms theorised to contribute to the development of chronic pain is ongoing nociceptive input or ongoing stress, specifically distress.

If either nociception or stress becomes chronic, the ensuing long-term maladaptive changes (behavioural and physiological), can negatively affect one's overall well-being (Abdallah & Geha, 2017; Vlaeyen & Linton, 2012).

Central sensitization is associated with an increase in activity of the pain neuromatrix with an element of control from the amygdala or "fear-memory centre" of the brain (Iannetti & Mouraux, 2010; Nijs, Girbes, Lundberg, Malfliet, & Sterling, 2015). Therefore, chronic pain is often associated with fear of movement and pain catastrophising (Vlaeyen & Linton, 2012). Both fear of movement and pain catastrophising further inhibit the endogenous opioid system, resulting in an "elevated immune response" and the release of pro-inflammatory cytokines (Porreca, 2015).

It is postulated that regular exposure to intense pain may force athletes into developing efficient pain coping strategies (Tesarz, Gerhardt, Schommer, Treede, & Eich, 2013). Endurance athletes, such as triathletes, may be exposed to significant amounts of pain whilst training and competing, and the resultant effect on their pain-related psychological processes is, an increased pain tolerance (Roebuck et al., 2018). Exercise-induced hypoalgesia, a form of endogenous pain modulation, has been characterised by increases in pain thresholds and tolerance as well as a reduction in pain intensity during and after exercise (Koltyn, Brellenthin, Cook, Sehgal, & Hillard, 2014).

As pain is multidimensional in nature, biological, psychological and social factors that contribute to pain and the development of chronic pain should be considered when understanding the epidemiology of chronic pain (Moseley, 2017). When evaluating chronic pain, one must, therefore, ensure the use of appropriate tools in an attempt to gain a holistic awareness of the functional and psychological status of people with chronic pain.

1.2 Chronic musculoskeletal pain in triathletes.

Triathlon is a highly demanding sport that does not allow for long periods of recovery from injuries or recovery essential for the prevention of exercise-induced muscle injuries (Hotfiel et al., 2019). Muscle fibre damage seems to be a key factor in muscular fatigue associated with triathlons and triathlon training due to the rigours of training and competitions where athletes endure pain and stress for up to several hours at a time (Geva & Defrin, 2013; Hotfiel et al., 2019). Muscle injuries and delayed onset muscle soreness can result in impaired muscle performance (Hotfiel et al., 2019).

A study investigating the incidence of neck and discogenic pain in triathletes, with the main aim being to identify risk factors in this population group, concluded that sports-related injuries and overuse injuries were the two major factors contributing to long term injuries in triathletes (Alan, Theresa, Sigita, & Jeff, 2007). Another study investigated the incidence of low back pain amongst a sample of 92 Japanese triathletes (Manninen & Kallinen, 1996). This was a mixed gender sample with the main aim being to establish the incidence of low back pain amongst triathletes. Low back pain, which accounted for 28% of all the injuries reported in the aforementioned study, was, however, exceeded by knee pain with a 33% incidence.

A 2013 study investigated alterations in pain perceptions and pain modulation of triathletes, together with possible underlying factors (Geva & Defrin, 2013). The triathletes showed higher pain tolerance, lower pain ratings, and lower fear of pain than controls. Their conditioned pain modulation was significantly greater, showing a negative correlation with fear of pain and perceived mental stress whilst training, and during competition in comparison to controls. The greater pain tolerance and more efficient pain modulation in triathletes may contribute to their ability to persevere despite pain during training and competition and may be enhanced by psychological factors such as self-motivation, positive self-talk, and emotional control resulting in more efficient ways of coping with fear of pain and mental stress (Serpell, 2019). These alterations in physiological responses to nociception recorded in triathletes may result in a difference in the prevalence of chronic musculoskeletal pain when compared to other population groups. A difference in the prevalence rate in this group of athletes is relevant as pain frequently interferes with sport training (a meaningful life role) and functioning in activities of daily living. It is evident, from the literature reviewed thus far, that a gap exists in the research. None of the identified studies focused on the prevalence and characteristics of chronic musculoskeletal pain in triathletes.

1.3 Study Aims

The aims of this study were to determine the prevalence and characteristics of chronic musculoskeletal pain in adult triathletes as described in the literature and in adult South African (SA) triathletes. Therefore, two studies were conducted: (i) a systematic review of the literature to determine the prevalence and characteristics of chronic musculoskeletal pain in adult athletes competing in the sports of swimming, cycling and running, and adult triathletes and (ii) a cross-sectional survey of South African triathletes to determine the prevalence and characteristics of chronic musculoskeletal pain in this group.

Chapter 2: Systematic Review

Triathlon is an endurance sport comprising of swimming, cycling and running in one event (McHardy et al., 2006; Wicker et al., 2012). The distances vary from the short event comprising a 750m swim, a 20km cycle and a 5km run, to the ultradistance event, known as the Ironman, which is made up of a 3.8km swim, a 180km cycle and a 42km run (Hotfiel et al., 2019; McHardy et al., 2006). The sport of triathlon is well-marketed, growing steadily and increasing in popularity in South Africa (Wicker et al., 2012). The rise in sport participation at professional, amateur, and recreational levels, has led to an increase in the incidence of sports-related injuries among athletes in general (Ivković et al., 2007). This notable rise, therefore, suggests that the prevalence of musculoskeletal injuries amongst triathletes in particular could also be increasing.

Pain, a normal conscious construct of the brain, is defined by the International Association for the Study of Pain (IASP) as "an unpleasant sensory and emotional experience associated, or resembling that associated with, actual or potential tissue damage"(Raja, et al., 2020). Pain can be acute or chronic in nature. Acute pain, is pain of recent onset, playing a protective role by alerting one to actual or potential physical injury, resolving within six weeks of onset and easing with healing (Stanos et al., 2016). Chronic pain, as defined by the IASP, is recurring pain that persists for more than three months (Treede et al., 2019). Chronic pain, a growing problem globally, affects 11% to 55% of the world's adult population, placing a strain on healthcare worldwide (Daenen et al., 2015). Chronic pain and the disability often accompanying it, are mediated by a range of biopsychosocial factors (Vlaeyen et al., 1995).

Injury in the context of sport is defined as "tissue damage or other derangement of normal physical function due to participating in sports as a result of rapid or repetitive transfer of kinetic energy" (Bahr et al., 2020). Because pain and tissue damage or injury don't always go hand-in-hand, it is possible to have pain without injury, to have pain after the injury has healed and to have an injury without any pain (Moseley, 2017). The dissociation between pain and injuries can be understood when the physiology of pain is explored.

There is consistent support for a reduction in pain sensitivity after exercise or exercise-induced analgesia (Flood et al., 2017).

A meta-analysis comparing pain sensitivity in athletes compared to normally active controls, concluded that regular vigorous exercise, as performed by athletes, imparts a higher tolerance for pain (Tesarz et al., 2012). More recent evidence suggests that participating in vigorous physical activity can increase pain tolerance in healthy adults (Umeda et al., 2016). These findings support investigations of the effect of aerobic exercise on healthy non-athletes, showing increases in pain tolerance (Ransdell et al., 2009).

Regular physical activity and exercise have been shown to reduce the excitability of central neurons, change neuroimmune signalling in the central nervous system and cause an increase in the release of endogenous opioids and an increase in serotonin levels in the inhibitory pathways for nociception in the brainstem, thus buffering the system for pain (Law & Sluka, 2017). These changes in the central nervous system as a result of regular exercise may contribute to athletes' physical perseverance when in pain during training and competition. In addition, the changes as a direct result of exercise may be further enhanced by psychological factors such as self-motivation, positive self-talk and emotional control resulting in more efficient ways of coping with fear of pain and mental stress (Serpell, 2019). The combination of these biopsychosocial factors may lead to the assumption that people who regularly participate and compete in sports such as triathlon may be protected from developing chronic pain.

However, the lack of prevalence studies of chronic musculoskeletal pain in adult triathletes does not provide a definitive estimate of prevalence, and therefore leaves a gap in our understanding of chronic musculoskeletal pain, and the characteristics thereof, in this population group. Due to the lack of literature, a study to determine an estimate of the prevalence of chronic musculoskeletal pain in adult triathletes is indicated to develop an informed conclusion on this subject. Therefore, we conducted a systematic review of the literature to determine the prevalence of chronic musculoskeletal pain in adult athletes and triathletes.

2.1 Methods

A systematic review protocol was developed according to the Preferred Reporting Items of Systematic Reviews and Meta-Analysis Protocol (PRISMA-P) guidelines (Shamseer et al., 2015). The review protocol was registered on PROSPERO [ID: CRD42020214094]. The PRISMA criteria fulfilled by this systematic review are presented in Appendix A.

2.1.1 Data sources and search procedure

The lead investigator (GF) and a senior health sciences librarian used a comprehensive search strategy [Appendix B] with Medical Subject Headings (Kartiosuo et al., 2019) including: prevalence, chronic musculoskeletal pain, triathletes, athletes, adults, to search for relevant articles published between 1971 and 2020 from the following databases: MEDLINE/PubMed (via EBSCOhost), Cochrane Library, SCOPUS, SCIENCEDIRECT and AFRICA-WIDE INFORMATION (via EBSCOhost), Academic Search Premier, CINAHL, PsycArticles and PsycINFO. The reference lists of all eligible studies were searched manually to identify any additional studies that could be included in this review. Identified studies were saved in the EndNote X9 manager software program which was also used to remove duplicates (Agrawal & Rasouli, 2019). Grey literature was searched using OpenGrey www.opengrey.eu.

2.1.2 Study selection

We included cross-sectional and cohort studies that investigated the prevalence and characteristics of chronic musculoskeletal pain in athletes and triathletes who were 18 years or older. The initial search for studies including triathletes only, yielded only one study. Therefore, the search terms were expanded to include studies which included “athletes” with the goal of including studies of athletes participating in the individual sports which comprise triathlon i.e., swimming, cycling, and running. Case studies, case series, intervention studies and literature reviews were excluded. Two reviewers (GF and KL) independently screened the study titles and abstracts for eligibility for full-text review. The two independent reviewers assessed the full-text articles for eligibility using the inclusion/exclusion criteria (Table 1) Microsoft Excel spreadsheet was used to classify each of the studies as either eligible or ineligible. In this we deviated from the registered protocol which specified the use of Covidence, because Covidence has limited usability offline.

A PRISMA flow diagram (Figure 1) represents the entire screening process, detailing the numbers of included and excluded studies, with reasons for exclusion. At the end of each stage, results were compared, and disagreements resolved through discussion.

