Injury Surveillance in Elite New Zealand Track Cyclists

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INJURY SURVEILLANCE IN ELITE NEW ZEALAND TRACK CYCLISTS

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The Auckland University of Technology Ethics Committee (AUTEC) granted ethical approval for this research on 14 May, 2015. Ethics Application Number 15/108 (see Appendix 1).

Attestation of authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed  Date_____28.2.17_____

ABSTRACT:

Introduction: Injury surveillance is an essential component of elite sport. Little data is available on injury rates in track cyclists, with the majority of cycling research focussed on road cycling, and suggesting cyclists are at highest risk of overuse knee, back and neck injuries, and acute injuries involving the shoulder/clavicle, lower back and knee.

Purpose: This research aims to establish the baseline incidence and prevalence of injury, and its effect on training and competition for elite New Zealand track-cyclists.

Methods: All members of Cycling New Zealand's elite track squad were invited to take part in this prospective, longitudinal study. Participants completed two baseline questionnaires detailing current and past injury status, current training volume, and other baseline characteristics. They then completed an online self-reporting injury survey every week for 52 consecutive weeks in the form of the Programme for Injury and Illness Surveillance (PILLS) tool. Injuries were classified using the OSICS-10 classification system. Key outcome measures were injury incidence and prevalence. Also recorded were self-reported measures of training exposures and intensity, injury classification, treatment received, duration of injury and where (geographical location) the injury occurred. Comparison of participant and therapist injury classification were made, and all outcome measures were calculated for the squad as a whole, as well as with breakdown for gender and squad.

Results: Data were collected from 33 members of the elite NZ track cycling squad, comprising 17 males (17-32 years - mean 22.71, SD: 4.45), and 16 females (17-31 years - mean 21.5 years, SD: 4.82). 21 of the 33 participants sustained an injury during the period of inclusion in the study. Four reported injuring multiple body sites at one time, with one participant reporting two multi-site incidents during the period

of data collection. 13 participants sustained multiple injuries, and 12 reported no incidence of injury. 11 injuries occurred in sports specific training, 20 in the gym, six in competition and seven other (mean 11, SD 6.38). 82% of injuries were recorded as being acute, 18% recurrent, with no overuse injuries reported. 8962 training exposures were planned (mean 689 exposures per four-weeks, SD 142), with 60 sessions (0.67%) missed and 84 (0.94%) modified due to injury, totalling 144/8962 (1.6%) training exposures affected by injury (mean 11.1, SD 7) per four-week block of surveys. Injury Incidence was 4.9 injuries per 1000 training and competition exposures. For all injuries sustained (53 body parts injured from 44 events), the injury incidence was 5.9 per 1000 exposures. Point prevalence ranged from one injury per four-week block to seven (mean 3.38, SD 1.80). No significant relationships were found between squad, gender, previous injury, years in sport, new injuries or injury frequency, or number of treatments.

Conclusion: This research provides the first descriptive injury profile for the elite New Zealand track cycling cohort. 64% of participants sustained an injury over the study period, however injury incidence and prevalence was low with rapid return to training and competition. Greatest number of injuries was seen in the lower back, hip/buttock/pelvis region, and the knee, possibly reflecting the biomechanical requirements of cycling and the nature of the training required for this cohort. Previous studies investigating road cycling describe similar body sites injured, but with a large proportion classified as overuse whereas no overuse injuries were self-reported in this study. Further research is required to determine any reason for this. Total training exposures were recorded however little detail was documented on the

intensity, nature and load of each specific training session and warrants more detailed investigation through future research.

CHAPTER 1: Introduction

1.1 Statement of problem

The current problem for those attempting to minimise injury risk for track cyclists is a lack of published research on injury surveillance of track cyclists. Without this surveillance, future programmes to reduce the risk of injury for this group of athletes will not be able to be validated as there is no data available with which to compare before and after for any intervention that might be introduced.

1.2 Cycling and High Performance Sport in New Zealand

Cycling is one of the key funded high performance sports in New Zealand (NZ) and track/velodrome cyclists are currently performing well on the world stage. Cycling New Zealand (CNZ) has developed a centralised track cycling program whereby elite track cyclists and support staff are predominantly based at the "Home of Cycling" (HOC) – the Avantidrome, in Cambridge, NZ. The elite NZ cycling squad are all registered as "carded" athletes with High Performance Sport New Zealand (HPSNZ) and the HPSNZ website states that "Performance support available to carded athletes can include injury and illness prevention and rehabilitation….." (HPSNZ., n.d.). The strategic and operational delivery of HPSNZ "Medicine and Rehabilitation support" was revised in 2015 with a new focus towards "Performance Health". The new vision expanded on the more traditional elements of injury and illness management, to include expansion into injury and illness prevention, monitoring, planning, performance optimisation and clinically relevant research, with the primary aim of optimising athlete availability (http://hpsnz.org.nz/news-events/optimising-health-high-performance-medical-team).

The primary care clinicians who work with these athletes are also based at the HOC (Physiotherapists, Doctor, Massage therapists). The goal of these support staff should be to prevent injuries occurring in the first instance in order to help athletes reach their full potential (Bahr & Holme, 2003). Implementing programmes to minimise injury risk is crucial for minimising time lost from training and competition, and physiotherapists and other performance health team members are required to achieve this. However, with little knowledge about injury incidence or prevalence in track cycling it is challenging, if not impossible to determine if this goal is achieved.

HPSNZ has developed a Program for Injury and Illness Surveillance (PILLS), including a non-validated tool which is a self-reported injury and illness survey conducted on a smartphone or tablet which the athlete must complete weekly. The PILLS tool asks for information primarily on injury and illness, training volume, effect of injury and illness on training, and the athlete's perception of their readiness to train and compete. A full list of the PILLS survey questions is available in Appendix 8. The PILLS survey questions are designed to capture incidence of injury by recording individual injuries as they occur, and by measuring across the squads each week, it can also be used to determine prevalence of injury in a squad at a given time. The specific PILLS application tool has not been validated, however when looking at this self-reporting tool from an injury surveillance point of view, the PILLS survey meets the key requirements of an Injury Surveillance system as described by Van Mechelen et al (van Mechelen, 1997) of assessing injury incidence, severity, aetiology and mechanism - which are detailed further in section 1.3, the literature review, and the methods sections.

1.2.1 High Performance Sport New Zealand (HPSNZ) funding

HPSNZ state their role is to lead the high performance system in New Zealand is to work:

> *"in partnership with national sport organisations, allocate resources to sports organisations and athletes, and delivers world-leading support to impact performance*. *Key investment priorities are sports and athletes with medal potential at the Olympic Games (summer and winter), non-Olympic targeted sports that can win at world championships, and sports and athletes with gold medal potential at the Paralympic Games (summer and winter)"*
> *(HPSNZ., n.d.).*

HPSNZ provides funding to selected sports, grants to aid with living expenses to athletes, and scholarships for study and professional development for both athletes and their support staff. Because performance outcomes determine funding, and with injury having a negative impact on performance for an athlete and their team, minimising injury risk and reducing incidence of injury become not just a performance issue but a financial issue. Reduction in funding may lead to a significant change in an athlete's ability to train and compete (e.g. needing/not needing to work, study/life balance and the effect of this on an athlete's ability to train appropriately for their competition needs).

1.3 Injury Surveillance

Injury surveillance is an essential component to any prevention model (Bahr & Holme, 2003; Finch et al., 2012; Finch & Cook, 2013). According to Van Mechelen (1997) there is a need for sports injury prevention and this should be based on the outcome of scientific research as part of the 'sequence of prevention'.

Van Mechelen's sequence of prevention involves four steps:

1. Establish the extent of the injury problem (Incidence and severity)
2. Establish the aetiology and mechanism of sports injury
3. Introduce a preventative measure
4. Assess its effectiveness by repeating step 1.

> *"In applying the 'sequence of prevention', first the incidence and severity of the sports injury problem need to be established. Secondly the aetiology and the mechanism of sports injuries need to be identified. Only based on this information can preventative measures be introduced, which must subsequently be evaluated for effectiveness. The principle of the 'sequence of prevention' cannot be applied without proper sports injury surveillance."*
> *(van Mechelen et al, 1997, pg. 164)*

According to Van Mechelen (1997), injury prevention tools cannot be validated without having baseline measures for pre and post intervention comparison. Therefore, this research needed to determine what injury surveillance was currently available to clinical support staff working with track cyclists. In addition to this, to be able to compare study results and undertake comparable research in the future, it is vital to have clear descriptions on what you are trying to measure. Therefore, this work also needed to determine what qualifies as an injury, and how it can be classified (for example acute/chronic/recurrent).

Injuries within track cycling are anticipated to be multifactorial, as cyclists are exposed to a number of different forms of training and competition load over the course of a season (for example road cycling, gym strength and conditioning, cycle ergometer sessions, track racing). When looking at injury surveillance and injury prevention it is also important to know the risks associated with the cross training methods used, and

therefore it was also important to look at gym/resistance training in the literature review.

Furthermore, within track cycling each squad (Men's Sprint, Women's Sprint, Men's endurance, Women's Endurance) will be exposed to different training based on the needs of their specific events, and thus potentially have different injury risks. Therefore, a literature review would also need to consider cycling kinematics and research relating to gym or resistance training.

1.4 Purpose of Study

As Van Mechelen (1997) states, without proper injury surveillance to determine the incidence, severity, aetiology and mechanism of injury, it is difficult to accurately assess any injury prevention measure. The current research aims to provide a descriptive analysis of the injury profile of elite track cyclists over a full training and competition year, such that injury risk can be established, and subsequently those working with the cyclists can target cycling specific injury prevention methods, and training programs to reduce this risk. This is with the overriding aim of enhancing performance through reducing training and competition time lost to injury.

1.5 Significance of the Problem

Little published research is available on injury in track cyclists, with the majority of cycling based research focussed on road and community cycling. Review of those articles looking at road cycling, and combining this with anecdotal evidence, is detailed further in Chapter Two Literature Review but suggests that road cyclists are at highest risk of knee, back and neck overuse injuries (Athanasopoulos et al., 2007; Clarsen,

Krosshaug, & Bahr, 2010; Griffiths-Fable, 2006; Junge et al., 2009; Palmer-Green, Burt, Jaques, & Hunter, 2014).

There are many possible implications of this lack of research. One such issue is an inability for the clinicians working with track cyclists to adequately support them with validated injury prevention programmes because of a lack of baseline information for comparison before and after any given intervention. As a result, it is difficult to predict or change injury incidence in track cyclists with possible health (injury), training, performance and subsequent financial detriment to the cyclist, their team, and their support staff.

As detailed above, in New Zealand each national sporting organisation's (NSO's) government funding is determined by HPSNZ with performance outcomes at major targeted events (World Championships, Olympic Games) as the key measures. Loss of training and competition time due to injury may have a negative impact on performance, and therefore it is the desire of all NSOs and the athletes and staff involved with them to decrease this time lost as much as possible to minimise any such performance detriment effect. Retention of athletes is also likely to be important to long term individual performance and also the development of depth of athletes within a sport, so reducing loss of athletes through injury or retirement secondary to injury is also valuable for this reason of development of junior riders.

It is also important to realise that it is not just the athlete who sustains the injury who is affected by that injury, but also their team members (for example the team pursuit event has four riders, and the team sprint – two in the women's event and three for the men's event), whose training and performance are understandably effected when one

member of the team is removed or changed, and also their coaches, and all their support staff whose careers are essentially judged on the performance outcomes of the athletes.

Summary

Establishing baseline injury data is essential for assisting injury prevention. Before any injury prevention measures can be undertaken effectively, it is necessary to establish the current injury profile of the given cohort. Quality research requires quality study design, and the key points in planning an appropriate injury surveillance study are as follows. The researcher must determine the best methods of injury surveillance, the specific demands of the selected sport or activity, and gather any current information on injury surveillance in the chosen cohort. Only from that information can a quality research project be designed, upon the results of which future injury prevention methods can be assessed.

CHAPTER 2: Review of the Literature

Introduction

This chapter comprises three sections. It begins with a review of cycling biomechanics, and cycling discipline and training requirements, providing contextual information of contributing factors to injury risk in the track cycling cohort. Section two describes injury surveillance, including what makes a quality injury surveillance tool, and definitions associated with injury surveillance. The final section covers cycling specific injury surveillance – in both track and road cycling disciplines, and concludes with recommendations on how to create or select a quality injury surveillance tool, with reference to this in the elite (specifically cycling) sporting environment.

2.1 Cycling disciplines and the biomechanical factors contributing to injury in cycling

At an elite level, cycling is a sport involving track cycling, road cycling, cycle ergometer, mountain bike and bicycle motocross (BMX) disciplines. For this study, road, track cycling, and cycle ergometer biomechanics will be discussed as the general pedal stroke is consistent. Track cycling predominantly involves the lower aerodynamic posture versus upright cycling, and the effect of this posture will be reviewed below. By contrast Mountain bike and BMX involve static postures and jumps not found in track or road cycling.