Table 1 Criteria for selection

Inclusion criteria	Exclusion criteria
Study design and participants: published and unpublished prevalence longitudinal studies, cross-sectional studies and cohort studies on chronic musculoskeletal pain in adult triathletes and athletes	Case studies
Outcome: prevalence of chronic musculoskeletal pain and/or risk factors for musculoskeletal pain in adult triathletes	Case series
Study setting: studies conducted worldwide on adult athletes and triathletes	Intervention studies
Language of publication: studies published in English	
Years: 1971-2020 as relevant literature relating to our study was found in this period	

The two reviewers were Glenda Francis (this current author) and Katleho Limakatso. GF is in private practice in Cape Town and is associated with the Department of Physiotherapy, University of Cape Town. KL is associated with the Department of Anaesthesia and Perioperative Medicine, University of Cape and the Pain Unit, University of Cape Town, D23.30 Groote Schuur Hospital, Observatory, Cape Town 7925, South Africa Town, Cape Town, South Africa
The third, independent reviewer, was Romy Parker. RP supervised this project and is associated with the Department of Anaesthesia and Perioperative Medicine, the Pain Unit and the Department of Physiotherapy, University of Cape Town, D23.30 Groote Schuur Hospital, Observatory, Cape Town 7925, South Africa Town, Cape Town, South Africa

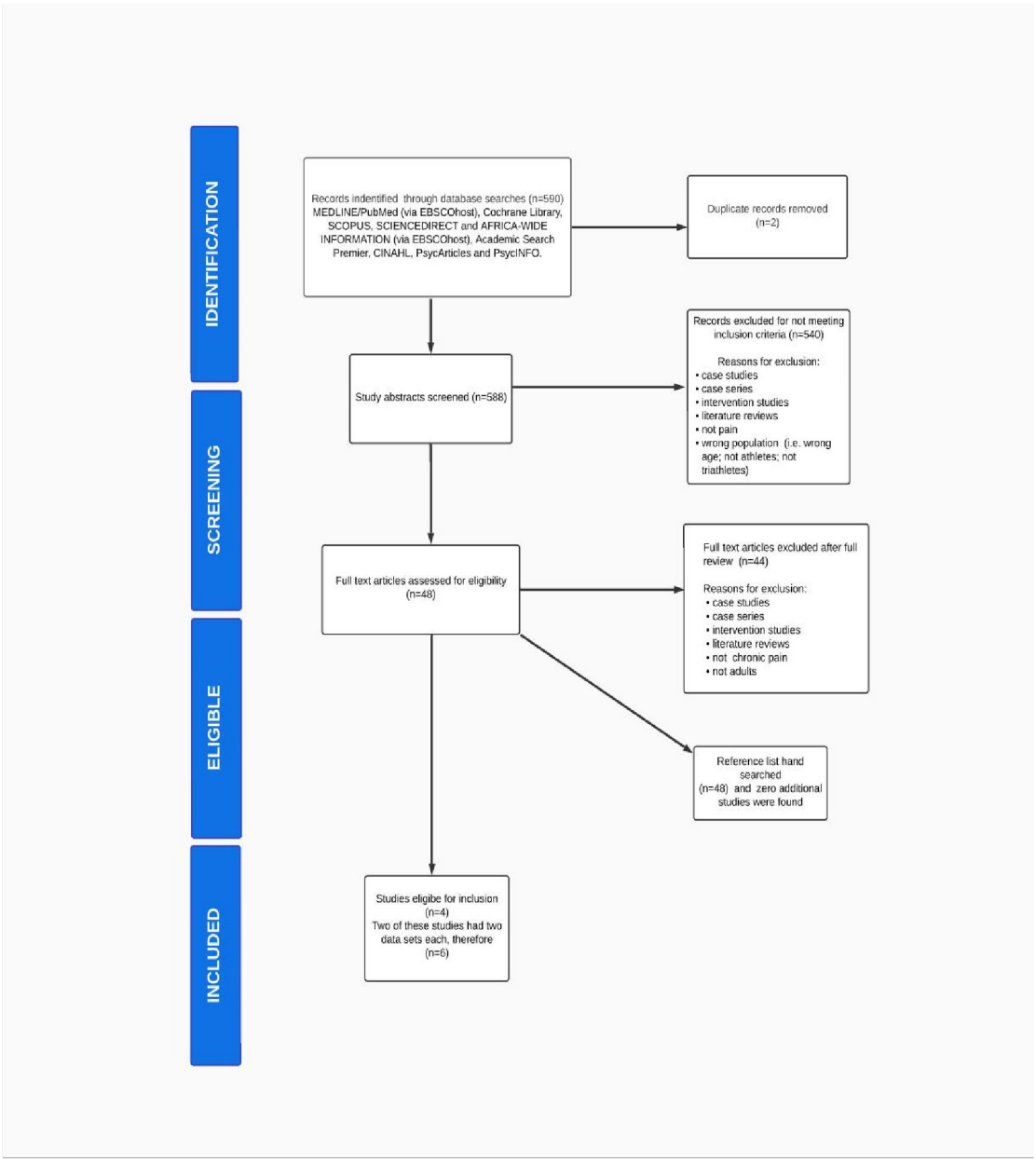

Figure 1 PRISMA Flow Diagram

(Shamseer et al., 2015)

2.1.3 Risk of bias assessment

The reviewers (GF and KL) independently assessed all included studies for risk of bias by making use of a risk of bias assessment tool for prevalence studies [Appendix C](Hoy et al., 2012). This tool assesses the risk of bias based on 10 categories which evaluate a study's internal and external validity. Each category of this tool was set as "high risk' if the study scored "high risk" for any single item within that category and "low risk" if it scored "low risk" for items in that category. The summary risk of bias rating for each study was presented as "low risk" (score: 0-3), "moderate risk" (score: 4-6) or "high risk" (score: 7-10). Disagreements between reviewers were resolved by discussion.

2.1.4 Data extraction

Two independent reviewers (GF and KL) independently extracted relevant data using a piloted customized data extraction sheet. The following data were extracted: authors, year of publication, study type, country of study, study setting, method of data collection, sample size, participants' age, chronic musculoskeletal pain characteristics and prevalence, risk factors and measure of association.

2.1.5 Data analysis

Data extracted from individual studies were analyzed descriptively. Cohen's Kappa was calculated to determine the level of inter-rater agreement during screening, data extraction and risk of bias assessment, and was presented as minimal (0-0.39), weak (0.40-0.59), moderate (0.60-0.79) or strong (0.80-0.90)(Cohen, 1960). The risk of bias summary [Appendix D shows the overall risk of bias of all the included studies in this review. To determine the prevalence of chronic pain, the data were pooled, and weighted means ($\overline{x}$) calculated for prevalence of the same or similar sites of pain using the formula: $\overline{x} = \frac{w1x1+w2x2}{w1+x2}$ where, w = sample size for that characteristic and

and x = prevalence.

Confidence interval (CI) is reported at 95%.

2.2 Results

The initial literature search returned 590 records of which 588 remained after removal of duplicates. Initial screening of titles and abstracts identified 48 studies that were eligible for full-text review. Full-text review identified six studies that were eligible for inclusion in this systematic review but after further analysis, two studies did not meet the inclusion criteria and were thus excluded. Two of the studies reported two studies each, therefore, a total of six data sets were included in our analysis. The entire screening process reflected strong agreement (Kappa = 0.90) between reviewers.

2.2.1 Risk of bias

The results of the risk of bias assessment are reported in Appendix D. All the studies included in this review scored high risk for using a sample that was not a close representation of the national population of triathletes. All the included studies scored high risk for not using a random selection process during recruitment. Three of the four included studies scored high risk for a recruitment response rate of less than 75% (Nakata Teixeira, Lunardi, Aparecido da Silva, Dias Lopes, & Carvalho, 2016; Oliveira de Almeida, Hespanhol Junior, & Dias Lopes, 2015; Villavicencio, Burneikiene, Hernández, & Thramann, 2006). All the included studies scored high risk for not providing an acceptable definition for pain (Clarsen, Krosshaug, & Bahr, 2010; Nakata Teixeira et al., 2016; Oliveira de Almeida et al., 2015; Villavicencio et al., 2006). All the included studies scored high risk for using an instrument that has not been shown to have reliability or validity. All the included studies scored low risk for using the same mode of data collection. Three of the four studies scored high risk for the likelihood of non-response bias and the remaining study (Clarsen, Krosshaug, & Bahr, 2010) scored low risk. Three of the included studies scored low risk for appropriate length of the shortest prevalence period for the parameter of interest and the fourth study (Villavicencio et al., 2006) scored high risk. All the included studies scored low risk for providing appropriate numerator and denominator for the parameter of interest. Three of the four included studies scored moderate risk for the overall risk of bias and the remaining study (Villavicencio et al., 2006) scored high risk. The risk of bias assessment on 44 items revealed strong agreement (Kappa = 0.99) between reviewers.

2.2.2 Study characteristics

The study characteristics are summarized in Table 2. The included studies (n=6) used cross-sectional designs. Two of the studies were conducted in the United States of America, two in Norway and two in Brazil. Two of the studies were conducted online using online questionnaires, two at training camps via face-to-face interviews and two at competitions. Of the two studies conducted at competitions, one study made use of a questionnaire and the remaining study was conducted using a face-to-face interview**.** Table 2 reflects the similarity in data collection approaches used. Included studies were published between 2006 and 2016.

2.2.3 Participant characteristics, prevalence and characteristics of chronic musculoskeletal pain

The included studies provided data from a total of 659 participants (Table 2). Two of the studies did not specify the number of participants identifying as either male or female. Participants ages ranged from 20-68 years. Participants in two of the studies were triathletes, the participants in two studies were road cyclists, participants in one study were marathon runners and in one study were swimmers.

The sites of pain were reported as being in the back, neck, low back, knee and musculoskeletal.

The prevalence of pain across included studies is shown in Table 2. The prevalence of “back pain” was estimated to be between 63%-67.80%, “neck pain” 48.30%, “knee pain” 39%, whilst “musculoskeletal pain” had an estimated prevalence of 21%-75%. Prevalence of “chronic low back pain” was 23.70%, “chronic cervical pain” 21.40% whilst “chronic knee pain” and “chronic musculoskeletal pain” were not reported on further.

The pooled data for participants with “back pain” yields a sample size of 203 of which 132 participants reported having “back pain”. This is a 65.02% (95%CI 58.04%-71.57%) prevalence of “back pain”. The pooled data for participants with “musculoskeletal pain” yields a sample size of 456 of which 203 participants reported experiencing “musculoskeletal pain”. This is a prevalence of 44.52% (95%CI 39.89%-49.21%). Table 2 shows a breakdown of the prevalence rates for each of the included studies in this systematic review.

2.2.4 Risk factors for chronic musculoskeletal pain

Two of the included studies (Table 2) identified previous sport-related injuries as a risk factor for developing “chronic musculoskeletal pain” and one study identified number of triathlons completed as a potential risk factor. The other four did not report potential risk factors for developing “chronic musculoskeletal pain”.

Table 2 Study and participant characteristics

Authors	Year of Publication	Study Type	Country of Study	Study Setting	Method of Data Collection	Sample Size	Sample Size (M/F)	Participants' age	Site of pain	Prevalence (%)	Risk Factors	Measure of association
Villavicencio	2006(a)	Cross-sectional	USA	Online	Online questionnaire	87	31/56	36.1 (20-68)	Back	67.80	Number of triathlons Previous sports-related injuries	(p=0.02)* (p<0.00001)*
Villavicencio	2006(b)	Cross-sectional	USA	Online	Online questionnaire	87	31/56	36.1 (20-68)	Neck	48.30	Previous sports-related injuries	(p<0.00001)*
Clarsen, B.	2010 (a)	Cross-sectional	Norway	Training camp	Face-to-face interview	116	___	26±4	Low back	63	___	___

Clarsen, B.	2010 (b)	Cross-sectional	Norway	Training camp	Face-to-face interview	116	___	26±4	Knee	39	___	___
Oliveira de	2015	Cross-sectional	Brazil	Competition	Questionnaire	257	140/117	20.1±3.8	Musculoskeletal	21	___	___
Nakata Teixeira	2016	Cross-sectional	Brazil	Competition	Face-to-face interview	199	164/35	34 (30-39)	Musculoskeletal	75	____	___

**Logistic regression analysis was used to determine these associations*

2.2.5 Characteristics of pain

The nature of pain was presented as acute, subacute, and chronic pain (Table 3). This allowed further insight into the pain experienced by the athletes in these studies. Intensity and frequency of pain were not reported consistently across all the studies included in this review.

The pooled data for "acute back pain" in this sample size of 203 participants was 99 with a prevalence of 48.77% (95%CI 41.7%-55.86%). The pooled data for "subacute back pain" (n=203) was 28 with a prevalence of 13.79% (95%CI 9.37%-19.31%). The pooled data for "chronic back pain" (n=203) was 24 with a prevalence of 11.82% (95% CI 7.72%-17.08%).

Table 3 Characteristics of pain

Characteristics	Duration		
	Acute (%)	Subacute (%)	Chronic (%)
Low back pain (Villavicencio et al., 2006),(Clarsen et al., 2010)			
Prevalence	62.70% 37.93%	13.60% 13.79%	23.70% 2.58%
Intensity (VAS Score)	1-10 -	3-9 -	3-10 -
Frequency	1-6 -	1-6 -	3-6 -
Cervical pain (Villavicencio et al., 2006)			
Prevalence	67.70%	11.90%	21.40%
Intensity (VAS Score)	1-8	4-8	4-9
Frequency	1-6	3-6	6

Knee pain (Clarsen et al., 2010)			
Prevalence	27.58%	6.03%	0
Intensity	-	-	-
Frequency	-	-	-
Musculoskeletal pain (Oliveira de Almeida et al., 2015),(Nakata Teixeira et al., 2016)			
Prevalence	21% (no subcategories) 75% (no subcategories)	-	-
Intensity (VNS)	– 8-10 (29%) intense	- 3-7 (42%) moderate	- 1-2 (29%) mild
Frequency	3.70% (continuous pain)	- -	- -

**Where a characteristic was not reported, it is denoted by a dash (-)*

2.3 Discussion

To our knowledge, this is the first systematic review to pool literature on the prevalence and characteristics of chronic musculoskeletal pain in athletes and triathletes. Globally, chronic pain affects 11% to 55% of the world's adult population (Daenen et al., 2015). The pooled prevalence of pain in this systematic review population (n=659) is similar to global prevalence rates at 48.96% (95%CI 45.57%-52.35%).

Low back pain is the leading cause of disability globally with more than 85% of low back pain patients reporting no specific musculoskeletal cause for their pain (Mousavi et al., 2019). In this systematic review, the pooled prevalence for low back pain was 65.02% (95%CI 58.04%-71.57%), within the global prevalence for "chronic pain". Further breakdown of prevalence reveals a pooled prevalence of 11.82% (95% CI 7.72%-17.08%) for "chronic low back pain" (CLBP) in this population. This is lower than global prevalence rates for CLBP at 19.60% for those between the ages of 20 and 59 years (Meucci, Fassa, & Faria, 2015). As the population in this study were athletes, the question arises as to the possible risk factors for their pain. In addition to the previously identified biopsychosocial risk factors for "chronic low back pain", "chronic low back pain" in athletes appears to also be related to the number of triathlons they competed in and/or previous sports-related injuries as reported in two of the studies in this review (Villavicencio et al., 2006).

All the studies included in this review scored high risk of bias for using a sample that was not a close representation of the national triathlete population as well as for not using a random selection process during recruitment, and for not providing an acceptable definition for pain. These methodological issues could have contributed to an overestimation of pain prevalence with recruitment bias. These weaknesses, together with the two studies that did not report on gender (male or female), makes it more difficult to generalise findings to the athlete and triathlete population groups, thereby, making comparisons with the general population difficult as well.

It is evident, from the material reviewed thus far, that a gap exists in the research. The cohort of athletes in this review was comprised of road cyclists, swimmers, marathon runners and triathletes. None of the studies reviewed focussed on the prevalence of chronic musculoskeletal pain in adult triathletes as a defined population. Gender differences relating to pain were not fully reported as two of the included studies did not report on gender. None of the included studies reported differences in pain experienced by these athletes relating to age or education. when determining the prevalence of chronic pain in this athletic population.

2.4 Conclusion

This systematic review included six data sets (n=659) of cross-sectional studies carried out in runners, cyclists, swimmers and triathletes from the United States of America, Norway, and Brazil. It is apparent from the literature in this review that chronic musculoskeletal pain is commonly experienced by athletes and triathletes and that the prevalence of chronic pain in these athletes and triathletes is consistent with global prevalence rates. However, none of the literature reviewed reported on the effects of variables known to increase risk of chronic pain in the general population (gender, culture, and level of income) as possible contributing factors for chronic pain or chronic musculoskeletal pain in this population, and none of the studies reported on whether the participants were disabled by their pain i.e., were unable to participate in meaningful activities such as their sport, because of their chronic pain or chronic musculoskeletal pain.

To date, no studies focussing on the prevalence or characteristics of chronic musculoskeletal pain as experienced by adult triathletes in Africa or South Africa were identified. Thus, little is known about the prevalence and characteristics of chronic musculoskeletal pain in South African triathletes. Prevalence studies in this population group have the potential to give researchers more insight into the characteristics of chronic musculoskeletal pain in this population and provide insight into the factors which contribute to disabling or high impact chronic musculoskeletal pain or which mitigate against disability.

Chapter 3: Methods for Cross-sectional survey

In this chapter, Phase II of the studies, a cross-sectional survey to determine the prevalence of chronic musculoskeletal pain in South African triathletes will be reported on.

3.1 Aims

The purpose of this survey was to determine the prevalence and characteristics of chronic musculoskeletal pain in adult triathletes in South Africa.

3.2 Objectives

In a group of adult triathletes, to determine:

- the prevalence, nature, and characteristics of pain using the Brief Pain Inventory (BPI) (Cleeland & Ryan, 1991)
- levels of pain catastrophising using the Pain Catastrophising Scale (Sullivan, Bishop, & Pivik, 1995)
- levels of fear avoidance or fear of reinjury using the Tampa Scale for Kinesiophobia (TSK-11) (Woby, Roach, Urmston, & Watson, 2005)
- whether a relationship exists between age and chronic musculoskeletal pain
- whether a relationship exists between sex and chronic musculoskeletal pain
- whether demographic factors such as type of triathlon (sprint, Olympic, long distance/half Iron Man or Iron Man), number of days spent training per week, duration of training sessions, duration per discipline (swim, cycle, run), number of days off due to pain in a 12 month period, number training of days lost due to injury in a 12 month period are associated with chronic musculoskeletal pain.

3.3 Setting

Triathlon South Africa, known as TSA, is the official body overseeing triathlon in South Africa (SA). Triathlon clubs are based in each province and each provincial club is affiliated to TSA. According to TSA, there are at least 2000 triathletes registered (at club, provincial and national level) in SA. The athletes communicate through various social media online platforms including Facebook. This study was conducted online via the social media platforms of TSA ,who gave approval.

3.4 Study design

A cross-sectional survey was conducted to determine the prevalence and characteristics of chronic musculoskeletal (msk) pain in adult triathletes in South Africa.

3.5 Participants and Sample Size

The sampling frame included all adult triathletes over the age of 18 years, currently participating in triathlon in SA in either the Sprint, Olympic, Half Iron Man or Iron Man distances. Inclusion criteria listed in Table 4 included having competed in the sport prior to the onset of our study. At present, this figure is estimated to be 2000 (based on information taken off the TSA website), hence the sampling frame was 2000 athletes.

With a confidence level of 95% and a sampling of error of 5%, using the Yamane formula,

$$n = \frac{N}{1 + N(e)^2}$$

where *N* is the study population and *e* is the constant equal to 0.05, a sample size (n) of 333 would be required to make this study generalisable to the sampling frame with 95% confidence.

Table 4 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
- Adult triathletes in South Africa - Over the age of 18 years - Participated in either sprint, Olympic or long distance (Half Iron Man) or Ultradistance (Iron Man) in the last year	- None

3.6 Instrumentation

3.6.1 Demographic Questionnaire [Appendix E]

A demographic questionnaire was created to collect data on variables associated with training, overtraining and the risk of developing injuries, and variables known to increase risk of developing chronic msk pain. In Table 5, justification is provided for the inclusion of each item on the demographic questionnaire with supporting evidence.

Table 5 Demographic questionnaire justification

DEMOGRAPHIC	REASON	EVIDENCE/REFERENCE
1. Sex	There is a difference in pain prevalence in men and women	(Lepers, 2019; Parker, Jelsma, & Stein, 2017)
2. Date of birth	Age plays a role in development of chronic pain with increasing prevalence with increasing age	(Gremeaux et al., 2012)
3. Level of education	Prevalence of chronic pain is higher in populations with lower levels of education	(Mielck, Reitmeir, Vogelmann, & Leidl, 2013)
4. Current tax bracket	Economic status and social class has been found to impact the risk of developing chronic pain	(Kim & Park, 2015)
5. Length of time competing	Longer history of training and competing leads to more injuries and overuse and possibly chronic pain	(Ransdell et al., 2009)
6. Distances	Shorter distance events are associated with less training, therefore, possibly less exposure to the development of injuries	(Alan et al., 2007; Roebuck et al., 2018)
7. Event history over past 12 months	Relates to the training load in a 12 month period	(Hotfiel et al., 2019; Roebuck et al., 2018)
8. Training days per week	This gives insight into the training load	(Geva & Defrin, 2013; Roebuck et al., 2018)
9. Hours spent training per discipline	This gives insight into areas of the body placed under more or less strain and training load	(Geva & Defrin, 2013; Ransdell et al., 2009)

10.Other exercise/sporting activities and time spent on each	Risk factors which may arise from other sports	(Hotfiel et al., 2019)
11. Triathlon related Injuries in past 12 months	Injuries may be contributors to chronic pain	(Ellapen, Chetty, et al., 2011)
12. Triathlon related injuries in past 6 weeks	This informs us of whether current pain is acute or chronic	(Hotfiel et al., 2019)
13. Training days lost due to injury in past 6 months and 12 months	Consequences of pain in terms of impact on sports participation.	(Hotfiel et al., 2019; Ransdell et al., 2009)

3.6.2 Brief Pain Inventory (BPI) [Appendix F]

The BPI is a widely used tool to assess pain, whilst also briefly assessing mood, relations with other people and sleep as well as interference of function as a result of pain (Cleeland & Ryan, 1991). The BPI is relatively quick and easy to complete and the body chart allows the participant to mark the area(s) of pain. The BPI as an assessment tool, has shown internal validity, reliability and is useful in that it can be used in both acute and chronic pain settings and the two subscales for pain allow for assessing a global pattern of pain over time. In the South African context, the BPI has tested well for validity, and reliability in a range of South African languages (Parker et al., 2016).

3.6.3 Pain Catastrophising Scale (PCS) [Appendix G]

The PCS is widely used to assess the presence of pain catastrophizing in adults. It has adequate validity, reliability and consistency, providing insight into the subscales of pain catastrophizing, namely: rumination, helplessness and magnification (Severeijns, van den Hout, Vlaeyen, & Picavet, 2002). It has been translated and validated for use in English, Afrikaans and isiXhosa (Morris, Grimmer-Somers, Louw, & Sullivan, 2012).

3.6.4 Tampa Scale for Kinesiophobia (TSK-11) [Appendix H]

The TSK-11, is a shortened version of the TSK and has shown validity, reliability and sensitivity to change when assessing pain related fear of movement or fear of reinjury in both chronic pain patients and in the sporting population where fear of reinjury can negatively impact rehabilitation and ultimately, return to sport (Hapidou et al., 2012; Woby et al., 2005). An Afrikaans version of the TSK-11 is available, however, it has not been validated (Morris et al., 2012).

3.7 Procedure

Ethical approval to conduct this study was granted from the University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee (HREC) (reference number 511/2020) Appendix I]. Approval was also obtained from TSA to conduct this study [Appendix J, Appendix K Appendix L]. Members of TSA and affiliated triathlon and multisport clubs were contacted by TSA and invited to participate in the study via an advertisement in the TSA monthly electronic newsletter and on TSA's social media platforms with an online link to the Microsoft Forms survey [Appendix M Clicking on the link provided took them to the relevant Microsoft Forms page where a page explaining the study and asking for informed consent was provided [Appendix M and Appendix N]. By clicking on the tick box, the participants were informed that they have given their consent to participate in the study [Appendix N]. The questionnaires [see AppendixAppendix E, Appendix F, Appendix G and Appendix H] were then accessed and completed. The demographic questionnaire screened for appropriate age, as well as identification as being a triathlete. A participant under the age of 18 years or a participant who did not identify as being a triathlete, was unable to proceed further and a message thanking them for participating appeared on the screen.

Prior to commencement of the study, and once ethical approval was obtained, 10 known triathletes were asked to pilot the questionnaire. The questionnaire was made available to these triathletes via a Microsoft Forms link [Appendix M]. We deviated from the registered protocol where we stated that the athletes in the pilot study would receive the questionnaire via email. This was done so as to test the online system and to assess the flow of the tick boxes and the forms as a whole. The triathletes who piloted the questionnaire were then asked not to participate in the main study. However, it was not possible to know if they participated as all information was anonymous.

The data obtained from the pilot study were analysed using descriptive statistics to evaluate how well the questionnaire worked, identify whether or not the questions were understandable, if the questions were relevant and the time taken to complete the questionnaire. The information obtained was used to amend the questions before finally rolling out the questionnaire. A key to the anatomical regions was added on the body chart . This was done to clarify a region (e.g. lower leg included ankle and foot) (Table 6).