Road cycling involves long duration training and racing (from day races to multi week tours), and bikes with changeable gears when compared to the shorter duration (usually

maximum one hour), fixed gears of track cycling. However, road cycling forms a large part of a track cyclist's training load, and as such it is appropriate for road cycling injury surveillance papers to be reviewed here.

Track cycling is a sport which involves sprint and endurance disciplines and as with road cycling is divided into male and female races. The range of events in track cycling span from a nine to 11 second flying lap sprint, to an hour long 50km points race (Craig & Norton, 2001). Omnium riders compete in multiple events in a day, including both sprint and endurance disciplines.

In track cycling the bicycle has a fixed gear that cannot be changed during a race. The fixed gear bike means that there is no freewheeling (i.e.: when the pedals turn the wheels turn). A slowing of cadence will slow the bike, and no pedalling will stop the bike. As with any sport, an elite athlete will need to have a physiology which matches the demands of their event. In a sprint event speed is maximised by harnessing the power supply from all available sources and as a result sprint cyclists are generally heavier and stronger than endurance cyclists (Craig and Norton, 2001). In order to generate the power required for sprint racing, track cyclists (sprint in particular) typically have a component of resistance training in their program, which carries an injury risk of its own (Faigenbaum & Myer, 2010) and is described briefly in the following section.

It is also important to note that in track cycling the large majority of endurance events (individual pursuit, team pursuit) and all sprint events involve the lower, "aerodynamic" versus upright position on the bike. This is because studies have shown a strong positive relationship between power produced for a given traveling speed and the frontal projected area of cyclists, where cyclists were able to reduce the power required for the

same speed, indicating a smaller effect of drag forces when in the aerodynamic position (Grappe et al, 1997). This is important to consider in relation to the effect of bike set up on forces on the body, where the aerodynamic position involves a higher seat and lower handlebar set up, resulting in increased thoraco-lumbar and hip flexion than the upright road and cycle ergometer posture.

During the cycling pedal stroke muscles contract in an orderly, coordinated pattern, and the muscle activation pattern is highly reproducible even with changes to resistance (Houtz & Fischer, 1959), but it is unclear from current research if changes to cadence have any significant effect on the coordination of muscle activation patterns (Fonda & Sarabon, 2012). Chapman et al (2008) determined that changing from an upright to an aerodynamic posture did not result in significant changes to muscle activation patterns in professional cyclists, and hypothesised that any changes in muscle activation with a change in upright to aerodynamic postures was largely due to neurological and not biomechanical factors. However, this differs from Sanderson & Amoroso (2009), and Dorel, Couturier & Hug's (2009) studies, that describe upper and lower body position as being critical in determining muscle activation patterns (Bini et al., 2011; Dorel, Couturier, & Hug, 2009; Sanderson & Amoroso, 2009), and which state that changes in upper body lean and saddle height are the two most important settings in body position of cyclists during pedalling. Furthermore, Savelberg, Van de Port & Willems (2003) describe that changing upper body position has a consistent effect in activation of upper and lower body muscles, with upper body position having been related to changes in activation of lower limb muscles, which have been shown to affect performance in cycling (Jobson, Nevill, George, Jeukendrup, & Passfield, 2008). They state that the greater the forward lean, the larger the effects (increased flexion of lumbar pelvis

region) observed in the lumbo-pelvic region. This may increase load or risk of injury to this region (Srinivasan & Balasubramanian, 2007). It could therefore be hypothesised that the above evidence of changes to bike set up (seat and handlebar height, along with crank length and seat tilt, amongst other aspects of bike set up) play a significant role in changing load, power, muscle activation and other factors in the cyclist. This indicates that bike set up also plays a significant role in the injury status of an athlete, and not just their performance.

For individual and team pursuit events in particular, track cyclist use aerobars to decrease frontal projected area and thus improve aerodynamics, as described above. Dorel et al., (2009) determined that gluteus maximus, vastus medialis, and vastus lateralis activation was improved when pedalling at the aerobars compared to upright cycling. Greater forward lean of the upper body is also considered to increase hip and knee joint extensor recruitment (Dorel et al., 2009). In order to maintain trunk position, upper body muscle recruitment is utilised. Low back pain (LBP) has been linked to excessive recruitment of these muscles, especially with long duration riding (>30 min) (Srinivasan & Balasubramanian, 2007). It is therefore suggested that to maintain a quality aerodynamic position, adequate trunk strength is required, and the risk of LBP may increase if this were not the case (Srinivasan & Balasubramanian, 2007). It is also suggested that cyclists (both road and track) are at risk of training overuse injury (Dorel et al., 2009; Clarsen et al., 2010; Bini & Hume, 2011), especially if their bike set up or training load is not appropriate for them. This is because of the highly repetitive nature of the cycling pedal stroke, the force and power produced by track sprinters, and the long duration training rides of the endurance athletes, as well as the aerodynamic posture utilised in track cycling events (Dorel et al., 2009).

2.1.1. Gym – Resistance training

Given the large strength, power, plyometric and therefore gym requirements for the sprint team's program in particular, gym or resistance training is a part of an elite cyclist's training program and therefore warrants mention here in relation to other possible injury risks for track cyclists. Faigenbaum & Myer (2010) conducted a literature review into epidemiology of injury in youth resistance training. They determined that resistance training involves progressive use of a range of resistive loads, using differing velocities of movement, and a variety of training modalities. These modalities may include weight machines, free weights (barbells and dumbbells), elastic bands, medicine balls and plyometrics. They concluded that although with undertaking resistance training there is potential for injury to the lower back, this is reduced if qualified professionals supervise sessions and provide age appropriate instruction on lifting procedures and training guidelines. Therefore, the quality of supervision and instruction, exercise technique, progression of training loads and weekly training volume are all key factors in minimising injury risk with resistance training. Limitations of this study in relation to the current research is the use of a younger cohort, but useful information can still be taken from this with regards to the benefit of resistance sessions being supervised and time and care being taken to ensure correct technique and appropriate training loads. Further research into resistance training with this cohort would be required when it came to the point of assessing and implementing strategies to minimise injury risk.

2.2 Search Methods:

The presentation of the next section of the literature review is a narrative but using a systematic approach to how the literature was sourced. A full systematic review was not appropriate as there was such a limited amount of papers in this area (see Figure 2.1). In order to gather information on injury surveillance in cycling a literature search was undertaken on the Mendeley website, and the Auckland University of Technology (AUT) Library, which uses the AMED, Cinahl, OVID and Medline databases searching from 1930 to year 2014. The following combinations of key words were used: cycling, track cycling, injury surveillance, injury prevention, influence of injury in sport, impact of injury in sport, gym training, and resistance training, and limiting the search to scholarly/peer reviewed journals. A total of 703,110 articles were found using cycling as the key word which was reduced to 355 with combinations of the keywords. The titles and abstracts of the articles identified were reviewed for relevance by the author. The full text of all relevant articles was then analysed for final inclusion, including those from the reference lists of the initial articles that were related to the key words, with a final reference list of 83 articles.

A flow diagram of this study's search strategy is shown further below in Figure 2.1. The first and second steps of the flow chart produced the full article list used for this study, as described above. The third and final step of the flow chart relates to narrowing the search to cycling specific injury surveillance, which is outlined in section 2.4.

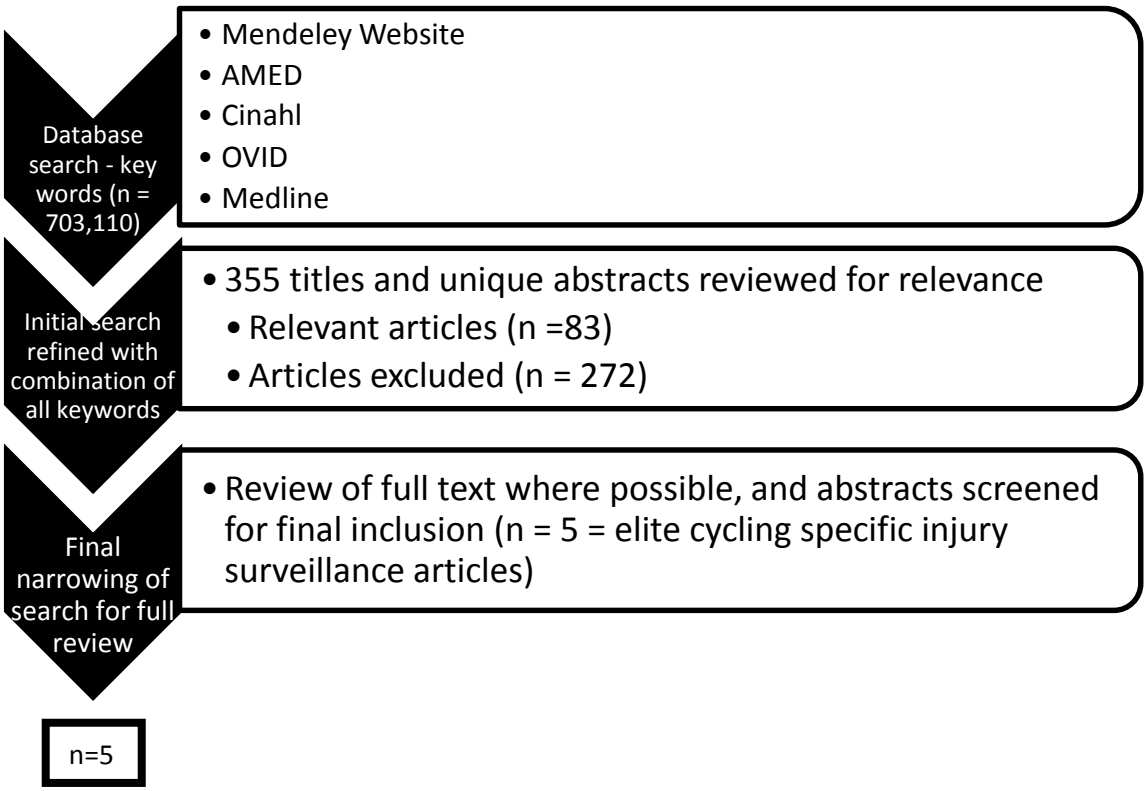


Figure 2.1 Flow Diagram of search strategy

2.3 Injury Surveillance

Injury surveillance is an essential component of high performance sport (Van Mechelen, 1997). Without sound information on how and when injuries occur, the type and location of injury, and subsequent impact on training and competition for an athlete, then injury incidence and prevalence in sports will remain unknown. There are several injury surveillance and injury prevention models in the literature which are detailed and referenced below. Van Mechelen (1997) proposed an early comprehensive model for injury surveillance, upon which further models have been developed.

Van Mechelen (1997) suggested there is a need for sports injury prevention which should be based on the outcome of scientific research as part of the 'sequence of prevention'. The first step in any injury prevention programme is the collection of both

baseline and subsequent prospective data on injury incidence. Only with this information known is it possible to implement and evaluate future injury prevention programmes to determine if they reduce the number and type of injury an athlete may experience, and therefore enhance performance outcomes.

Orchard (Orchard & Finch, 2002) reinforced the importance of injury surveillance and its use in preventing sporting injuries at a national level. Orchard describes how Government funded injury surveillance led to the introduction of an injury prevention program which subsequently lowered the incidence rates of catastrophic spinal injuries in NZ rugby by over 50%. He also details the importance of Van Mechelen's sequence of prevention in injury surveillance and reduction of injury risk.

When conducting injury surveillance research, Van Mechelen states that it is necessary to have a clearly defined research question in order to determine the injury surveillance system to be used. This system must be "sensitive enough to answer a specified "how many, how often, how long, how serious?" question" (Van Mechelen et al, 1997, pg. 165). It needs to be easy to use, unchanging, and have clearly expressed definitions of the variables involved.

Van Mechelen's 1997 literature review on injury severity outlined that severity is usually measured based on the following six criteria – nature of sports injury, duration and nature of treatment, sporting time lost, working time lost, and monetary cost. His review describes these criteria in further detail. Information on the duration and nature of treatment provides further detail of injury severity which can then lead to an estimate of the cost of the injury. The studies reviewed by Van Mechelen (1997) indicate that there is a strong relationship between the nature of the injury and duration and nature

of treatment. Van Mechelen also described that working time lost was an indicator of the financial impact an injury may have on society. For an elite athlete – their sport is their work so this is very important for them. Injuries which result in permanent damage should be the first to have injury prevention measures introduced because of their long term negative impact on the athlete and possible financial cost to society. Van Mechelen summarises that assessing the severity of the sports injury is an essential component of identifying the extent of any problem. It should come under Step 1 in the sequence of injury prevention detailed above. All of Van Mechelen's suggested components can be used in defining severity for injury surveillance, or appropriate criteria can be selected based on the specific research question as long as clear definitions of the criteria selected are defined.