The questionnaire was made available online for a period of six months (15 January 2021 up to and including 16 June 2021). The link to the online survey was then closed and no further participation in this study could take place.

Participants were informed that they could withdraw from the study at any time should they no longer want to take part in the study. TSA, their affiliates and participants were given the option to be emailed feedback on the results by leaving their email addresses on a separate, delinked section at the end of the questionnaire. Nobody left their email addresses and no requests for feedback were made via TSA or affiliated clubs. Results, will be shared with TSA and affiliated clubs to distribute to their members as per our registered protocol. In an attempt to increase chronic pain awareness in athletes, TSA has the option to distribute material about chronic pain to their members.

Table 6 Feedback from pilot study

OBJECTIVE	FEEDBACK	CHANGES
1. Clear understanding of questions	If unclear get feedback on how to improve	A key to anatomical regions was included on the body chart to clarify what the region included
2. Relevance of questions	If some questions are deemed irrelevant, find out why and remove the question(s)	None
3. Completion of the questionnaire	If questions were left unanswered, find out why and improve the questioning	None
4. Time taken to complete	If too long, improve on this	None

3.7 Data Analysis

Once all questionnaires were completed and collected, data were entered into an Excel spread sheet. The data were then summarised and tested for distribution using the Kolmogorov-Smirnov test (Wang & Wang, 2010). The data were not normally distributed and therefore, non-parametric analysis has been conducted throughout with reporting of medians (Interquartile Range, IQR) or number (percentage) or frequency. STATISTICA was used to conduct data analysis as it a strong tool for graphical analysis, data mining, sigma six quality and process control statistics, multivariate analysis and non-parametric methods (Hilbe, 2007).

Once all questionnaires were completed and collected, data were exported into an Excel database. The prevalence of chronic msk pain was calculated and expressed as a percentage with a 95% confidence interval. The association between the presence of chronic msk pain, socio-demographic variables, training and injury history were explored by comparing each variable in those with chronic msk pain to those without chronic msk pain. Statistical significance was accepted at $p<0.05$ for all analyses.

3.8 Ethical Considerations

The study adhered to the ethical principles of non-maleficence, beneficence, justice and autonomy as set out by the Declaration of Helsinki (World Medical, 2013). Ethical approval was obtained from the UCT Faculty of Health Sciences Human Research Ethics Committee as well as Triathlon South Africa . We obtained informed consent from all participants at the onset of the study and participation in the study was on a voluntary basis [Appendix M and Appendix N].

3.8.1 Non-Maleficence

Non-maleficence refers to the commitment of health professional(s) to protect patients/participants from any harm they may come to experience during the study or as a result of the study (Orb, Eisenhauer, & Wynaden, 2001 2001; World Medical, 2013). There was minimal risk involved in this study as there was no physical contact with potential participants but the chance that information was inadvertently shared does exist.

3.8.2 Beneficence

According to the Declaration of Helsinki beneficence and non-maleficence go hand in hand (World Medical, 2013). Our study was designed in such a way that exposure to participants was minimal and we ensured that all information obtained will not be used to cause harm to participants nor their sporting community. As participant names were linked to numbers, we will be able to make contact with them should the need arise. Participants who would like feedback on the outcome of the study, were asked to supply their email addresses. This was done via a separate link at the end of the questionnaire. No participants requested feedback.

3.8.3 Justice

All participants were treated fairly and equally, and were not discriminated against regardless of race, gender, age, ethnicity, culture, religion, or socio-economic status (World Medical, 2013). This study will not undermine or violate any human and/or constitutional rights of the participants.

3.8.4 Autonomy

Autonomy was upheld by providing the participants with clear and comprehensive information about the study and obtaining informed consent from all participants. All participants were informed that their participation was voluntary, and, as such, they could withdraw consent at any point during the study but any information obtained before their withdrawal, could still be used (Orb et al., 2001; World Medical, 2013).

3.8.5 Confidentiality

We maintained the confidentiality of all participants at all times. No personal information was used on the questionnaires and age was verified by date of birth. Measures to ensure confidentiality of all participants, such as password protection of soft copies on computers and the use of participant numbers instead of names, was employed to secure data received and ensure its safety. There were no hard copies of any information given by the participants.

As ethical approval was granted until 30 October 2021 [Appendix I], an extension of ethical approval was applied for [Appendix O] and granted until 30 October 2022.

There is no conflict of interest on the part of any of the investigators in this study.

Chapter 4: Results of the Cross-Sectional Survey

A total of 301 triathletes registered with Triathlon South Africa (TSA), as well as those registered with provincial and district triathlon and multisport clubs completed consent and initiated the survey with 297 respondents completing the full survey (Figure 2). The target sample size for the study was 333 to achieve 95% confidence. Post hoc analysis revealed that this sample (n=297) has an 89.19% confidence level.

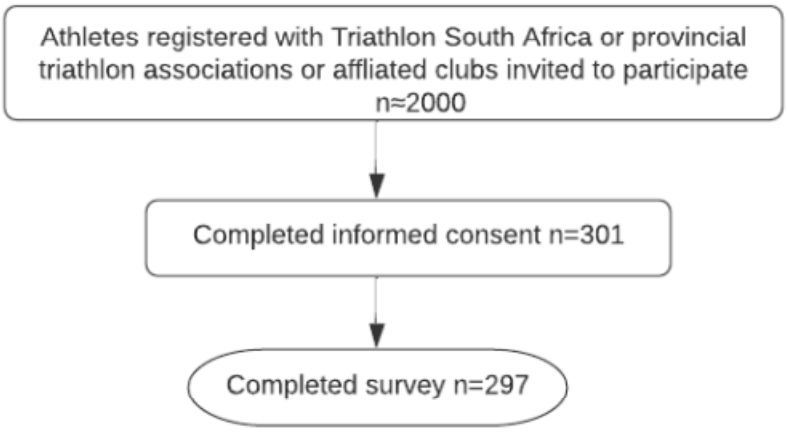

Figure 2 Flowchart of participant recruitment

4.1 Sociodemographic characteristics (n=297)

The median age of the respondents was 40y (IQR 33-46). The majority of respondents were female (165; 55.56%), had completed tertiary education (218; 73.40%) and were earning above ZAR555 601 per annum (186; 62.63%) (Table 7).

Table 7 Sociodemographic characteristics of respondents (n=297)

Variable	Frequency (%)
Gender	
Male	132 (44.44)
Female	165 (55.56)
Highest level of education	
Completed Grade 12	79 (26.60)
Tertiary education	218 (73.40)
Income level (current tax bracket)	
305 850 and less	24 (8.08)
305 851 - 423 300	36 (12.12)
423 301 - 555 600	51 (17.17)
555 601 - 708 310	77 (25.93)
708 311 - 1 500 000	73 (24.58)
1 500 001 and above	36 (12.12)

4.2 Triathlon and Training History

The respondents had been participating in triathlon for a median of 7y (IQR=5-9) and had competed in a median of 2 (IQR=1-2) races in the last 12 months. The majority of respondents were participating in the Olympic and Long/half-iron man distance races and training 5 (IQR=5-6) days of the week for 16 (IQR=14-18) hours (Table 8).

Table 8 Triathlon and training characteristics

Race distance	**Frequency (%)**
Sprint	87 (29.19)
Olympic	224 (75.17)
Long	259 (86.91)
Ultra	115 (38.59)
Training characteristics	**Median (IQR)**
Training days per week	7 (5-9)
Total training hours per week	16 (14-18)
Swimming	2.5 (2-3)
Cycling	9 (7-10)
Running	5 (4-6)

A total of 105 respondents participated in a wide range of other sporting activities (Table 9).

Table 9 Other sports respondents participated in (n=105)

Sport	Frequency (%)
Yoga	24 (22.86)
Gym	19 (18.10)
Pilates/Core training	16 (15.24)
Surfing	8 (7.62)
Zumba	8 (7.62)
MTB/Trail cycling	7 (6.67)
Horse riding	7(6.67)
Stretch	6 (5.71)
Trail running	4 (3.81)
Rock climbing	4 (3.81)
HITT	3 (2.86)
Hiking	3 (2.86)
Soccer	3 (2.86)
Dirt bike/Motor cross	3 (2.86)
Supping	2 (1.90)
Boxing	2 (1.90)
Functional fitness	1 (0.95)
Walking	1 (0.95)
Paddling	1 (0.95)
Cross country	1 (0.95)
Diving	1 (0.95)
MMA	1 (0.95)
Kitesurfing	1 (0.95)

4.3 Prevalence of chronic pain

Of the 297 respondents, 87 (29.29%; 95%CI 28.40-30.18) reported that they had experienced pain on most days for more than three months, i.e., had “chronic msk pain”.

4.4 Brief Pain Inventory (BPI) (n=87)

The median pain severity score (PSS) on the BPI indicated mild pain at 3.02 (IQR 2.50-3.50) and the median pain interference score (PIS) was also mild at 2.23 (IQR 1.43-2.57) (Table 10).

Table 10 Severity of pain on BPI (n=87)

Item on the Brief Pain Inventory	**Median (IQR)**
Pain Severity Score (PSS)	3.02 (2.50-3.50)
Worst pain	4.00 (3.00-5.00)
Least pain	2.00 (1.00-3.00)
Pain on average	3.00 (2.00-3.00)
Pain right now	3.00 (2.00-4.00)
Pain Interference Score (PIS) (pain interference with…)	2.23 (1.43-2.57)
General activity	1.00 (1.00-2.00)
Mood	1.00 (0-2.00)
Walking ability	1.00 (0-1.00)
Normal work	1.00 (0-1.00)
Relations with others	0 (0-1.00)
Sleep	2.00 (1.00-3.00)
Enjoyment of life	0 (0-1.00)

The respondents with pain were using various over the counter analgesic and anti-inflammatory medication, homeopathic medication, prescribed medication or using various forms of manual therapies such as physiotherapy, chiropractic, acupuncture, or massage to treat their pain. The respondents were obtaining 80% (IQR 70.00-80.00) relief from their pain with these treatments.

The most common sites of pain were the neck, lower leg, lower back, upper leg, and the shoulder (Table 11).

Table 11 Sites of pain (n=87)

Area of body	**Frequency (%)**
Neck	31 (35.63)
Lower leg	23 (26.44)
Lower back	19 (21.85)
Upper leg	18 (20.67)
Shoulder	17 (19.54)
Upper back	6 (6.90)
Lower arm	6 (6.90)
Hip	6 (6.90)
Buttock	6 (6.90)
Upper arm	4 (4.60)
Jaw	1 (1.15)
Abdomen	1 (1.15)
Chest	1 (1.15)

The body chart (Figure 3) shows the most common sites of pain together with the frequency (%) of pain.

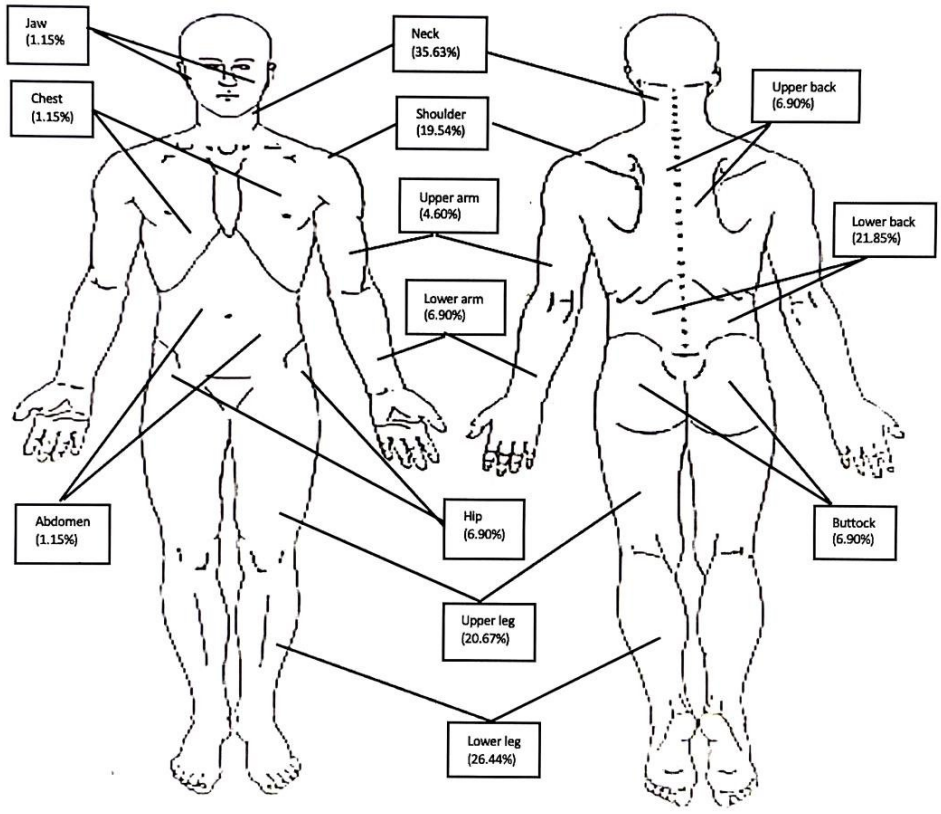

Figure 3 Sites of pain (n=87)

4.5 Pain Catastrophising Scale (PCS)

On the PCS, (Table 12), the respondents with chronic msk pain (n=87) had significantly higher median total scores of 1 (IQR 0-3.00) compared with the respondents without pain [0 IQR 0-1.00) (U=7003.00; p<0.001)].

Table 12 Pain catastrophising dimensions (n=297)

PCS Dimension	**Chronic msk pain n=87**	**Not Chronic msk pain n=210** **Median (IQR)**	**Statistical test**
Rumination	0 (0-1)	0 (0-0)	U=7262.50; p<0.01
Magnification	0 (0-1)	0 (0-0)	U=8178.50; p=0.06
Helplessness	0 (0-1)	0 (0-0)	U=7569.50; p<0.01
Total PCS score	1 (0-3)	0 (0-1)	U=7003.00; p<0.01

4.6 Tampa Scale for Kinesiophobia (TSK-11)

On the TSK-11 the respondents with chronic msk pain (12.00 IQR 12-13) had significantly higher scores than those without (11.00 IQR 11-12) (U=5839.50; p<0.01). A TSK score of 11 is negligible for kinesiophobia (Hapidou et al., 2012; Woby et al., 2005).

4.7 Differences in sociodemographic characteristics between those with and without chronic musculoskeletal pain

The respondents with chronic msk pain were older than those without (p<0.01) (Table 13). The respondents with chronic msk pain were also significantly wealthier (p=0.01) (Table 13).

Table 13 Differences in sociodemographic characteristics between those with and without chronic msk pain (n=297)

Variable	**Chronic msk pain (n=87)**	**No chronic msk pain (n=210) Median (IQR)**	**Statistical Test**
Age	42.92 (37-49)	37.99 (32-44)	U=6170.00; p<0.01*
Gender	N(%)		Spearman's
Male	38 (43.68)	94 (45.24)	R=-0.01; p=0.86
Female	49 (56.32)	116 (54.76)	
Highest level of education			R=-0.05; p=0.37
Grade 12	20 (24.14)	59 (27.62)	
Tertiary education	67 (75.86)	15 (72.38)	
Income level (current tax bracket)			R=0.15; p=0.01
305 850 and less	7 (8.04)	17 (8.10)	
305 851 - 423 300	5 (5.75)	31 (14.76)	
423 301 - 555 600	11 (12.64)	40 (19.05)	
555 601 - 708 310	25 (26.44)	52 (24.76)	
708 311 - 1 500 000	22 (26.44)	51 (24.29)	
1 500 001 and above	17 (20.69)	19 (9.05)	

4.8 Differences in triathlon and training history between those with and without chronic musculoskeletal pain

Although the respondents with chronic msk pain had significantly higher TSK scores than those without chronic msk pain, this did not appear to affect their training. Apart from swimming, where those with chronic msk pain were spending significantly longer in the water, the respondents showed no significant difference in training history or training characteristics (Table 14).

Table 14 Triathlon and training history

	Chronic msk pain n=87 Median (IQR)	**Not chronic msk pain n=210**	**Statistical Test**
Number of years doing triathlon	7 (6-11)	7 (4-9)	U=7844.50; p=0.05
Race distance	N(%)		Spearman's
Sprint (750 swim, 20km cycle, 5km run)	27	59	R=0.03; p=0.62
Olympic (1500m swim, 40km cycle, 10km run)	69	154	R=-0.06; p=0.28
Long (1.9km swim, 90km cycle, 21.1km run)	81	178	R=-0.11; p=0.05
Ultra (3.8km swim, 180km cycle, 42.2km run)	32	83	R=0.03; p=0.66
Training characteristics	Median (IQR)	Median (IQR)	MWU
Training days per week (average)	5 (5-6)	6 (5-6)	U=8721.00; p=0.50
Training hours per week (average)	16 (14-18)	16 (14-18)	U=9049.50; p=0.90
Swimming (average)	3 (2-3)	2.25 (2- 3)	U=7769.50; p=0.04*

Cycling (average)	9 (7-10)	9 (7-10)	U=8366.00; p=0.25
Running (average)	5 (4-6)	5 (4-5.5)	U=8268.00; p=0.18

4.9 Injury

Respondents with chronic msk pain had sustained significantly fewer triathlon related injuries in the past 6-weeks than those without chronic msk pain. Conversely, those with chronic msk pain had sustained significantly more triathlon related injuries in the past 12 months (Table 15). Similarly, respondents with chronic msk pain lost fewer training days to injury in the last 6 months but had lost more training days to injury in the last 12 months (Table 15).

Table 15 Triathlon related injury

	Chronic msk pain n=87 N(%)	**Not chronic msk pain n=210**	**Statistical Test**
Triathlon related injuries 6 weeks	13 (14.94%)	66 (31.43%)	R=0.17; p<0.01*
Triathlon related injuries 12 months	60 (68.97%)	86 (40.95%)	R=-0.26; p<0.01*
	Median (IQR)		
Training days lost 6 months	0 (0-2)	0 (0-4)	U=7595.50; p<0.01 *
Training days lost 12 months	5 (0-7)	0 (0-4)	U=6105.50; p<0.01*

There were no differences in the number of non-triathlon related injuries sustained between the two groups (Table).

Table 16 Non-triathlon related injury

	Chronic msk pain n=87 N(%)	**Not chronic msk pain n=210**	**Statistical Test**
Non-triathlon related injuries 6 weeks	5	12	R=0.01; p=0.99
Non-triathlon related injuries 12 months	9	15	R=0.05; p=0.36
	Median (IQR)		
Training days lost 6 months	0 (0-0)	0 (0-0)	U=8937.50; p=0.49
Training days lost 12 months	0 (0-0)	0 (0-0)	U=8738.00; p=0.19
Injuries sustained elsewhere (non-sport related)	0 (0-2)	0 (0-1)	U=8337.00; p=0.13

Chapter 5: Cross-Sectional Survey - Discussion and Conclusion

5.1 Discussion

The aim of this study was to determine the prevalence and characteristics of chronic musculoskeletal pain in adult triathletes in South Africa. In this sample, 29.29% (95%CI 28.40-30.18) of the respondents reported chronic msk pain. A recent South African prevalence study revealed that 18.3% (95%CI 17.0-19.7) of adult South Africans report chronic pain (Kamerman et al., 2020). Global figures show chronic pain prevalence for adults between 11% and 55% (Daenen et al., 2015). The pooled prevalence for CLBP in our systematic review was 11.82% (95% CI 7.72%-17.08%). The prevalence of chronic msk pain in our cohort of seemingly healthy triathletes is 29.90%. This is quite surprising as it is greater than population based prevalence in South Africa and greater than the pooled prevalence for CLBP in our systematic review but falls within the global percentages for chronic pain prevalence.

The global prevalence for CLBP in adults is estimated at 19.60% (Meucci et al., 2015). The pooled prevalence for CLBP in our systematic review was 11.82% (95% CI 7.72%-17.08%). The prevalence for CLBP in our study, where the respondents were continuing to actively participate in triathlon, is higher at 21.85%. So, perhaps, the real question is not whether or not people have chronic pain, but rather, whether or not they have high impact chronic pain which impairs their ability to participate in meaningful life roles. High impact chronic pain is defined as sustained pain which impairs participation in work, social activities and self-care activities (Dahlhamer et al., 2018). Thus, in this cohort it is apparent that the presence of chronic msk pain does not necessarily mean disability. The degree of impact that chronic pain has on meaningful life roles can, however, lead to disability (Dahlhamer et al., 2018; Von Korff et al., 2020). Factors known to increase disability in people with chronic pain include fear avoidance beliefs, fear avoidance behaviours, pain catastrophising, pain-related beliefs, anxiety, age, sex, depression, income and social factors.

A score of 1-4 on the BPI is mild pain, 5-6 is moderate pain and 7-10 is severe pain (Cleeland & Ryan, 1991). This cohort had mild PSS [3.02(IQR 2.50-3.50)] and mild PIS [2.23 (IQR 1.43-2.57)]. Reports on BPI scores in chronic pain populations show mean PSS of 6.40 and mean PIS of 7.00 (Nicholas et al., 2019). It is evident that even though this study cohort reports having chronic msk pain, their PSS and PIS were not impacting participation in their sport.

Further, the respondents were obtaining 80%(IQR 70.00-80.00) relief from pain with various treatments. This pain relief could also be a reason for their continued participation in their sport. It is evident that these respondents are empowered to look after themselves. Participation in sport has been shown to promote healthy behaviour and improved quality of life as well as improved mental health (Malm, Jakobsson, & Isaksson, 2019).

In this cohort, the most common sites of pain together with the frequency include the neck (35.63%), lower leg (26.44%), lower back (21.85%), upper leg (20.67%) and shoulder (19.54%). The systematic review revealed similar sites of pain with back pain (67.80%), neck (48.30%), low back (63%), knee (39%) and musculoskeletal (21%). However, the systematic review shows higher values for frequency of pain. This might be due to flaws in the designs of the included studies as described earlier [Appendix D].

Fear avoidance behaviours, fear of movement or re-injury and fear avoidance beliefs are strongly related with disability in people with chronic pain (Vlaeyen et al., 1995). Thus, levels of physical inactivity tend to be higher in people living with chronic pain (Parker, Bergman, Mntambo, Stubbs, & Wills, 2017). Although mechanisms underlying the inactivity remain widely unknown, there is significant evidence in favour of the roles played by the fear of pain and pain anxiety in the development of chronic pain and disability (Hasenbring, Chehadi, Titze, & Kreddig, 2014).

While pre-existing inactivity or reduced activity during acute pain may increase risk of disability in people with chronic pain, continued activity, despite pain, may also lead to disability. Recent studies indicate that apart from fear-avoidance responses, endurance pain responses may also be a route by which people develop disabling chronic pain (Hasenbring et al., 2014; Hasenbring & Verbunt, 2010; Titze et al., 2021). This perseverance-endurance model is associated with a gradual decline in levels of physical activity with overactivity - underactivity cycles.

The results of our study reveal that while our study population reports experiencing chronic musculoskeletal pain, their low PCS 1.00 (IQR 0-3.00) and TSK 12.00 (IQR 12-13) scores and continued participation in vigorous physical activity suggest reasons why this population are not disabled. Sports with long durations of physically intense activity and increased aerobic capacity, are associated with an increase in the ability to tolerate pain (Geva & Defrin, 2013; Pettersen, Aslaksen, & Pettersen, 2020).

Regular physical activity and exercise has been shown to reduce the excitability of central neurons. Changes in neuroimmune signalling in the central nervous system result in an increase in the release of endogenous opioids and serotonin in the inhibitory pathways for nociception in the brainstem, thus buffering the system against pain (Law & Sluka, 2017). Thus, the fact that the respondents with chronic msk pain in this study had continued to train, may be the reason for their lack of associated disability and their low levels of pain on the BPI.

The effect of their continued engagement in vigorous activity may have been further enhanced by psychological factors, enabling better coping mechanisms with fear of pain and mental stress (Geva & Defrin, 2013; Serpell, 2019). The low scores on the TSK and PCS suggest resilience which may have reduced the impact of their pain.