Meeuwisse & Love (1997) reviewed Athletic Injury Reporting systems in use in North America, and gave four recommendations to the future researcher based on this for collecting and publishing data which, if used, should enable data from different injury reporting systems to be compared. They determined that research must provide specific details of the injury surveillance design and methodology of data collection, must provide precise injury definitions, outcome information should be recorded for each event in order to have clear injury definitions at data collection, and that it must acknowledge possible sources of error. Their review also indicates that an ideal system for injury surveillance and athlete risk assessment should be simple and easy to use, flexible in order to address changing injury patterns, must collect exposure data and contain uniform recording of injury diagnosis, and must include data collection by the therapists working with the athletes (Meeuwisse & Love, 1997).

Steffen & Engebretson's (2010) literature review on injury surveillance in elite young athletes in Olympic sports identified 13 studies on the topic, 10 of which were prospective studies, with eight of those ten on football and one each on gymnastics and field hockey. They reinforce the importance of Van Mechelen's sequence of intervention and agree that injury surveillance is vital - initially for the purpose of monitoring injury trends and subsequently to target injury control measures in order to minimise injury risk. They state that with knowledge of the cause or mechanism of injury, and increased knowledge on intrinsic and extrinsic risk factors, then "high risk" athletes may be identified earlier in their careers and have interventions introduced in an attempt to minimise injury risk. Injury prevention is also important to try and reduce risk of additional injuries, and decrease possible serious long term health consequences from injury and dropout from the sport altogether. They concluded that there is minimal information available in quality (or otherwise) injury surveillance in Olympic sports in this cohort (young elite athletes competing in Olympic sports) outside of football (Steffen & Engebretsen, 2010).

Finch (1997) expands on the Van Mechelen model, stating clarity is needed on the nature and mechanism of injury, but also that research methods need to include detail on the level of supervision and external supports (e.g. braces, helmets), the characteristics of the injured person, and the level of sporting participation (exposure data including hours of activity, level of activity, training or competition). This is described as the Translating Research into Injury Prevention Practice (TRIPP) model, which expands Step 3 and Step 4 of Van Mechelen's model to include development of preventive measures and scientific review of these measures in the context of the sport or environment they are implemented in (Finch, 1997).

Finch highlights the importance of clear definitions when creating and implementing a sports injury surveillance system, stating that a sports injury surveillance system is essential in order to guide sports safety and injury prevention activities, which may also include prioritising those interventions. Definitions of risk exposure factors are vital to the validity and usefulness of the resulting outcomes as data collection and validity rely on being able to measure those factors. Definitions may vary between studies, but without clear definitions it is difficult to compare one set of research data with another. Key points are detailed on what information should be collected in a quality sports injury surveillance system. Finch reports that the four key areas requiring clear descriptions are definitions of nature and mechanism of Injury, measures of severity, identification of the population at risk, and degree of exposure. Bahr & Holme (2003) also reviewed research on the methodology for injury surveillance systems and injury prevention. They state that the goal of support staff working with athletes should be to prevent injuries occurring in the first instance in order to help athletes reach their full potential (Bahr & Holme, 2003). Their study reinforced that the methods described by Van Mechelen, and Meeuwisse & Love – as detailed above – are the key factors in creating and undertaking an injury surveillance system. The focus needs to be on clear definitions of injury incidence, severity, aetiology and mechanism, and precise descriptions of methodology, in order for the data to be valuable to a broad range of possible users in the future, and be reproducible for possible future research.

Defining the nature of an injury involves detailing the time frame in which that injury occurs. (Finch & Cook, 2013) described injuries as being Acute, Overuse or Recurrent. Acute being any physical complaint that is caused by the inability of the body's tissues to maintain its structural and/or functional integrity following an instantaneous transfer

of energy to the body (Finch & Cook, 2013; Orchard & Finch, 2002). Overuse injuries are those caused by an accumulated energy transfer, rather than a clearly identifiable single event (Finch & Cook, 2013; Fuller et al., 2006). Recurrent injuries are an injury of the same type and at the same site as an index or initial injury and which occurs after a player's return to full participation from the index injury (Finch, 2013). Finch also developed a model for classifying subsequent injuries (Subsequent Injury Categorisation or SIC) which categorises injuries in relation to a previous or initial incident, and includes information on whether or not the injury had fully resolved, with detail based on symptoms in relation to a primary or index injury.

Clarsen (Clarsen & Bahr, 2014; Clarsen, Myklebust, & Bahr, 2013) developed and validated the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire which is a self-reported questionnaire looking at overuse injuries in various areas of the body. This questionnaire has been validated, and provides a way of capturing the prevalence of overuse injuries, and the severity of those injuries (Clarsen et al., 2013).

Fuller, Ekstrand, Junge et. al., (2006) produced a consensus statement on injury definitions in football, providing definitions for the nature of the injury, severity, and training and competition exposure (Fuller et al., 2006). Having clear definitions and a detailed method of recording injury type is helpful in both clinical practice and research. Orchard et al (2005) developed the Orchard Sports Injury Classification System (OSICS) which is now in its revised form known as OSICS-10 (J. Orchard, 2010), and looks to further detail injury classification for researchers and clinicians. The OSICS-10 classification system allows the clinician or researcher to code injuries based on body site and type of injury using four letter codes and has been shown to demonstrate a high

level of agreement amongst treating/assessing clinicians, particularly with the first two characters of coding (Finch et al., 2012).

Also crucial when recording injury data is recording the degree of exposure. de Loës (1997) presents a review of different approaches to study designs in sports epidemiology, and determined that a study design that is aimed at a specific sport or diagnoses and which includes data on injury exposure, along with agreement on methodology and clearly defined issues is needed (de Loës, 1997). This produces research with quality injury surveillance and reproducible results, and allows for future comparison of studies. Exposure may be measured in training or competition hours, or in training exposure (i.e. per session of training, regardless of time). This may be useful to use when comparing between sports or subsets of sports where the training duration may be quite different (sprinters on repeated maximal track efforts versus endurance riders on three-hour long sub maximal ride).

To have further clarity around exposure and training or competition intensity, when duration can be different, rate of perceived exertion (RPE) can also be recorded which gives an indication of the intensity of the exercise undertaken (Gabbett, 2016; Gabbett & Seibold, 2013). The RPE scale has been shown to provide a valid measurement of intensity when compared with heart rate and blood lactate concentration (Dunbar & Bursztyn, 1996; Herman, Foster, Maher, Mikat, & Porcari, 2006). Therefore, it could be hypothesised that modified versions of the RPE scale to record training intensity can be used in future studies to gain a self-reported measure of intensity.

Once these injury definitions are clear, and if these injuries are recorded accurately over time, incidence and prevalence can be calculated. Injury incidence is defined as the

number of new injuries per 1000 training and competition exposures (Clarsen, Rønsen, Myklebust, Flørenes, & Bahr, 2014; Finch & Cook, 2013; Fuller, Laborde, Leather, & Molloy, 2008). Injury prevalence can be calculated by dividing the number of athletes reporting injuries, with the number of completed questionnaires received, and expressed as a percentage, as was used by Clarsen et al (2014).

High Performance Sport New Zealand (HPSNZ) has developed a smart phone/tablet APP - the Program for Injury and Illness Surveillance (PILLS) which fits the guidelines suggested by Van Mechelen, Finch, and others. The PILLS app is a non-validated tool which is a self-reported injury and illness survey conducted on a smartphone or tablet APP which the athlete must complete weekly. The PILLS tool asks for information primarily on injury and illness, training volume, effect of injury and illness on training, and the athlete's perception of their readiness to train and compete. The PILLS survey questions are designed to capture incidence of injury by recording individual injuries as they occur, and by measuring across the squads each week it can also be used to determine prevalence of injury in a squad at a given time. When looking at this self-reporting tool from an injury surveillance point of view, the PILLS survey fits the key requirements of an Injury Surveillance system as described by Van Mechelen et al in their 1997 review paper assessing injury incidence, severity, aetiology and mechanism (Van Mechelen et al, 1997).

2.4 Cycling specific injury surveillance

The following section reviews the studies found on injury surveillance in cycling, with a brief section on track cycling as only one study was found, and more detail on road cycling studies.

2.4.1 Search methods

The initial injury surveillance search strategy outlined in Figure 2.1 above found 83 articles relevant to this review. From this 83 the abstract and titles were read and it was determined that only five were specific to injury surveillance in elite cycling, with four articles on elite road cycling and one published article (and only in abstract form) available on track cycling (See final step of search methods flow chart illustrated in Figure 2.1 above). These papers were then reviewed and summarised in Table 2.1. One further study found examined injury surveillance at the Olympic Games across all sports, which includes track cycling. They indicate that injuries do occur in cycling at the Olympic Games, however, they do not provide any further specific details of the cycling injuries so were not reviewed further here (Athanasopoulos et al., 2007). It is clear from the literature search for this current research that there are limited papers available looking at injury surveillance for elite (senior/open grade) track cycling. Inclusion of studies for that section was based on an elite cycling cohort (road or track), needed to contain injury surveillance studies, and be in a peer reviewed journal. Palmer-Green's 2014 study was the only track-cycling study found in the literature search, hence it being included here despite only being available in abstract form (Palmer-Green et al, 2014). Efforts to contact the author to gain access to a full article were unsuccessful. Although this would normally result in its exclusion, it was included

here for cohort specific reference. This highlights the lack of published research in this area and the need for further investigations such as this study.

2.4.2 Track cycling injury surveillance

As described above, only one study (Palmer-Green et al, 2014) was found specifically on track cycling injury surveillance which looked at the British Cycling team. Palmer-Green et al (2014) conducted a longitudinal prospective surveillance study (n=61 participants) of injury in British Cycling from 2011-2013. Definitions for injury, time-loss and performance-restriction were used to identify the rate and severity of injury, with the main outcome measures of injury rate, severity and causes. The primary limitation to using this study is that only the abstract is available in published form, so it is difficult to review, analyse or reproduce the methodology and definitions used. Secondly, endurance track cyclists have been grouped with endurance road cyclists which does not provide a clear picture of the track cycling group (although the author acknowledges that the endurance track riders also do some road racing as cross training in the off season from track competition). However, it was the only study found that looked in detail at track cycling.

This study used standardised reporting forms completed by the medical staff and showed 95 injuries during this two-year period of the study. 35% of the squad sustained at least one injury per season, with each injury lasting 16 days on average. Training injuries were more prevalent than competition injuries (n=77 vs n=18 respectively), and more severe (24 vs 14 days missed), with the endurance squad having the lowest injury prevalence and severity (compared to sprint and Bicycle Moto-Cross/BMX). The lumbar spine (29%), knee (18%) and shoulder/clavicle (14%) were the most common injury sites, with overuse injuries (58%) and recurrent injuries (35%) being the most common type

of injury, with only 7% acute injuries. Injuries involving contact with a static object were the most severe injuries (32 days missed). In splitting the sprint and endurance squads – weight training related lumbar spine injuries in the sprinters and road cycling related shoulder/clavicle and knee injuries in endurance resulted in the greatest number of days lost to injury.

Table 2.1

Cycling injury surveillance studies

Study (Author & Year)	Participants	Study Design	Results
Barrios et al (2015)	Male professional cyclists n=131 Historical group n=65 male riders surveyed between 1983-1995 Contemporary group (currently competing) n=66 interviewed 2003-2009, reporting injuries from 2000-2009.	Retrospective descriptive epidemiologic survey	Injury Profile: HG: 86 injuries cf CG: 141 injuries. Injury/Cyclist ratio: HG: 1.32, CG: 2.13 TI: HG: 39.5%, CG: 53.9% (significant increase, p<0.05) Severe traumatic lesions decreased significantly (p<0.01) HG:49.9%, CG 10.5%. Patellofemoral pain decreased (p<0.01): HG: 28.8%, CG: 6.1% Muscle injuries substantially increased (p<0.01) HG: 13.4%, CG: 44.9% Injury rates: HG: 0.104 per year per cyclist, and 0.003 per 1000km training and competition CG: 0.287 per year per cyclist, and 0.009 per 1000km training and competition Summary: CG double risk of TI cf HG but those lesions less severe. Anatomical region: In both HG and CG >half injuries occurred in the upper extremity or shoulder girdle (HG 52.8%, CG 61.7%) OI: CG more muscle injuries than HG (CG: 44.9%, HG: 13.4%) AIS severity scale: Severe lesions decrease. (p<0.001) from HG: 49.9% to CG: 10.5% OI Location: HG: Knee 63.4%, Muscle 0 injuries Recorded, Spine 13.4%, Other 23.1%; CG: Knee 36.9%, Muscle 21.5%, Spine 29.2%, Other 12.3%
Palmer-Green et al (2014) (Only abstract – not full article – published at time of this research)	British national team cyclists across BMX, Mountain-bike, Track sprint, Road/track endurance n=61 cyclists (16 female, 45 male)	Longitudinal prospective cohort study (surveillance)	95 injuries lasting average of 16 days, 35% of squad with 1 injury per season PREVALENCE: Training injuries 30% (n=77), Competition injuries 11% (n=18) SEVERITY: Training injuries 24 days missed, Competition injuries 14 days missed Overuse injuries: Lower back 29% (n=17), Knee 18% (n=9), Shoulder 35% (n=23) TIME LOSS: Acute injuries: 32 days missed

KEY: HG: Historical group, CG: Contemporary Group, AIS: Abbreviated Injury Scale, BMX Bicycle motocross, TI: Traumatic Injuries, OI: Overuse injury, LBP: Low back pain

Table 2.1

Continued

Study (Author & Year)	Participants	Study Design	Results
Clarsen et al (2015)	5 sports monitored including: n=98 cyclists (from 5 professional teams - 84 males, 14 females)	Prospective Cohort study	Cyclists – 92% response rate Prevalence: All overuse injuries (injury tally with 95% C.I.) Knee 23 (17-28) Lower back 16 (12-20) Shoulder 7 (4-10) Thigh 8 (7-9) Substantial overuse injuries (with 95% C.I.) Knee 8 (7-9) Lower back 6 (4-7) Shoulder 1 (0-1) Thigh 4 (3-5)
Steffen et al (2012)	Athletes competing at Beijing and Vancouver Olympic games – of which n=518 cyclists	Injury surveillance – prospective cohort study	518 cyclists 30 injuries – 22% of all Olympic injuries 5.7% of participating athletes
Clarsen et al (2010)	Professional male road cyclists from 7 professional teams n=109	Descriptive epidemiological cohort study (cross sectional, retrospective)	94 injuries in 63 athletes, 45% in back, 23% knee TIME LOSS INJURIES: 23: Knee 57%, Lower back 22%, Lower leg 13% PREVALENCE: LBP 58% with 19% seeking medical treatment, Anterior knee pain 36% with 19% seeking medical treatment MISSED/MODIFY COMPETITION: Knee 9%, Lower back 6% MISSED/MODIFY TRAINING: Knee 27% TIME LOSS INJURY: Knee 57%, Lower back 17%, Lower leg or Achilles 13% 1 career ending lower back injury Average time loss of 13.5 days per injury (excl. career ending back injury)

KEY: HG: Historical group, CG: Contemporary Group, AIS severity scale, BMX Bicycle motocross, TI: Traumatic Injuries, OI: Overuse injury, LBP: Low back pain

2.4.3 Road cycling injury surveillance

Clarsen, Krosshaug and Bahr (2010) carried out a descriptive epidemiological study in professional road cyclists, looking at overuse injuries with a particular focus on anterior knee and low back pain. The authors attended the training camps of 7 professional road cycling teams and interviewed 109 of the 116 cyclists (94%) on any overuse injuries incurred in the prior 12 months. Injuries that involved time lost from cycling or required review by medical staff were recorded and additional information on knee and lower back pain was collected using specific questionnaires for these regions. Results showed a total of 94 injuries being registered with 45% in the back and 23% occurring at the knee. Twenty-three injuries resulted in time lost to the sport, with 57% in the knee, 22% in the lower back, and 13% in the lower leg. Lower back pain had been experienced by 58% of all cyclists during the previous 12 months with 19% seeking medical attention. Only small numbers had missed competitions because of anterior knee pain (9%) or lower back pain (6%). Limitations to this study include it being a cross-sectional study with retrospective data collection, whereas the prospective longitudinal cohort studies are considered the gold standard for injury surveillance research (Meeuwisse & Love, 1997; van Mechelen, 1997). The challenge of recall bias limits the value of retrospective studies.

Subsequently, Clarsen, Bahr, Heymans and Engedahl (2015) investigated sports injuries with a prospective cohort study on injury surveillance across five different sports including road cycling, with 98 professional cyclists from five different professional teams (n=98, with 84 males and 14 females) (Clarsen et al., 2015). Participants were asked to complete an overuse injury questionnaire every week for 26 weeks using online software for distribution and data collection. Cyclists had a 92% response rate. Data

collected looked at prevalence for all overuse injuries and also the sub category of substantial overuse injuries (substantial meaning causing a moderate-severe reduction of training volume or sports performance, or complete inability to participate in training or competition. Results indicated that cyclists had the highest prevalence of knee injuries (23%) followed by Lower back (16%), Thigh (8%) and Shoulder (7%). Substantial overuse injuries followed the same trend, with Knee highest at 8%, followed by lower back (6%), Thigh (4%) and Shoulder (1%). Limitations in this study included that the questionnaire was specific only to overuse injuries and that the questionnaire used looks only at specific areas of the body, so it may miss some injuries (i.e. upper extremity and lower leg injuries).

Steffen, Soligard and Engebretson (2012) conducted a prospective cohort study involving injury surveillance of athletes competing at the Beijing Summer Olympics (2008) and Vancouver Winter Olympics (2010) across a number of sports, including cycling at the Beijing Games (K. Steffen, Soligard, & Engebretsen, 2012)(Vanhegan et al., 2013). In their study 518 cyclists competed at the games, sustaining 30 injuries (22% of all Olympic injuries), with 5.7% of competing cyclists sustaining an injury during the period of the Beijing Olympics. Injuries were recorded by team medical support and Olympic medical pool personnel using standardised injury surveillance reporting forms. Exact details of the nature and severity of the cycling injuries were not recorded, nor was it divided into the sub-disciplines of cycling at the Olympics which are Track cycling, Road Cycling, BMX and Mountain bike. More detail would be required for this article to provide further useful information for the current research.

Barrios, Bernardo, Vera, Laiz and Hadala (2015) conducted a retrospective descriptive epidemiologic survey of professional road cyclists, comparing historical injury

surveillance data with currently competing cyclists' injury surveillance data (Barrios, Bernardo, Vera, Laíz, & Hadala, 2015). The injury register used in both studies attempted to cover all traumatic and overuse injuries the cyclist had suffered since their debut as professionals. Only injuries which affected training or performance were considered. Injuries were recorded as acute or overuse, and new or recurrent, and classified using the abbreviated injury scale (AIS) with 1 being minor, 2 moderate, 3 severe but not life-threatening, 4 severe and life-threatening, and 5 severe with uncertain survival. Injuries were also classified according to Ekstrand's 3-point scale of minor, moderate or severe based on time loss to training or competition (Fuller et al., 2006). The injury/cyclist ratio was 1.32 in the Historical Group (HG) compared to 2.13 in the Contemporary Group (CG). Of these injuries, there was a significant increase in the percentage of traumatic injuries in the CG compared with the HG (HG: 39.5%, CG: 53.9%, $p<0.05$), however alongside this there was a significant reduction in severe traumatic lesions, with HG: 49.9%, and the CG 10.5% ($p<0.01$). When looking at the location and nature of the injury, they found that patella-femoral pain significantly decreased ($p<0.01$) from the HG (28.8%) to the CG (6.1%), and muscle injuries substantially increased ($p<0.01$) with 13.4% of the HG's injuries being muscular, compared to 44.9% in the CG. In both HG and CG more than half of the injuries occurred in the upper extremity or shoulder girdle (HG 52.8%, CG 61.7%). The CG had double the risk of traumatic injury as the HG and those lesions sustained were significantly less severe.

Overuse injuries were also recorded, with the CG sustaining more muscle injuries than the HG (CG: 44.9%, HG: 13.4%). According to the AIS severity scale, severe lesions decreased ($p<0.001$) from 49.9% in the HG to 10.5% in the CG. Overuse injuries were recorded as being in the knee, muscle, spine or other (with further percentage

breakdown also detailed). For the HG, 52 overuse injuries were recorded, and were located in the knee 63.4%, muscle 0 injuries recorded, spine 13.4%, other 23.1%; In the CG, 24 overuse injuries were recorded with 36.9% in the knee, 21.5% recorded as muscle injuries, 29.2% in the spine and 12.3% registered as "other". It should be noted that while no muscle injuries were recorded in the HG, seven cases of low back pain where training or competition was affected (13.4%) recorded those injuries as having a component of muscle contractures of the lower back and were recorded in the spine category versus the muscle category.

The authors describe the introduction of compulsory helmet wearing as a major contributing factor to the reduction of severe head injuries and thus the Grade 3-5 injuries on the AIS. They theorise that current training protocols and pedalling techniques may be responsible for a change in nature from tendon to muscular injuries and also suggest that although there was a significant reduction in reports of patellofemoral pain from the HG to the CG, it remains a relatively common overuse injury in cycling. This is supported by Clarsen et al's 2010 study. Issues such as patellar malalignment, leg-length discrepancy, muscle imbalance, varus or valgus knee alignment, and poor muscle flexibility around the pelvic girdle may contribute to this issue, and the type of saddle, seat height, cleat type and position, shoes, gear lengths may also be relevant (Bini et al, 2011; Bini et al, 2012, Chapman et al, 2008; Clarsen et al 2010). As such, all of the aforementioned factors are usually assessed by support staff associated with professional teams, which may be the reason for the reduction in patellofemoral joint pain seen in the CG compared to the HG.

Summary

Effective injury prevention requires quality injury surveillance. Prospective longitudinal cohort studies are the gold standard for this type of research, to ensure capture of any seasonal differences across at least one full year of training and competition. A robust surveillance tool must be used which is easily accessed and implemented. Clear descriptions firstly of the research question itself are required, but also detailed definitions and classifications of injury, with reproducible methodology, and clear descriptions of outcome measures to allow for future research in the same area. To establish injury incidence, you need to provide detailed descriptions of how and when an injury occurs, the type of injury, training and competition exposure/load, and the impact of the injury on training and performance. From this, injury incidence and prevalence can then be calculated.

Current literature suggests that cyclists have a high risk of knee, lower back and shoulder injuries, though this is largely based on data from research on road cyclists. Limited research has been published addressing injury incidence and prevalence in elite track cycling and this is information is essential if anyone working with these athletes wants to make informed decisions about strategies to minimise injury risk and optimise an athlete's availability for performance. Cycling biomechanics and muscle activation have been described above, but for injury surveillance purposes in track cycling in the first instance, it is most important to consider the differences in both training and competition loads of track cycling compared to road cycling, which will also help to determine if the greater supply of published road cycling injury surveillance studies are of relevance when treating track cyclists. Research methodology for injury surveillance on track cyclists will need to address the above points.

CHAPTER 3: Methods

Introduction

In the current study, the cohort was elite New Zealand Track Cyclists, from the 2015-2016 cycling season. The type and amount of cycling training and competition undertaken, as well as detail on any injuries which occurred during the 52-week period were collected.

3.1 Study design

A prospective longitudinal descriptive cohort study of elite New Zealand track cyclists over a consecutive 52-week period.

3.2 Ethics

Ethical approval was gained from the AUT Ethics Committee (AUTEC) for all components of this research (Reference number 15/108 – see Appendix 1).

3.3 Sampling

All members of the NZ high performance track cycling squad were invited to take part in the study. Those who consented to participate then completed two separate baseline surveys followed by 52 consecutive weekly injury surveillance questionnaires. Variables recorded were injury occurrence (including cause, nature and duration of injury, and training missed or modified due to injury), training intensity and perceived readiness to train or compete. Data were recorded via excel spreadsheet and analysed by the lead

researcher with the aid of AUT statistical analysis staff at the completion of the 52 weeks of data collection.

3.3.1 Sample Size

This study used a sample of convenience – the 2015 New Zealand Track Cycling squad – defined as those athletes listed as "carded" track cycling athletes with High Performance Sport New Zealand (HPSNZ, n.d.) All carded track cyclists were invited to participate, which at the time the research was undertaken was a total of 41 athletes split amongst the four squads of Men's Sprint, Women's sprint, Men's endurance, Women's endurance.

3.3.2 Inclusion criteria:

- The 2015-16 New Zealand Track Cycling squad – defined as all those athletes listed as "carded" track cycling athletes with HPSNZ as selected March 2015.

3.3.3 Exclusion Criteria:

- Any athlete who withdraws from the squad between time of selection and beginning of research program.
- Loss of carding status
- No phone / computer access

3.3.4 Study Site*:*

The study was conducted from the "Home of Cycling", Avantidrome – Hanlin Rd, Cambridge 3283

3.4 Injury Surveillance Tools

3.4.1 Questionnaire 1 – basic history questionnaire (see Appendix 6)

Cyclists completed an initial survey to provide basic baseline characteristics, including age, and self-reported years in sport, current and previous injuries.

3.4.2 Questionnaire 2 – Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire (see Appendix 7)

The Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire is a validated tool that captures the overuse nature of injuries and the impact of these injuries on the athlete's performance (Clarsen et al., 2013). The OSTRC overuse injury questionnaire has three sections relating to the knee, the lower back, and the shoulder. As these areas are commonly injured in cycling this survey was selected as the baseline overuse injury questionnaire. It has also been utilised in other cycling injury surveillance studies and therefore its use here makes comparison of studies more appropriate. This was completed at baseline/entrance into the study.

3.4.3 Programme for Injury and Illness Surveillance (PILLS) app (see Appendix 8)

Injury surveillance for this study was achieved utilising the Programme for Injury and Illness Surveillance (PILLS) tool which is a non-validated tool created and introduced by High Performance Sport New Zealand (HPSNZ). The PILLS tool, which is completed using the iSurvey application, allows for a consistent method of gathering self-reported athlete data. It is easy to use and accessible via any internet connection, as long as the athlete has access to either a smartphone or tablet device.