The only difference in training history and training characteristics in those with chronic msk pain compared to those without chronic msk pain is regarding swimming, where respondents with chronic msk pain spent longer hours. The number of hours spent training may further impact tolerance to pain and painful stimuli. This phenomenon is noted in our systematic review where previous sports-related injuries and the number of triathlons are listed as risk factors for developing chronic pain and or chronic musculoskeletal pain, yet the athletes in those studies were also still training and competing.

The respondents in our study were between 33 and 46 years old, compared to the systematic review where those with chronic pain were between 20 and 68 years old.

This is consistent with findings in the general population in middle income African countries where it was found that people in older age groups are likely to have more pain than younger age groups, and that the prevalence of chronic pain increased from 11.30% (95% CI: 9.6-13.3) for the age range 15 to 24 years to 34.40% (95% CI: 30.6-38.4) for the age range over 65 years (Kamerman et al., 2020).

Consistent with the results of the systematic review, the majority of the respondents were women. While this may be a response bias as women are more likely to respond to surveys than men(Meucci et al., 2015) Keogh, McCracken, & Eccleston, 2005). However, this may be a reflection of differences between men and women. Women are more likely to have chronic pain than men and CLBP prevalence is higher in women than in men (Meucci et al., 2015; Kamerman et al., 2020). Women also report more pain than men, thus gender may play a role in reports of pain (Keogh, McCracken, & Eccleston, 2005).

All the respondents with chronic msk pain (n=87) had completed Grade 12 whilst 67 of the respondents reported completing tertiary education. This is in contrast to global data indicating that low levels of education are risk factors for developing chronic pain. Once again, this finding may be a result of a response bias as more educated and affluent or middle class populations are likely to participate in surveys (Goyder, Warriner, & Miller, 2002; Smith, 2008). This may be partly explained by the time-consuming nature of online surveys.

This cohort of athletes, both with and without chronic msk pain falls into a high income bracket . There has been a dramatic rise in the burden of musculoskeletal conditions in developing countries, particularly as a result of rapidly ageing populations together with an increase in obesity (Hoy, Geere, Davatchi, Meggitt, & Barrero, 2014). According to the 2016 Global Burden of Disease (GBD) data for noncommunicable diseases, the steepest rise in noncommunicable diseases between 1990 and 2016 has been observed in low-income settings (Briggs et al., 2018). The high income of the sample and of the respondents with chronic pain is in contrast to global populations with chronic pain and could be due to sampling bias. It may be proposed that in a country such as South Africa, participating in a sport such as triathlon requires significant income to support the purchase of equipment, nutrition, and hours spent training, resulting in a population of athletes with significant income.

5.1.1 Study Limitations

The strengths and weaknesses of this study (Table 17) have been evaluated using the Strengthening the Reporting of Observational Studies in Epidemiology [STROBE] guidelines (von Elm et al., 2007).

As this study was carried out as a retrospective cross-sectional survey, data collected lends itself to recall error and possible inaccuracies when compared to prospective studies, and as such, the results must be interpreted with caution. The results are also based on self-reported information without verification from an independent source and could therefore be inaccurate. We are unable to determine why respondents with chronic msk pain were spending longer hours training for swimming. We are also unable to determine causation as would be the case in a prospective longitudinal study.

Cross-sectional surveys of this nature are open to a risk of response bias. The greater number of female respondents in this study (55.56%) might not be a true reflection of the actual numbers of males and females participating in the sport of triathlon. As mentioned above, this may be a reflection of women's greater tendency to participate in surveys.

As raised earlier, the respondents in this study had high levels of income. In future studies it may be valuable to explore income further by asking about unemployment and or sponsorship to participate in their sport.

South Africa is a multi-cultural and ethnically diverse population and English is not the first language of many people. Conducting the study in English may have further contributed to recruitment and sampling bias. Future studies should offer participants multiple language options. Finally, future studies using prospective longitudinal designs in this field could explore the role of cultural differences, gender and income or sponsorship in an attempt to address sampling bias as well as response bias.

The response rate for this study (89.19% CI) fell below our target sample of n=333 to achieve a 95% CI (Figure 2). This poor sub-optimal response rate could be a consequence of the COVID-19 pandemic and the restrictions placed on training and on sport during the national lockdown in South Africa

during 2020. Thus, many triathletes were unable to make use of training facilities as these were closed and competitions were either cancelled or if they did take place, the number of competitors were severely restricted.

Table 17 STROBE Statement - Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation	Yes/Not applicable
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes
Methods			
Study design	4	Present key elements of study design early in the paper	Yes
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Yes
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of	Yes

		assessment methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	Yes
Study size	10	Explain how the study size was arrived at	Yes
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes
		(*b*) Describe any methods used to examine subgroups and interactions	Yes
		(*c*) Explain how missing data were addressed	Yes
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Yes
		*(e)*Describe any sensitivity analyses	Yes
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study - e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Yes
		(b) Give reasons for non-participation at each stage	Yes
		(c) Consider use of a flow diagram	Yes
Descriptive data	14*	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	Yes
		(b) Indicate number of participants with missing data for each variable of interest	Yes
Outcome data	15*	Report numbers of outcome events or summary measures	Yes
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates	Yes

		and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done - e.g. analyses of subgroups and interactions, and sensitivity analyses	Yes
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Modifications to STROBE Guidelines: We added a fourth column to check inclusion and to mark as either “yes” or “not applicable”.

5.2 Conclusion

In line with the study protocol and from previous literature reviewed, the outcomes offer substantial support for the hypothesis that chronic musculoskeletal pain is prevalent amongst adult triathletes. By reporting on the prevalence and characteristics of chronic msk pain among adult South African triathletes, this study contributes to the current literature in the field of pain among adult triathletes. Even with our moderate sample size, the results obtained still show a significant level of chronic msk pain without disability in this athletic population.

The Graded Chronic Pain Scale-Revised, with a 5-item activity limitation indicator was developed to differentiate between mild, bothersome and high impact chronic pain and provides a brief, simple and valid method for assessing the impact of chronic pain beyond its mere presence or absence (Von Korff et al., 2020). Future research in this field should consider including this psychometric tool when assessing the effect of high impact chronic pain on a population and as clinicians, we should be making use of psychometric tools such as this one to effectively and objectively measure pain in our patients.

Our research shows that although this cohort of triathletes reported having chronic msk pain, they were still participating in sport, and therefore still participating in something they found to be meaningful.

As physiotherapists and clinicians, it is important to remember that chronic pain does not mean disability and may not mean stopping sport. When rehabilitating athletes in both acute and chronic settings, we need to remember that being an athlete is a huge part of that person's identity. So, returning to sport after injury is important for these athletes as it is a significant life role and contributor to identity. When we take away sport or regular physical activity or exercise in the rehabilitation setting by advising prolonged periods of rest as part of recovery, we impact a meaningful part of someone's life. As clinicians, we need to be cognisant of this, for, as we know, pain is a biopsychosocial experience and exercise is medicine!

Currently, studies are focused on chronic pain and the burden it places on society and on economies. So, is chronic msk pain a problem in athletes if they are not disabled by it? Minimising disability associated with pain is important in athletes and non-athlete populations. We know that moderate

exercise and physical activity are prescribed as non-pharmacological treatment for chronic pain and that many chronic pain programmes are aimed at people who are disabled by their pain. When triathletes and athletes present with pain or chronic pain, as physiotherapists, a slightly different approach to rehabilitation is indicated. A strong, functional rehabilitation programme, specifically tailored to that athlete's needs, keeping in mind injury prevention, must be considered. We need to rehabilitate them keeping in mind the high level of activity, strength and endurance that is required for optimal performance not only in competition, but in training as well. Patient education is key to achieving change! Thus, by educating athletes about the long term effects of over training , as well as chronic pain and the mechanisms involved in chronic pain maintenance, we can empower them to improve their longevity in their sport. We hope that our study will benefit the entire triathlete population by improving awareness of chronic musculoskeletal pain in the sport of triathlon. By educating athletes about chronic pain we hope to improve longevity in their chosen sport.

Chapter 6: References

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Appendix A

Prisma criteria

PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol*

Section and topic	Item No	Checklist item
ADMINISTRATIVE INFORMATION		
Title:		
Identification	1a	Identify the report as a protocol of a systematic review
Update	1b	If the protocol is for an update of a previous systematic review, identify as such
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number
Authors:		
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments
Support:		
Sources	5a	Indicate sources of financial or other support for the review
Sponsor	5b	Provide name for the review funder and/or sponsor
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol

INTRODUCTION		
Rationale	6	Describe the rationale for the review in the context of what is already known
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (Pérez Pico, Mingorance Álvarez, Caballé Cervigón, & Mayordomo Acevedo)
METHODS		
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated
Study records:		
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications

Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall's τ)
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)

* It is strongly recommended that this checklist be read in conjunction with the PRISMA-P Explanation and Elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015 Jan 2;349(jan02 1):g7647.

Appendix B

Search strategy

The search strategy included the following databases: MEDLINE/PubMed (via EBSCOhost), Cochrane Library, SCOPUS, SCIENCEDIRECT and AFRICA-WIDE INFORMATION (via EBSCOhost), Academic Search Premier, CINAHL, PsycArticles and PsycINFO.

1. Prevalence [MeSH] OR Incidence OR chronic musculoskeletal pain [MeSH] triathletes, athletes, adults
2. Chronic musculoskeletal [MeSH] OR Chronic musculoskeletal pain OR musculoskeletal pain
3. Triathletes [MeSH] OR Athletes OR adults OR adult triathletes [MeSH] OR adult athletes [MeSH]
4. 1 AND 2 AND 3

Appendix C

Risk of bias assessment tool

Name of author(s):_____

Year of publication:_____

Name of paper/study:_____

_____

This tool is designed to assess the risk of bias in population-based prevalence studies. Please read the additional notes for each item when initially using the tool. Note: If there is insufficient information in the article to permit a judgement for a particular item, please answer **No (HIGH RISK)** for that particular item.

Risk of bias item	***Criteria for answers (please circle one option)***	***Additional notes and examples***
External Validity		
1. Was the study's target population a **close representation** of the national population in relation to	**Yes (LOW RISK):** The study's target population was a **close** representation of the national population. **No (HIGH RISK)**: The study's target population was clearly **NOT** representative of the national population.	The target population refers to the group of people or entities to which the results of the study will be generalised. Examples: The study was a national health survey of people 15 years and over and the sample was drawn from a list that included all individuals in the population aged 15 years and over. The answer is: **Yes (LOW RISK).**

relevant variables, e.g. age, sex, occupation?		The study was conducted in one province only, and it is not clear if this was representative of the national population. The answer is**: No (HIGH RISK).** The study was undertaken in one village only and it is clear this was not representative of the national population. The answer is: **No (HIGH RISK)**
2. Was the sampling frame a **true or close representation** of the target population?	**Yes (LOW RISK):** The sampling frame was a **true or close** representation of the target population. **No (HIGH RISK):** The sampling frame was NOT a **true or close** representation of the target population.	The **sampling frame** is a list of the sampling units in the target population and the study sample is drawn from this list. Examples: The sampling frame was a list of almost every individual within the target population. The answer is: **Yes (LOW RISK).** The cluster sampling method was used and the sample of clusters/villages was drawn from a list of all villages in the target population. The answer is: **Yes (LOW RISK)**. The sampling frame was a list of just one particular ethnic group within the overall target population, which comprised many groups. The answer is: **No (HIGH RISK).**
3. Was some form of **random selection** used to select the sample, OR, was a census undertaken?	**Yes (LOW RISK):** A census was undertaken, OR, some form of random selection was used to select the sample (e.g. simple random sampling, stratified random sampling, cluster sampling, systematic sampling).	A census collects information from every unit in the sampling frame. In a survey, only part of the sampling frame is sampled. In these instances, random selection of the sample helps minimise study bias. Examples: The sample was selected using simple random sampling. The answer is: **Yes (LOW RISK)**.