Raw data drawn from the PILLS survey for this study included:

- Injury – any event which caused training or competition to be missed or modified, including location of injury and self-rated severity on a scale of 1-10 (see below "injury definitions and classification" for detail).
- Number of planned training and competition sessions vs number missed or modified
- Athlete's perceived readiness to compete at their best – measured as a percentage on a visual analogue scale
- Reason for training being missed/modified i.e.: illness, injury (from training, competition, outside of training), reason other than illness (i.e.: University exam)
- The PILLS survey also records the number of physiotherapy/ doctor/massage/other appointments for an athlete or sport, medical incidents, and number of investigations by an athlete or sport (i.e. Blood tests, x-rays, MRI scans), but for the purposes of this study, only the results of the injury specific data were requested, consented to release and used.

3.4.4 Completion of the PILLS survey

The participants completed the survey questionnaire weekly, with results recorded over a 52 consecutive week period. This information was then downloaded into a master spreadsheet and stored on a secure electronic database. Athletes were encouraged to set a reminder to complete the survey on their smart electronic devices. If athletes had not completed the survey within 48 hours of the scheduled time they were sent a single reminder from the primary researcher.

This study extracted only data relating to injury surveillance from the survey replies (it does not look at illness). A copy of the questions for the PILLS tool is available in Appendix 8 – the questions 17 to 23 are recorded in PILLS but not used in this research, so recorded data will only apply to questions 1-16 and 24-31.

3.4.5. Comparison of physiotherapy notes, Orchard Codes for new injuries.

All injuries requiring treatment by a HPSNZ clinician are required to be classified by that clinician using the Orchard Sports Injury Classification System (OSICS-10) (http://www.johnorchard.com/osics-downloads.html, Dr John Orchard Sports Physician (n.d.)). This classification system has been shown to demonstrate a high level of agreement amongst treating/assessing clinicians, particularly with the first two characters of coding (Finch et al., 2012). As a result, each week the lead researcher will code the injuries recorded in the PILLS questionnaire according to the OSICS-10 codes. Any self-reported injury recorded as receiving treatment (as identified in the answers to questions 1-16 in the PILLS database) will have its corresponding OSICS-10 code allocated and recorded by the lead researcher. This was to assess if the self-reported injury classification is comparable to the injury classification allocated by the treating Doctor and/or Physiotherapist.

3.5 Outcome Measures

3.5.1 Orchard Codes

Weekly self-reported injury surveillance data collected was classified by the lead researcher using the Orchard Sports Injury Classification System (OSICS-10) as this has been shown to demonstrate a high level of agreement, particularly with the first two characters of coding (Finch et al., 2012), and this will be compared to the injury

classification recorded for any treatment received. This was to assess if the self-reported injury classification was comparable to the injury classification allocated by the treating Doctor and/or Physiotherapist.

3.5.2 Injury definition and classification:

- Injury – any physical complaint which caused training or competition to be missed or modified, (amended from those definitions used in Fuller's (2006) football study, and Clarsen's (2010) cycling study, to capture both acute and overuse injuries (Fuller, 2006; Clarsen et al, 2010)).
- Further injury detail including location (geographical and body part) of injury and self-rated severity on a scale of 1-10 were recorded.
- Injuries were sub divided into acute, overuse and recurrent injuries as defined by (Finch & Cook, 2013).
    - Acute being any physical complaint that is caused by the inability of the body's tissues to maintain its structural and/or functional integrity following an instantaneous transfer of energy to the body (Finch & Cook, 2013; Orchard & Finch, 2002).
    - Overuse injuries are those caused by an accumulated energy transfer, rather than a clearly identifiable single event (Finch & Cook, 2013; Fuller et al., 2006).
    - Recurrent injuries are an injury of the same type and at the same site as an index or initial injury and which occurs after a player's return to full participation from the index injury (Finch, 2013).

Injury incidence was defined as the number of new injuries per 1000 training and competition exposures (Fuller et al., 2006, 2008).

- The injury incidence rate was expressed as the average number of positive responses per 1000 persons at risk and per 1000 exposures (Fuller et al., 2006, 2008).
- Injury prevalence was calculated by dividing the number of athletes reporting injuries, with the number of completed PILLS questionnaires received, and is expressed as a percentage – as per Clarsen et al's 2014 and 2015 studies(Clarsen et al., 2015; Clarsen & Bahr, 2014).
- Injury point prevalence is the number of reported injuries divided by the number of completed PILLS questionnaires received – **per 4 week block of surveys.**
- The PILLS survey captures information on training load in terms of duration and intensity of training. Intensity is measured on a scale of 1-4 (Easy – Moderate – Hard – Very Hard), and exposures in terms of 1 session versus duration in minutes.
- Results were described for track cyclists as a group, and also the sub groups of male and female sprinters, and, male and female endurance riders.

3.6 Procedure

All members of the NZ track cycling team (including those athletes who at the time of the study's initiation were already overseas or away training and competing) were contacted directly by email. The sprinters and women's endurance squads had meetings as a group prior to a full CNZ squad training session, and the men's endurance squad had a separate session as they were unable to attend the larger group meeting.

An information sheet and a consent form were issued to those willing to participate. Participants completed an initial survey to provide baseline characteristics, and an

overuse injury questionnaire to determine current or pre-existing injuries. The initial baseline questionnaire was given in person (at the meetings) or emailed (to those unable to attend the meetings) to all participants. Once completed the questionnaires were collated by the principal researcher. Athletes were educated on use of the application survey and those who had not already downloaded it (many were already completing the PILLS survey as required by HPSNZ and CNZ under their athlete-organisation contracts), had the iSurvey app downloaded onto their phones or tablets and the PILLS survey allocated to them.

Injury surveillance data collection commenced on **Monday May 18, 2015**. Participants were asked to complete the survey each Monday by 12 o'clock/midnight (to review the 7 days prior), and reminders were sent two days following this set day (on a Wednesday) to those who had not completed their surveys. Each Friday the lead researcher collected PILLS results data. This continued for each of the 52 consecutive weeks of the study. From this weekly data, self-reported injuries were classified using the OSICS-10 code by the lead researcher, and any self-reported injuries requiring treatment at an HPSNZ centre had their treating clinician's allocated OSICS-10 classification code recorded (also by the lead researcher). Following 52 consecutive weeks of injury surveillance via the PILLS tool, data were analysed by the lead researcher and Statistical staff at AUT University using SPSS.

3.7 Summary data

A summary of descriptive data was collected from the initial survey and subsequent injury questionnaires. The initial survey was analysed to show baseline characteristics across the groups of cyclists and was divided into Male and Female Sprint and Endurance Squads. Subsequent surveillance data evaluated planned training load (volume and intensity) and any modifications made to training due to injury. Other variables included treatments received and by whom (Physiotherapist, Doctor, Massage therapist), investigations carried out, and the athletes' perceived ability or readiness to train. All data were anonymised.

3.8 Statistical analysis

Data were initially analysed descriptively to ensure there were no extreme outliers and that the data were distributed normally. For the continuous variables the means and standard deviations were calculated, and for categorical variables frequencies were recorded. If the data was not distributed normally non-parametric tests were used and if it was distributed normally then parametric tests were employed. This was analysed using SPSS.

Due to the low participant numbers, survey responses were grouped from 52x1 week surveys, down to 13x4week blocks of surveys in order to see if any statistically significant results or relationships could be determined. The outcome measures were calculated for the research group/cycling squad as a whole, as well as separately for each track cycling squad (Men's and Women's Sprint, Men's and Women's Endurance).

CHAPTER 4: RESULTS:

Introduction

This chapter is divided into three sections which represent the main areas of the study. The first section provides a description of the participants that participated in the study. The second section provides the results of the injury surveillance, including incidence and prevalence of injury. The third section provides correlation analysis between injury, treatments received, study participants and training data to look at possible risk factors for, or associations with injury.

4.1 Participants

Forty-one participants met the inclusion criteria for this study - being members of the elite Cycling New Zealand (CNZ) track cycling squad. Of these 41 athletes contacted by the researcher, 33 consented to take part in the study, and agreed to complete the weekly survey over a 52-week period. During the course of the 52 weeks, five participants were withdrawn from the study because they left the CNZ team. This withdrawal occurred for all five participants after block 10 of the 13x four-week blocks (at weeks 40-41 of the study).

Data from the 33 participants were collected. There were 17 males aged between 17 and 32 years (mean 22.71, SD: 4.45), and 16 females aged between 17 and 31 years (mean 21.50 years, SD: 4.82). Male athletes' mean height was 180.59cm (SD: 4.52cm) and females' mean height was 170.24cm (SD: 6.01cm). There was one significant outlier in the female group with one participant being significantly shorter than her team mates

(154.40cm - >2SD). All other descriptive results indicated no significant outliers, with normal distribution of remaining data. There was homogeneity of variance as assessed by Levene's Test for Equality of Variances. Therefore, an independent t-test was run on the data.

There was no significant difference between males and females in terms of age, but there was significant difference in height and weight ($p<0.0001$). Descriptive characteristics are outlined in Table 4.1.

Table 4.1

Participant demographics at enrolment

Variable	Total (SD n=33	Male (SD) n=17	Female (SD) n=16	p-value
Mean age (years)	22.1 (4.6)	22.7 (4.5)	21.5 (4.8)	0.46
Mean height (cm)	175.6 (7.4)	180.6 (4.5)	170.2 (6.0)	0.0001
Mean weight (kg)	74.2 (11.8)	81.7 (10.4)	66.3 (7.2)	0.0001

Note SD = standard deviation. * = significant at p=0.05

Of the 33 participants, 20 (60.6%) were endurance athletes and 13 (39.4%) were sprint cyclists. Chi-square tests found no statistically significant differences between disciplines in male or female participants ($X^2=2.6$, $p=0.1$).

The athletes ranged in experience from being new to the sport of track cycling to very experienced with a range of 2-22 years' involvement in the sport (mean 8.3 years, SD 4.1), with average training hours per week ranging from 13-35 hours (mean 21.58 hours, SD 6.39), as shown in Table 4.2.

Table 4.2

Participant Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Average training hours per week	33	13.00	35.00	21.6	6.4
Years in sport	33	2.00	22.00	8.3	4.1

4.1.1 Participant exclusion/drop out

During the study five participants were excluded as they were removed from the NZ cycling squad. Four of those who withdrew did not pull out of the squad voluntarily or due to injury, and the fifth rider retired from the sport. This occurred for all athletes at weeks 40-41 which was when the final team was named for World Championships and a new squad selected for the 2016-17 season. Because outcome measures for this study are recorded as ratios or percentages, exclusion of the five participants does not necessarily skew the data, but does reduce the total possible data points able to be recorded.

4.1.2 Compliance

Compliance was recorded as the total number of survey responses received divided by the total number of responses (participants) available, giving compliance as a percentage. Mean compliance for the year was 75.41% (SD 14.8), this is outlined in Figure 4.1.

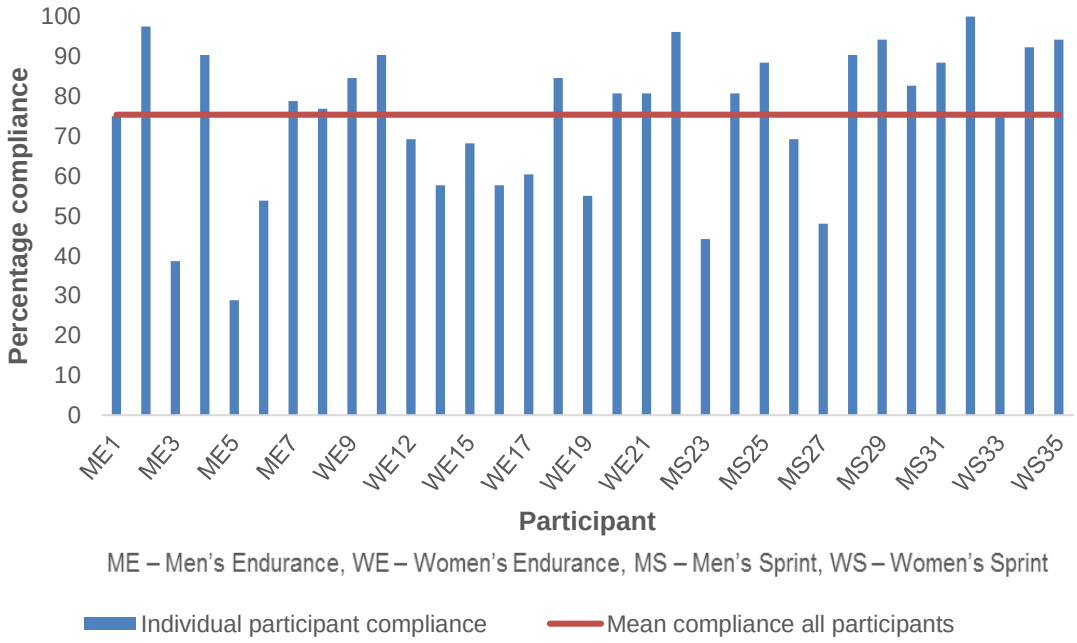


Figure 4.1. Participant Compliance with completion of PILLS survey

4.1.3 Oslo Sports Trauma Research Centre survey results/Baseline overuse injury status

The Initial survey results indicated that 5 of the 33 (15%) participants reported shoulder symptoms at the initiation of the research, 13 of 33 (39%) reported lower back symptoms, and 7 of the 33 (21%) reported knee symptoms. This is displayed in Figure 4.2 below.