	No (HIGH RISK): A census was NOT undertaken, AND some form of random selection was NOT used to select the sample.	The target population was the village and every person in the village was sampled. The answer is: **Yes (LOW RISK).** The nearest villages to the capital city were selected in order to save on the cost of fuel. The answer is: **No (HIGH RISK).**
4. Was the likelihood of **non-response bias minimal?**	**Yes (LOW RISK):** The response rate for the study was >/=75%, OR, an analysis was performed that showed no significant difference in relevant demographic characteristics between responders and non-responders **No (HIGH RISK):** The response rate was <75%, and if any analysis comparing responders and non-responders was done, it showed a significant difference in relevant demographic characteristics between responders and non-responders.	Examples: The response rate was 68%; however, the researchers did an analysis and found no significant difference between responders and non-responders in terms of age, sex, occupation and socioeconomic status. The answer is: **Yes (LOW RISK).** The response rate was 65% and the researchers did NOT carry out an analysis to compare relevant demographic characteristics between responders and non-responders. The answer is: **No (HIGH RISK).** The response rate was 69% and the researchers did an analysis and found a significant difference in age, sex and socio-economic status between responders and non-responders. The answer is: **No (HIGH RISK).**

Internal Validity		
5. Were data collected **directly from the subjects** (as opposed to a proxy)?	**Yes (LOW RISK):** All data were collected directly from the subjects. **No (HIGH RISK):** In some instances, data were collected from a proxy.	A proxy is a representative of the subject. Examples: All eligible subjects in the household were interviewed separately. The answer is: **Yes (LOW RISK).** A representative of the household was interviewed and questioned about the presence of low back pain in each household member. The answer is: **No (HIGH RISK).**
6. Was an **acceptable case definition** used in the study?	**Yes (LOW RISK):** An acceptable case definition was used. **No (HIGH RISK):** An acceptable case definition was NOT used.	For a study on low back pain, the following case definition was used: "Low back pain is defined as activity-limiting pain lasting more than one day in the area on the posterior aspect of the body from the bottom of the 12th rib to the lower gluteal folds." The answer is: **Yes (LOW RISK).** For a study on back pain, there was no description of the specific anatomical location „back" referred to. The answer is: **No (HIGH RISK).** For a study on osteoarthritis, the following case definition was used: "Symptomatic osteoarthritis of the hip or knee, radiologically confirmed as Kellgren-Lawrence grade 2-4". The answer is: **LOW RISK.**
7. Was the study instrument that measured the parameter of interest (e.g. prevalence of	**Yes (LOW RISK):** The study instrument had been shown to have reliability and validity (if this was necessary), e.g. test-retest, piloting, validation in a previous study, etc. **No (HIGH RISK):** The study instrument had NOT been	The authors used the COPCORD questionnaire, which had previously been validated. They also tested the inter-rater reliability of the questionnaire. The answer is: **Yes (LOW RISK).** The authors developed their own questionnaire and did not test this for validity or reliability. The answer is: **No (HIGH RISK).**

low back pain) shown to have **reliability and validity (if necessary)?**	shown to have reliability or validity (if this was necessary).	

8. Was the same mode of data collection used for all subjects?	**Yes (LOW RISK):** The same mode of data collection was used for all subjects. **No (HIGH RISK):** The same mode of data collection was NOT used for all subjects.	The mode of data collection is the method used for collecting information from the subjects. The most common modes are face-to-face interviews, telephone interviews and self-administered questionnaires. Examples: All eligible subjects had a face-to-face interview. The answer is: **Yes (LOW RISK)**. Some subjects were interviewed over the telephone and some filled in postal questionnaires. The answer is: **No (HIGH RISK)**.
9. Was the length of the shortest prevalence period for the parameter of interest appropriate?	**Yes (LOW RISK):** The shortest prevalence period for the parameter of interest was appropriate (e.g. point prevalence, one-week prevalence, one-year prevalence). **No (HIGH RISK):** The shortest prevalence period for the parameter of interest was not appropriate (e.g. lifetime prevalence)	The prevalence period is the period that the subject is asked about e.g. "Have you experienced low back pain over the previous year?" In this example, the prevalence period is one year. The longer the prevalence period, the greater the likelihood of the subject forgetting if they experienced the symptom of interest (e.g. low back pain). Examples: Subjects were asked about pain over the past week. The answer is: **Yes (LOW RISK)**. Subjects were only asked about pain over the past three years. The answer is: **No (HIGH RISK)**.

10. Were the numerator(s) and denominato r(s) for the parameter of interest appropriate?	**Yes (LOW RISK)**: The paper presented appropriate numerator(s) AND denominator(s) for the parameter of interest (e.g. the prevalence of low back pain). **No (HIGH RISK):** The paper did present numerator(s) AND denominator(s) for the parameter of interest but one or more of these were inappropriate.	There may be errors in the calculation and/or reporting of the numerator and/or denominator. Examples: There were no errors in the reporting of the numerator(s) AND denominator(s) for the prevalence of low back pain. The answer is: **Yes (LOW RISK)**. In reporting the overall prevalence of low back pain(in both men and women) the authors accidentally used the population of women as the denominator rather than the combined population. The answer is: **No (HIGH RISK)**.
11. Summary item on the overall risk of study bias		
LOW RISK OF BIAS: Further research is very unlikely to change our confidence in the estimate. **MODERATE RISK OF BIAS:** Further research is likely to have an important impact on our confidence in the estimate and may change the estimate. **HIGH RISK OF BIAS:** Further research is very likely to have an important impact on our confidence in the estimate and is likely to change the estimate.		

Appendix D

Risk of bias summary

	Was the Study's target population a close representation of the national population?	**Was the sampling frame a true or close representation of the target population?**	**Was some form of random selection used to select the sample, OR, was a census undertaken?**	**Was the likelihood of non-response bias minimal?**	**Were data collected directly from the subjects?**	**Was an acceptable case definition used in the study?**	**Was the study instrument shown to have reliability and validity?**	**Was the same mode of data collection used for all subjects?**	**Was the length of the shortest prevalence period for the parameter of interest appropriate?**	**Were the numerator and denominator for the parameter of interest appropriate?**	**Overall risk of bias**
Villavicencio (2006)	High	High	High	High	High	High	High	Low	High	Low	High
Clarsen (2010)	High	High	High	Low	Low	High	High	Low	Low	Low	Moderate

De Almeida (2015)	High	Low	High	High	Low	High	High	Low	Low	Low	Moderate
Nakata Teixeira (2016)	High	High	High	High	Low	High	High	Low	Low	Low	Moderate

Appendix E

Demographic questionnaire

***Are you a triathlete? Y ☐ N ☐**

Demographic Questionnaire: *please answer the following questions as best as possible*

1) Sex M F	2) Date of Birth: yyyy/mm/dd _____/_____/_____	3) Highest level of education: Gr. 10 Gr. 12 Tertiary
4) Current tax bracket (in Rands):	305 850 and less 305 851 - 423 300 423 301 - 555 600	555 601 - 708 301 708 311 - 1 500 000 1 500 001 and above

		Yes	No
5)	How long, in years, have you been competing in the sport of triathlon?		
6)	In which of the following distances do you compete? (tick all appropriate choices)		
	i. Sprint (750m swim, 20km cycle, 5km run) ii. Olympic (1500m swim, 40km cycle, 10km run) iii. Half Ironman/ Long distance (2km swim, 80km cycle, 21.1km run) iv. Ironman/Ultra distance (3.8km swim, 180km cycle, 42.2km run)		
7)	Have you competed in any triathlon events in the past 12 months? If **yes**, how many?		
8)	How many days per week do you train? How many hours per week do you train?		
9)	How many hours per week do you train in each discipline? - Swim: - Cycle: - Run:		
10)	Do you participate in any other forms of exercise or sporting activities? If **yes**, please name these together with the number of days/week and number of hours/week for each one		
11)	Have you sustained any triathlon related injuries in the past 12 months?		
12)	Have you sustained any non-triathlon related injuries in the past 12 months?		
13)	Have you sustained any triathlon related injuries in the past 6 weeks?		
14)	Have you sustained any non-triathlon related injuries in the past 6 weeks?		
15)	How many training days have you lost due to triathlon related injury in the past - 6 months - 12 months		
16)	How many days have you lost due to injuries sustained elsewhere?		

Appendix F

Brief Pain Inventory

BRIEF PAIN INVENTORY

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and
   toothaches). Have you had pain, during the last week?

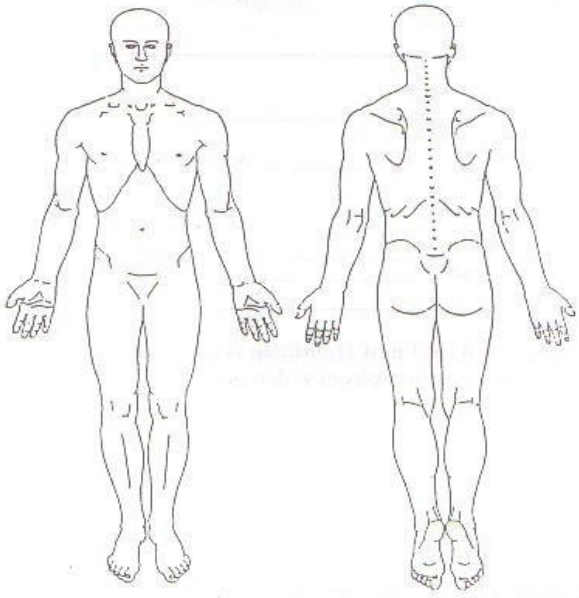
   Yes No

2. Have you been experiencing pain, other than the everyday kinds of pain, on most days for the past 3 months?

   Yes No

If you answered "yes" to either of the above questions, please continue here

3. On the diagram, shade in the areas where you feel pain. Put an X on the area that hurts the most.



4. Please rate your pain by circling the one number that best describes your pain at its ***worst*** in the last 24 hours.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

5. Please rate your pain by circling the one number that best describes your pain at its ***least*** in the last week.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

6. Please rate your pain by circling the one number that best describes your pain on the ***average.***

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

7. Please rate your pain by circling the one number that tells how much pain you have ***right now.***

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

What treatments or medications are you receiving for your pain?

---

8. In the last week, how much ***relief*** have pain treatments or medications provided? Please circle the one percentage that most shows how much *relief* you have received.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Relief										Complete Relief

9. Circle the one number that describes how much, during the past week, pain has ***interfered with*** your: A. ***General Activity***

0	1	2	3	4	5	6	7	8	9	10
Does not interfere										Completely interferes

B. ***Mood***

0 1 2 3 4 5 6 7 8 9 10

Does not interfere — Completely interferes

C. ***Walking Ability***

0 1 2 3 4 5 6 7 8 9 10

Does not interfere — Completely interferes

D. ***Normal Work*** (includes both work outside the home and housework)

0 1 2 3 4 5 6 7 8 9 10

Does not interfere — Completely interferes

E. ***Relations with other people***

0 1 2 3 4 5 6 7 8 9 10

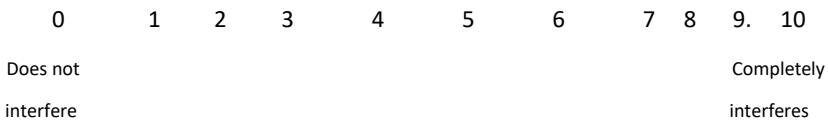
Does not interfere — Completely interferes

F. ***Sleep***

0 1 2 3 4 5 6 7 8 9 10

Does not interfere — Completely interferes

G. ***Enjoyment of life***



Scoring:

Pain Severity Score = Mean of items 3–6 (pain at its worst, pain at its least, average pain

Pain Interference Score = Mean of items 9A–9G (interference of pain with general activity, mood, walking, normal work, relations, sleep, enjoyment of life)

Appendix G

Pain Catastrophising Scale

Everyone experiences painful situations at some point in their lives. Such experiences may include headaches, tooth pain, joint or muscle pain. People are often exposed to situations that may cause pain such as illness, injury, dental procedures or surgery.

Instructions:

We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are thirteen statements describing different thoughts and feelings that may be associated with pain. Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are experiencing pain.