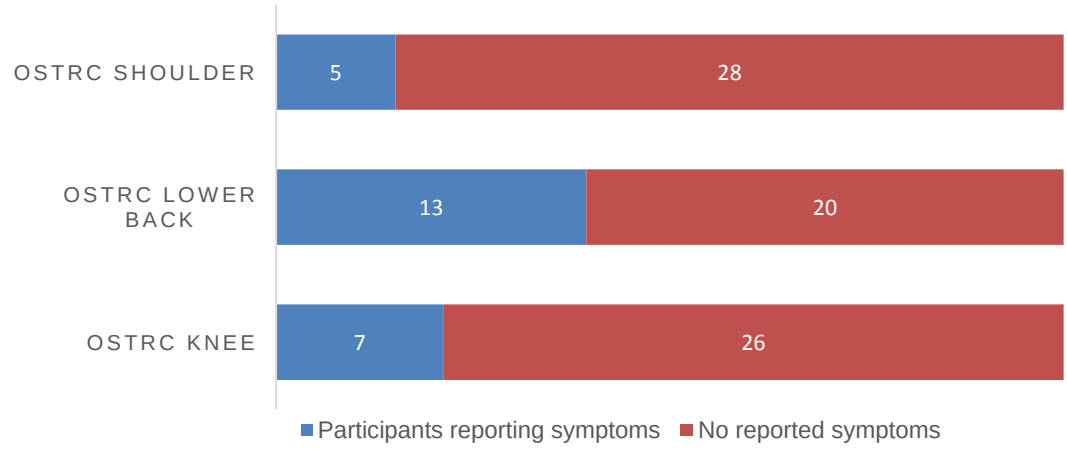


Figure 4.2 Oslo Sports Trauma Research Centre (OSTRC) initial survey results

4.2 Injury surveillance results

4.2.1 Injury details

Of the 33 participants, 21 (64%) sustained at least one injury during the period of inclusion in the study. Four of these participants reported injuring multiple body sites at the one time, with one participant reporting two multi-site incidents during the 52-week period. 13 participants sustained multiple injuries over the year, and 12 reported no incidence of injury for the period of data collection. Table 4.3 shows the injury count recorded, with a breakdown of the events based on squad and gender, with Figure 4.3 displaying the injury count per participant.

Table 4.3

Injury count, and breakdown for squad and gender

	1 body part injured	2 or more body parts injured
Injury occurrence	39	5
Sprint	22	1
Endurance	22	4
Male	24	2
Female	20	3
Men's endurance	11	2
Women's endurance	11	2
Men's sprint	13	0
Women's sprint	9	1

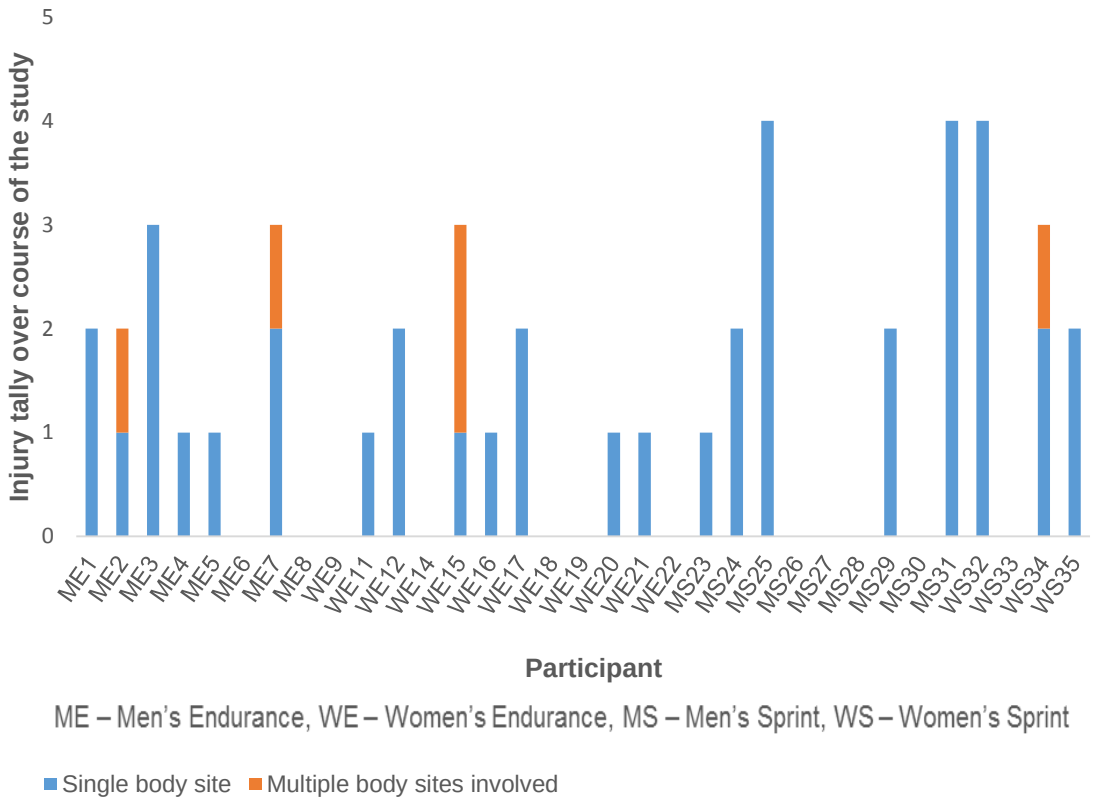


Figure 4.3. Injury count per participant

53 body parts were injured in 44 recorded events. The number of body parts injured per participant ranged from zero (12 of 33 participants or 36%) to nine body sites injured by one individual. Injuries per cycling squad by body region are displayed in Figure 4.4.

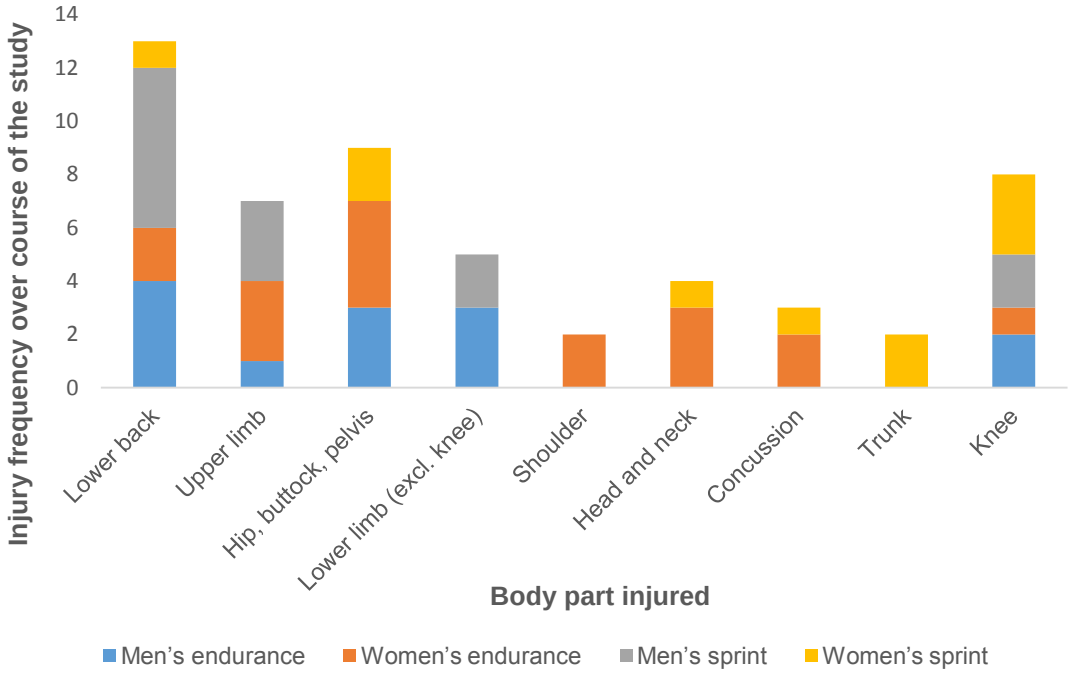


Figure 4.4. Injury count per body part

When the data were further condensed into four main body regions, the results were as follows in Table 4.4 and Figure 4.5, and are shown as proportional breakdowns for squad or gender in Figures 4.6 and 4.7.

Table 4.4

Condensed body parts – injury count per squad, male and female

Condensed body region	Upper Quadrant	Lower Quadrant	Trunk & Back	Head & Neck
Men's endurance	1	8	4	0
Women's Endurance	5	5	2	5
Men's Sprint	3	4	6	0
Women's Sprint	0	5	3	2
Endurance	6	13	6	5
Sprint	3	9	9	2
Male	4	12	10	0
Female	5	10	5	7
Total Frequency	9	22	15	7

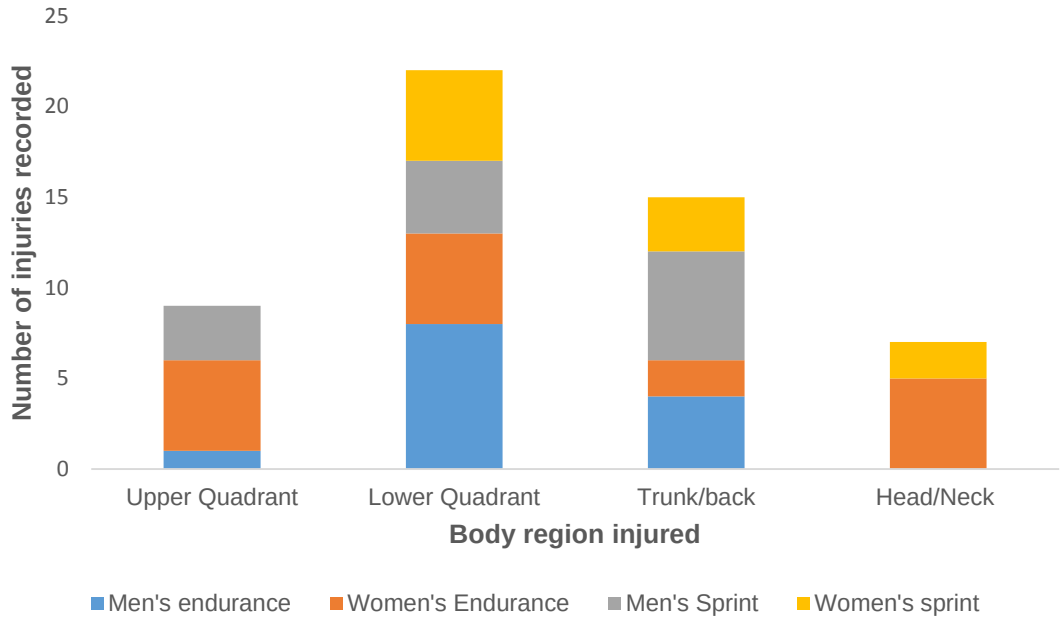


Figure 4.5. Number of injuries recorded – condensed body part, squad comparison

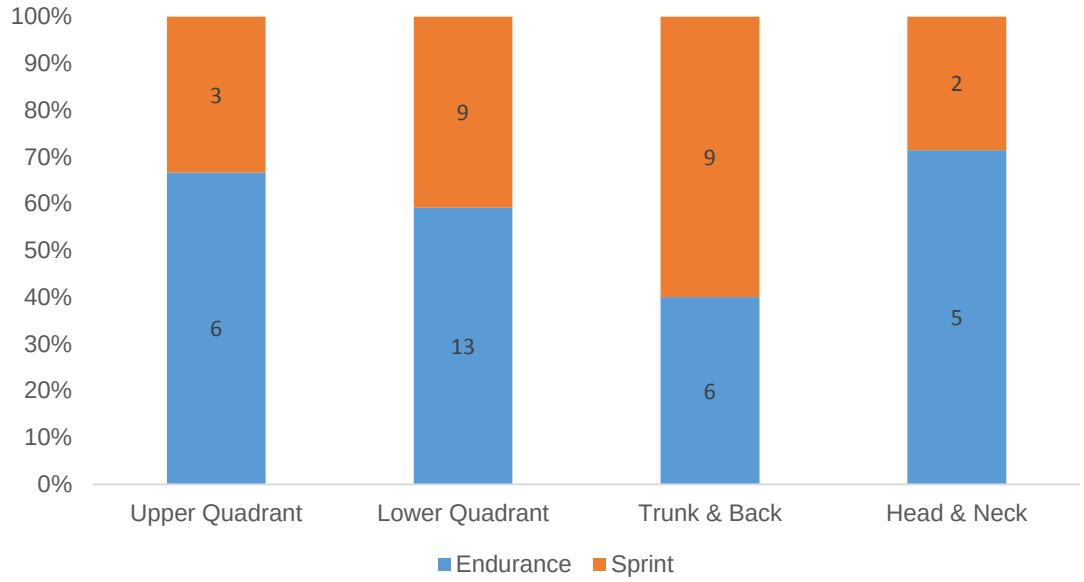


Figure 4.6. Proportional breakdown of each body site injured - Endurance versus Sprint