RATING	0	1	2	3	4
MEANING	Not at all	To a slight degree	To a moderate degree	To a great degree	All the time

When I'm in pain …

Number	Statement	Rating
1	I worry all the time about whether the pain will end.	
2	I feel I can't go on.	
3	It's terrible and I think it's never going to get any better	
4	It's awful and I feel that it overwhelms me.	
5	I feel I can't stand it anymore	
6	I become afraid that the pain will get worse.	
7	I keep thinking of other painful events	
8	I anxiously want the pain to go away	

9	I can't seem to keep it out of my mind	
10	I keep thinking about how much it hurts.	
11	I keep thinking about how badly I want the pain to stop	
12	There's nothing I can do to reduce the intensity of the pain	
13	I wonder whether something serious may happen.	

Appendix H

Tampa Scale for Kinesiophobia (TSK-11)

Computer number: **Date:**

This is a list of phrases which other patients have used to express how the view their condition. Please circle the number that best describes how you feel about each statement.

	Strongly Disagree	**Somewhat Disagree**	**Somewhat Agree**	**Strongly Agree**
1. I'm afraid I might injure myself if I exercise.	1	2	3	4
2. If I were to try to overcome it, my pain would increase.	1	2	3	4
3. My body is telling me I have something dangerously wrong.	1	2	3	4
4. People aren't taking my medical condition serious enough.	1	2	3	4
5. My accident/problem has put my body at risk for the rest of my life.	1	2	3	4
6. Pain always means I have injured my body.	1	2	3	4
7. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening.	1	2	3	4
8. I wouldn't have this much pain if there wasn't something potentially dangerous going on in my body.	1	2	3	4
9. Pain lets me know when to stop exercising so that I don't injure myself.	1	2	3	4
10. I can't do all the things normal people do because it's too easy for me to get injured.	1	2	3	4
11. No one should have to exercise when he/she is in pain.	1	2	3	4

Source: Woby et al. (2005), Psychometric properties of the TSK-11: A shortened version of the Tampa Scale for Kinesiophobia. Pain, 117, 137144.

Appendix I

HREC approval

UNIVERSITY OF CAPE TOWN

Faculty of Health Sciences

Human Research Ethics Committee

Room GSO- Old Main Building

Groote Schuur Hospital

Observatory 7925 Telephone [021] 406 6492 Email:hrec-enquiries@uct.ac.za

Website: www.health.uct.ac.za/fhs/research/humanethics/forms

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20 October 2020

HREC REF: 511/2020

A/Prof Romy Parker

Division of Anaesthesia & Perioperative Medicine

Ward D - 23 NGSH

Anzio Road

Observatory

7925

Email: romy.parker@uct.ac.za

Student email: glenda@iphysio.co.za

Dear A/Prof Parker

PROJECT TITLE: THE PREVALENCE AND CHARACTERISTICS OF CHRONIC

MUSCULOSKELETAL PAIN IN ADULT TRIATHLETES IN SOUTH AFRICA - A CROSS-SECTIONAL SURVEY-MSC CANDIDATE-MS GLENDA FRANCIS

Thank you for submitting your response 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 and 06 July 2020, found on the following website link: http:/www.health.uct.ac.za/fhs/research/humanethics/about

Approval is granted for one year until the 30 October 2021.

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)

We acknowledge that the student: Ms Glenda Francis will also be involved in this study.

Please quote the HREC REF 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 355/2020 le

Federal Wide Assurance Number: FWA00001637.

Institutional Review Board (IRS) 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 patents, 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.

Appendix J

Letter to Triathlon South Africa (TSA)

Department of Health and Rehabilitation Sciences

Faculty of Health Sciences

Divisions of Communications Sciences and Disorders, Nursing and Midwifery, Occupational Therapy, Physiotherapy

F45 Old Main Building, Groote Schuur Hospital, Observatory 7925

Tel.: +27 (0) 21406 6401 Fax: +27 (0) 21406 6323

Internet: www.uct.ac.za

Dear Triathlon South Africa

To Whom It May Concern:

I am a master's student in the department of Physiotherapy at the University of Cape Town (UCT). I am currently doing a study on the prevalence and characteristics of chronic musculoskeletal pain in adult triathletes in South Africa.

I would like to send our online survey to triathletes in South Africa via the Triathlon South Africa (TSA) social media and email communication platforms and, hereby, seek your permission to do this.

All the information provided by the participants will be collected, analysed and summarised by us. All responses will remain completely anonymous and no personal information will be recorded.

The information will be used to help health and rehabilitation professionals to better understand the prevalence

and characteristics of chronic musculoskeletal pain as experienced by South African triathletes. The protocol for this study was approved by the UCT Human Research Ethics Committee (reference number 511/2020).

On completion of the study, and once we have analysed all the data, we would be willing to share our findings with TSA. We believe that participation in our study would be beneficial to triathletes as it would increase their knowledge of chronic pain. To this end, at the end of our study, we would be willing to share a podcast on chronic pain with TSA which you can share with your triathletes.

Should you require more information about the ethical aspects of this research, please feel free to contact me (Glenda Francis) via email at glenda@iphysio.co.za/ or telephonically at 021 424 2426 or my lead supervisor, Prof. Romy Parker (tel.: 021 406 6431).

Thanking you in anticipation.

Yours sincerely,

Glenda Francis

Appendix K

Approval email from Triathlon South Africa

From: Beryl Campbell bcamps@mweb.co.za
Subject: research survey
Date: 15 January 2021 at 09:39
To: glenda@iphysio.co.za
Cc: TSA Office office@triathlonsa.co.za

Good morning, Glenda

Triathlon South Africa are very happy to support this project and assist where we can.

Please could you send the document to us and we will forward onto each province for them to send to all registered athletes. I am aware of a few social media groups which I will encourage to post your request on as well.

Looking forward to hearing from you.

Regards

Beryl Campbell
Vice President TSA
Cell: 0826888368

Appendix L

Response to TSA with survey link

From: glenda@iphysio.co.za.co.za
Subject: research survey
Date: 15 January 2021 at 16:00
To: Beryl Campbell bcamps@mweb.co.za
Cc: TSA Office office@triathlonsa.co.za

Good afternoon Beryl,

I would like to thank you and all at TSA for the positive response to our research.

Herewith, please find a link to the Chronic Musculoskeletal Pain Survey which can be forwarded to your members and affiliates as well as social media groups.

I am hoping to reach as many adult triathletes in the country as possible and hope that you will be able to resend the link a few times over the next 6 months.

Please find the advertisement attached with the Microsoft Forms link.

I have attached the link separately in this email should you want to add it to your newsletter.

https://forms.office.com/Pages/ResponsePage.aspx?id=NUNFkk5Wz0ywsCREW4wD90ew5cmz19dDvCqEoVBkVSBUM0tTWEtDVk9aN1RYQkpOWURJTDI4QUYxTS4u

Many thanks and kind regards

Glenda Francis

083 303 5277/ 021 424 2426

glenda@iphysio.co.za

Appendix M

Online survey advert

University of Cape Town

Department of Health and Rehabilitation Sciences

Division of Physiotherapy

Dear Triathlete

The **University of Cape Town** (UCT) in support of the **Department of Health and Rehabilitation Sciences** (DHRS), request your participation in a brief and novel survey that looks at how chronic musculoskeletal pain impacts triathletes.

Triathlon is a popular and growing sport requiring many hours of training and hard competitions, with triathletes picking up injuries along the way. Some of these injuries might be more painful and longer lasting than others. We would like to find out more about the prevalence and characteristics of your pain.

The survey will cover some of the following points:

- The prevalence of pain
- The nature of pain
- The duration of pain
- The effect of pain on your daily activities
- The effect of pain on personality and mood
- The relationship between age and chronic pain
- The relationship between sex and chronic pain
- Demographic factors that may contribute to the development of chronic pain

This survey is conducted on Microsoft Forms which is a secure web-based platform.

To voluntarily participate in the study, please click on the following link:

https://forms.office.com/Pages/ResponsePage.aspx?id=NUNFkk5Wz0ywsCREW4wD90ew5cmz19dDvCqEoVBk VSBUM0tTWEtDVk9aN1RYQkpOWURJTDI4QUYxTS4u

The protocol for this study was approved by the **Human Sciences Research Committee (reference number 511/2020).** Should you have any questions or require further information, please contact the lead researcher, Glenda Francis at 021 424 2426 or at glenda@iphysio.co.za. Alternatively, you may contact the lead supervisor, Prof. Romy Parker at 021 406 6431.

The data from this study will be used to inform health and rehabilitation professionals about the prevalence and characteristics of chronic musculoskeletal pain as experienced by triathletes.

Many thanks

Glenda Francis, Prof. Romy Parker, Katleho Limakatso

Appendix N

Informed Consent

Department of Health and Rehabilitation Sciences
Faculty of Health Sciences

Divisions of Communications Sciences and Disorders,
Nursing and Midwifery, Occupational Therapy, Physiotherapy

F45 Old Main Building, Groote Schuur Hospital, Observatory 7925

Tel.: +27 (0)21 406 6401 Fax: +27 (0) 21406 6323

Internet: www.uct.ac.za

SA Triathlete Chronic Musculoskeletal Pain Survey

Informed Consent

Dear Triathlete,

We, at the University of Cape Town's Department of Health and Rehabilitation Sciences have embarked on research to help us gain more insight into the prevalence and characteristics of chronic musculoskeletal pain in adult South African triathletes.

Triathlon is a popular and growing sport requiring many hours of training and hard competitions, with triathletes picking up injuries along the way. Some of these injuries might be more painful and longer lasting than others. We would like to find out more about the prevalence and characteristics of your pain.

The survey will cover some of the following points:

- The prevalence of pain
- The nature of pain
- The duration of pain
- The effect of pain on your daily activities
- The effect of pain on personality and mood
- The relationship between age and chronic pain
- The relationship between sex and chronic pain
- Demographic factors that may contribute to the development of chronic pain

This survey is conducted on Microsoft Forms which is a secure web-based platform.

All the information you provide will be collected, analysed and summarised by us. We will adhere to a strict ethical code of conduct and assure you that your information is, and will remain strictly confidential. We believe that your participation will benefit the entire triathlete population by improving awareness of chronic pain in the sport of triathlon. This study should pose no risk to you or your sporting community.

These findings will be used to inform health and rehabilitation professionals to better understand the prevalence and characteristics of chronic musculoskeletal pain from the triathletes' perspectives.

Your response is COMPLETELY ANONYMOUS and no personal information will be recorded. If you would like to participate in this survey, please respond to the statements and questions below. If you do not wish to participate, you may close this screen and no information will be recorded. If you do agree to participate, please complete all the questions to the best of your knowledge. This survey should take you no more than 10-12 minutes to complete.

Should you have any queries or complaints about the ethical aspects of this research, please feel free to contact the lead researcher, Glenda Francis, an M.Sc. student at UCT at 021 424 2426 or her supervisor, Prof. Romy Parker at 021 406 6431 or assistant supervisor, Katleho Limakatso at 021 406 6431.

If you would like to receive feedback on our findings on completion of the study, please enter your email address in the separate link provided at the end of the questionnaire.

Agreement to participate:

- I agree to voluntarily participate in this survey.
- I acknowledge that should I no longer wish to participate in this research
- I may withdraw at any point with no repercussions and no information will be recorded.
- I understand that I will not be asked to identify myself in any way and that all my responses are completely anonymous.

☐ OK

INFORMED CONSENT

☐ I hereby provide informed consent and agree to participate

☐ I do not provide consent and do not agree to participate

Appendix O

Letter to HREC for Ethics extension

Department of Anaesthesia and
Perioperative Medicine

Faculty of Health Science,
Anzio Road, Observatory

RE Parker BSc(Phys) BSc(Med)(Hons) Ex.Sci(Phys)
MSc(Pain) PhD

Director: Pain Management Unit

25 October 2021

Attention: Professor Marc Blockman

Human Research Ethics Committee

Faculty of Health Sciences

Room E52-24 Groote Schuur Hospital, Old Main Building

Observatory 7925

Dear Prof Blockman

PROJECT TITLE: The prevalence and characteristics of chronic musculoskeletal pain in adult triathletes in South Africa - a cross-sectional survey

Please find attached our renewal application form (FHS016) for our study with HREC REF. 511/2020 . Data collection has been completed and the data analysis and study write up are currently underway.

1. Renewal Application (FHS016)

Yours faithfully

Romy Parker (PI) and Glenda Francis BSc(Physiotherapy); MSc candidate