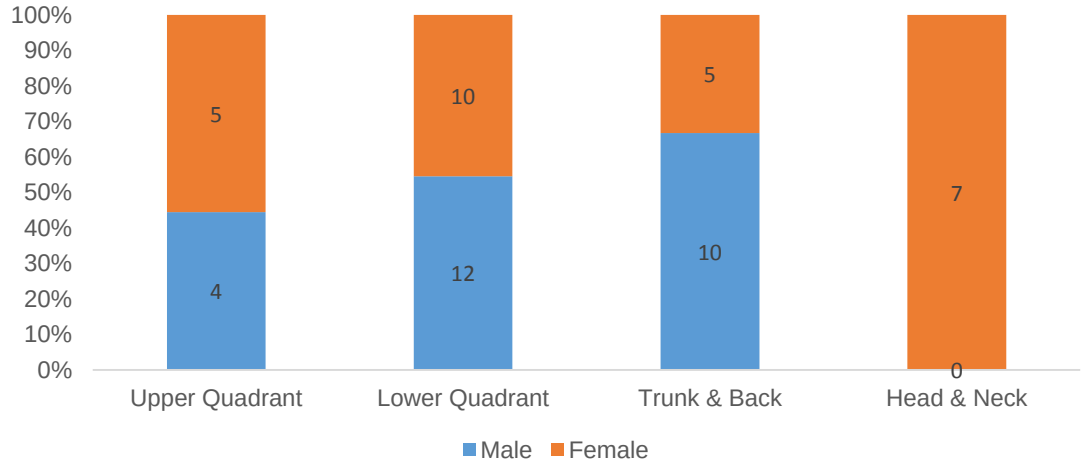


Figure 4.7. Proportional breakdown of each body site injured – Male versus Female

4.2.2 Participant and Therapist injury classification

Self-reported injuries were coded by the lead researcher using the OSICS-10 injury classification system, and the first two coding letters compared with the OSICS-10 code given by the treating clinician. In four cases, the athlete was not seen by a clinician for treatment so codes could not be compared. In all other cases, the primary injury described by the athlete, when coded by the researcher, matched the clinician's OSICS-10 classification's first two letters, a 100% match.

4.2.3 Duration of symptoms

Duration of symptoms was recorded in weeks, specifically the number of weeks it took until the athlete submitted a survey response that reported that they did not need to miss or modify their training because of injury. The duration of injury was measured as the number of weeks that training was effected per number of injury events. This ranged from one week to four weeks, with a mean duration of one (1.2) weeks and is detailed Figure 4.8.

Figure 4.8. Duration of time injury affected training (weeks)

4.2.4 Nature of the injury

The injuries were classified as acute, overuse or recurrent with 36 of the 44 (82%) recorded as being acute, eight recurrent (18%) with no overuse injuries reported using the PILLS app. No changes were needed to be made to the classification of the self-reported injuries on a secondary review of the medical notes.

4.2.5 Treatment received

The clinical notes were reviewed for the period of data collection and a record was made of all treatments received by each participant at the High Performance Sport Clinics. This is displayed in Table 4.5, with the descriptive statistics of treatments received detailed in Table 4.6. Mean number of treatments for the period of data collection was 56, with a range of nine to 113 (SD 26.8) treatments. This tally included all physiotherapy and massage treatments, and maintenance therapies or performance optimisation treatments including those not recorded against a specific injury in this study. This allowed an outcome measure of total number of treatments per athlete, and could then be compared with injury occurrence.

Table 4.5

Treatments received and injuries recorded

Participant code	TREATMENTS – Physio, Massage, Injury, massage, maintenance and Performance therapies	Injury tally
ME1	69	2
ME2	47	2
ME3	63	3
ME4	34	1
ME5	83	1
ME6	62	0
ME7	96	3
ME8	33	0
WE9	47	0
WE11	68	1
WE12	62	2
WE14	60	0
WE15	51	3
WE16	60	1
WE17	37	2
WE18	58	0
WE19	9	0
WE20	14	1
WE21	24	1
WE22	10	0
MS23	92	1
MS24	101	2
MS25	87	4
MS26	28	0
MS27	84	0
MS28	71	0
MS29	31	2
MS30	18	0
MS31	53	4
WS32	113	4
WS33	71	0
WS34	64	3
WS35	63	2

Table 4.6

Descriptive Statistics – Number of treatments and number of injuries

	N	Minimum	Maximum	Mean	Std. Deviation
Number of treatments	33	9.00	113.00	56.2	26.84
Number of injuries	33	.00	4.00	1.4	1.34

4.2.6 Location of the injury

11 of the injury-incurring incidents were sustained in sports specific training, 20 were sustained in the gym, six in competition and seven other (with a mean of 11 and SD 6.38). This is displayed in Figure 4.9 and 4.10.

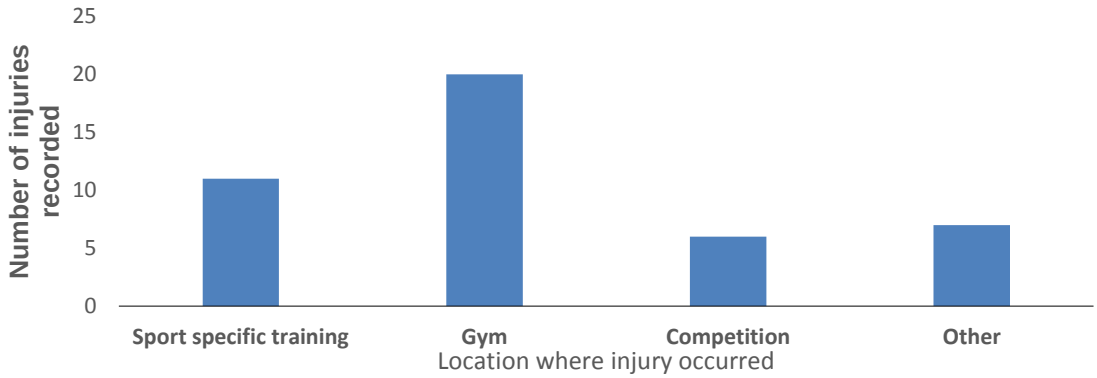


Figure 4.9. Location where injury occurred

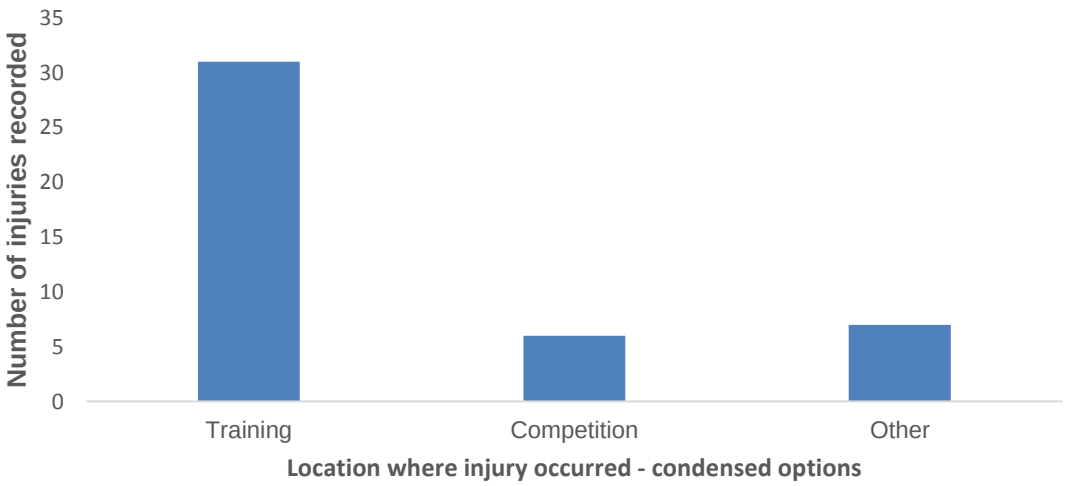
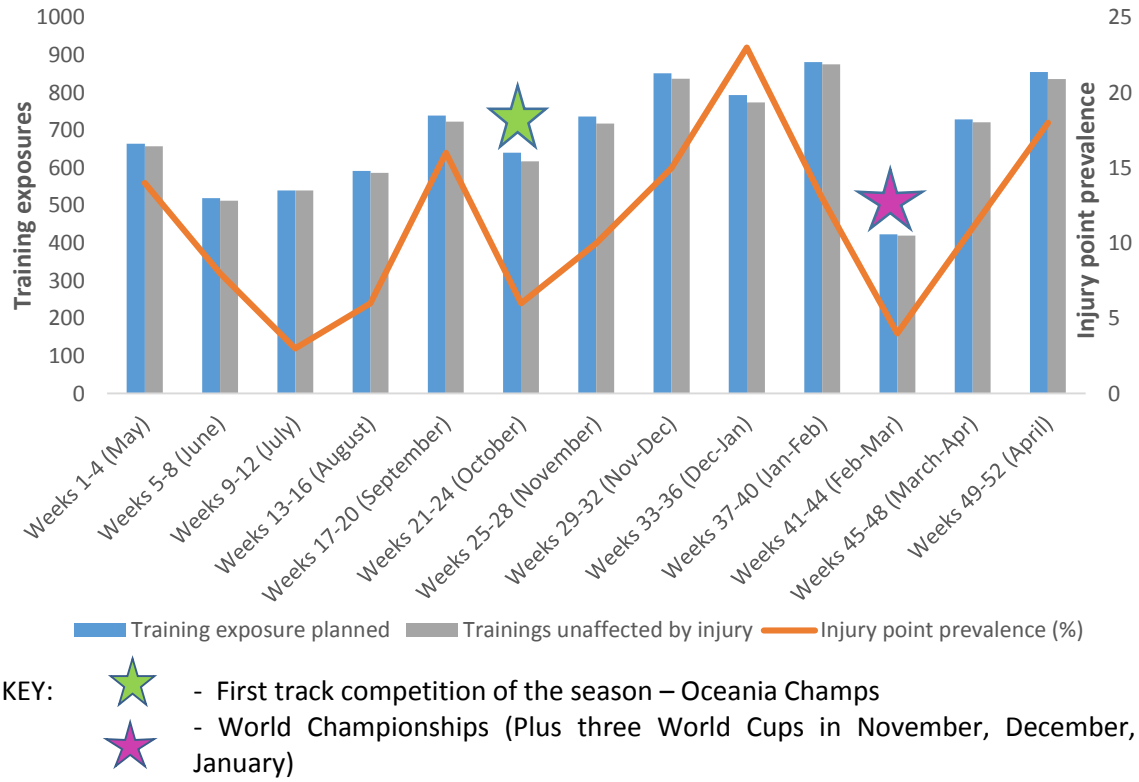


Figure 4.10. Condensed - Location where injury occurred

4.2.7 Effect on training: training planned versus training missed or modified due to injury

During the study, participants reported 8962 planned training exposures, at a mean of 689 exposures per four-week block of surveys (SD 142). Participants rated the intensity of training on a scale of 1 to 4, where 1 is Easy, 2 Moderate, 3 Hard and 4 Very Hard). Average training intensity was rated as 3 (Mean 2.7, SD .42). Of these 8962 planned sessions, 60 sessions (0.67%) were missed and a further 84 (0.94%) modified due to injury. This totalled 144 training exposures affected by injury, or 1.6%, with a mean of 11.1 (SD 7) trainings missed or modified per four week block of surveys. This is displayed in Figure 4.11. Also outlined in this Figure are the times of the year, to highlight major competitions, and the international track World Cup and Championship season – October through March. This is further separated into training exposures missed and modified due to injury in Figures 4.12 and 4.13.



KEY: - First track competition of the season – Oceania Champs
- World Championships (Plus three World Cups in November, December, January)

Figure 4.11. Training exposures vs injury point prevalence

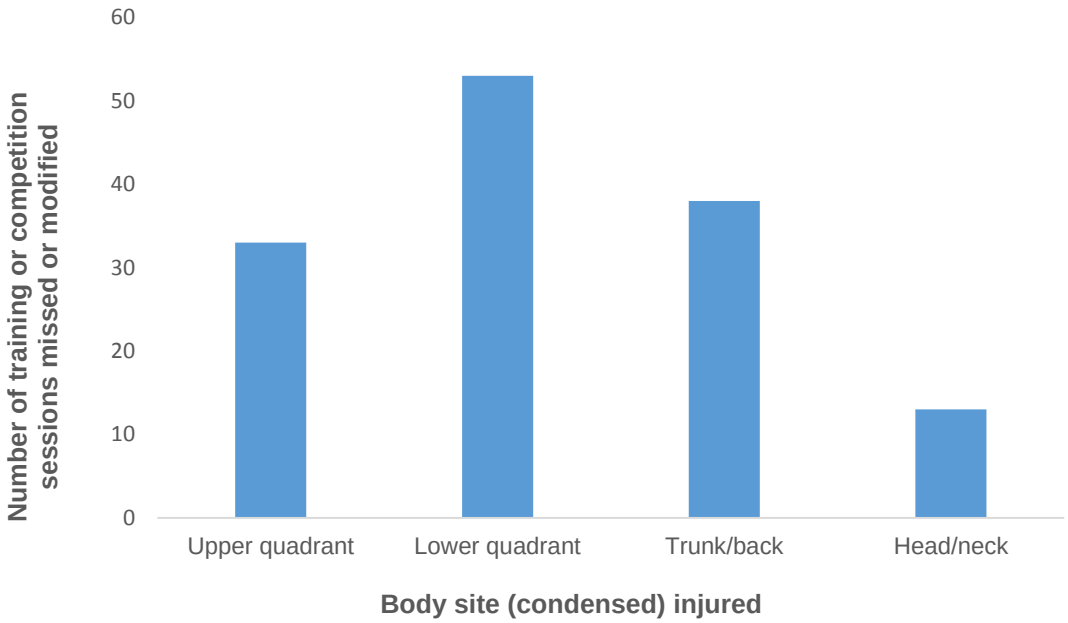


Figure 4.12. Total number of training exposures missed or modified due to injury – per body site

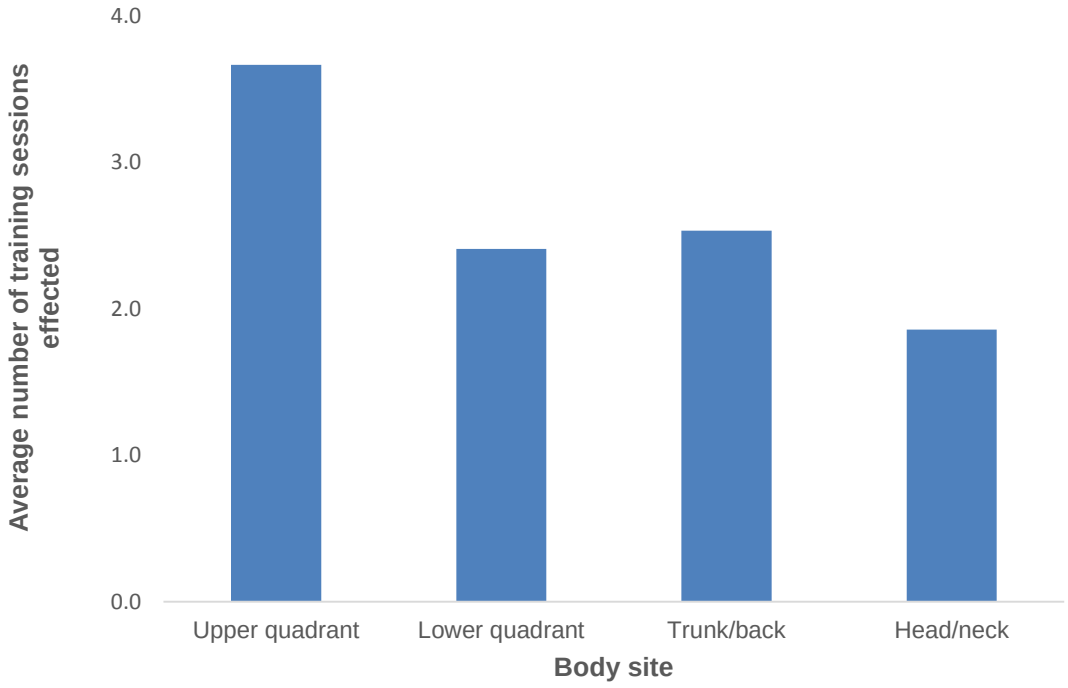


Figure 4.13. Average number of training exposures affected by injury (condensed body site comparison)

4.2.8 Injury incidence and prevalence

During the study six of the eight (75%) Men's Endurance athletes sustained at least one injury, with seven of 12 (58%) of the Women's endurance squad, five of the nine (56%) Men's sprint squad and three of four (75%) of the Women's Sprint squad sustaining an injury.

Injury Incidence in this study was described as the number of new injuries per 1000 training and competition exposures. Therefore, with 44 injury events over 8962 training exposures, the injury incidence was 4.9 per 1000. For all injuries sustained (53 injuries from 44 events) over 8962 training exposures, the injury incidence was 5.9 per 1000. Point prevalence through the year ranged from one injury per four week block to a maximum of seven (mean 3.38, SD 1.80). Injury prevalence was calculated by dividing the number of athletes reporting injuries with the number of completed questionnaires, and expressed as a percentage. This was recorded weekly, averaged per four-week period to provide prevalence at four-weekly intervals, and then calculated for the entire 52-week block. Results are detailed in Table 4.7.

Table 4.7

Injury point prevalence – per weekly block of surveys

Weeks:	1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32	33-36	37-40	41-44	45-48	49-52	TOTAL
Injured participants	4	2	1	2	5	2	3	5	7	4	1	3	5	44
Number of completed surveys	29	26	29	33	32	32	31	33	31	32	28*	28	28	392
Prevalence (injured participants per1000)	138	77	34	61	156	63	97	152	226	125	36	107	179	112
Prevalence (expressed as a %)	14	8	3	6	16	6	10	15	23	13	4	11	18	11

** point of the study period where 5 athletes were dropped from the squad and therefore excluded from the study from that point on.*

21 of the 33 participants (64%) sustained 1 injury or more during the 52-week period of the study, with 12 participants (36%) not reporting any injuries. Of these, eight were recurrences of a previous injury. Season total prevalence for the study was 112 injuries per 1000 surveys completed.

4.3 Statistical analysis

Statistical analysis was undertaken using SPSS. Pearson's chi square tests were performed for categorical data (squad comparisons) and paired t-tests and anova tests were performed for continuous variables to determine any relationship between squad, gender, previous injury, years in sport, and new injuries or injury frequency. No significant relationships were found between injury and any other variable.

CHAPTER 5: Discussion:

5.1 Summary

The purpose of this study was to provide an injury profile in track cyclists over a full training and competition year, so that injury risk could be established. This information will be of value to those working with the cyclists so that in future targeted cycling specific injury prevention methods and training programs can be implemented to reduce this risk, and therefore enhance performance by reducing training and competition time lost to injury.

This is the first study found that has investigated injury surveillance in the elite track cycling cohort in isolation and in detail. Palmer-Green reviewed injury surveillance in track cyclists, but only as part of a larger cohort of the British National Cycling team which included Road, BMX and Mountain Bike athletes (Palmer-Green et al., 2014). This makes drawing comparisons to the current research problematic. Other cycling specific studies have assessed road cyclists as the cohort, specifically male professional cyclists (Barrios et al 2015; Clarsen et al, 2010, 2014). These studies describe the knee, lower back, shoulder, lower leg and thigh as the predominant regions injured.

With differing cohorts (track vs road cyclists, and both male and female participants) it is difficult to directly compare this study with previous research, but it is possible to provide more general comparison with previous cycling injury surveillance research. Moreover, the findings of the current study provide a descriptive baseline injury profile for the track cycling cohort, upon which future injury surveillance and prevention measures can be based and/or developed for this group of athletes.

5.2 Participants

A total of 81% of eligible participants (athletes within the New Zealand elite track cycling squad) agreed to participate in the study, indicating that this study is representative of the elite New Zealand cycling population. No significant differences were found between the male and female participants for age, height or weight. Mean height for participants was 175.57cm (SD 7.4cm), and mean weight was 74.2kg (SD 11.8). The current study's participant age ranging from 17 to 32 years, with mean age 22.7 years (SD 4.5) for males and 21.5 years (SD 4.8) for females. Therefore, the participants are comparable to those of previous road cycling studies (Barrios et al., 2015; Clarsen et al., 2015, 2010; Palmer-Green et al., 2014). For example, Clarsen et al's (2010) study had an (albeit all male) average age of 26 years (SD 4), height 181cm (SD 6) and weight 70kg (SD).

5.3 Injury Profile track cycling cohort

Participants used the Program for Injury and Illness Surveillance (PILLS) self-reported survey on a smart phone application to record their injury and training data over a 52-week period. Recorded injury details were compared with therapist injury diagnosis using the Orchard Sports Injury Classification System (OSICS - version 10) to confirm accuracy of the participant self-reported diagnoses in all situations where the participant required treatment, as the OSICS-10 has been shown to be a reliable injury classification tool (Finch et al 2014). In this current study, injury classification codes were a 100% match to the first two classification letters between therapist-assigned and participant-described-researcher-assigned classification codes.

During the course of the study 64% of the participants sustained one or more injuries. This was further broken down into squads, where 75% of the Men's Endurance squad sustained at least one injury, 58% of the Women's endurance squad, 56% of the Men's sprint squad and 75% of the Women's Sprint squad. There was no significant difference in injury rate per squad. This equated to an injury ratio of 53:33 or 1.6 injuries per athlete, which is comparable to Clarsen's 2010 study of professional road cyclists which was 94:63 or 1.5 injuries per athlete (Clarsen et al, 2010). The injury incidence was 4.9 per 1000 training exposures, and for all injuries sustained the injury incidence was 5.9 per 1000. The injury prevalence was 112 per 1000 completed surveys, or 11%. Point prevalence through the year ranged from one injury per four-week block (3% point prevalence) to a maximum of seven (mean 3.38, SD 1.80), or 23% point prevalence. Of the injuries recorded, 25% involved the lower back, 17% Hip/buttock/pelvis, with the knee and upper limb 15% and 13% of recorded injuries respectively. Injuries were also sustained involving the lower limb (excluding the knee), shoulder, trunk, head/neck and concussion.

Previous studies investigating injury in road cycling (Barrios et al 2015; Clarsen et al, 2010, 2015) report similar body regions injured in their surveillance studies. Clarsen (2010) found 45% of injuries sustained involved the back and 23% occurring at the knee. Clarsen (2015) found prevalence rates of 23% for overuse knee injuries, 16% for the lower back, 8% for the thigh and 7% for the shoulder. Barrios et al (2015) found in their cohort of road cyclists surveyed from 1983-1995 that 64% of overuse injuries occurred in the knee, 13.4% in the spine, and 23% other(Barrios et al., 2015). All of these studies were all predominantly recorded as overuse injuries rather than acute onset events. Injury incidence was higher in this study than previous road cycling studies, however the

previous research only looked at cycling training and competition injuries whereas the current research recorded all injuries sustained. This may account for the lower rate in the previous studies given that the largest proportion of injuries reported in the current research took place in the gym.

With respect to the location of the injuries sustained, 45% (20/44) of the injury-incurring incidents were sustained in the gym, 25% (11/44) were sustained in sports specific training, 14% (6/44) in competition and 16% (7/44) other (with a mean of 11 and SD 6.38). Previous road cycling studies have only looked at injuries sustained in bike training or competition (Clarsen et al 2010, 2014, Barrios et al 2015) so there is no comparable data to this current research. In order to generate the power required for sprint racing, track cyclists (sprint in particular) need to have a component of gym (resistance) training in their program, which has been shown both in this research and in previous studies, to provide an injury risk of its own (Faigenbaum & Myer, 2010). It is not clear from the current training exposure data what proportion of time was spent between the different types of training exposure (gym, sport specific training or competition), as the PILLS survey does not record this information. Therefore, conclusions as to why more injuries occurred in the gym cannot be drawn. It is possible that they were related to incorrect technique, excessive resistance, overload in conjunction with other on-bike training and/or competition, or a combination of all three, but none of this can be determined through the current research. Changes to training should not be made based purely on these results, but should be looked into in more detail in future studies.

The duration of symptoms was recorded in weeks, specifically the number of weeks it took until the athlete submitted a survey response that reported that they did not need

to miss or modify their training because of injury. The duration of injury ranged from one week to four weeks, with a mean duration of one (1.2) weeks (number of weeks training effected/number of injury events). This is comparable to Clarsen's 2010 study, where average time loss was 13.5 days per injury (Clarsen et al, 2010). Of the 8962 planned sessions over the 52 weeks of the current research, 60 sessions (0.67%) were missed and a further 84 (0.94%) modified due to injury. This totalled 144 training exposures affected by injury, or 1.6%, with a mean of 11.08 (SD 6.97) trainings missed or modified per four week block of surveys. In recent research into the impact of injury on performance in athletics, Raysmith and Drew (2016) found that if an athlete completed 80% or more of their training then they were seven times more likely to achieve their performance goal. Raysmith and Drew's study reviewed the athletics cohort so is not directly comparable to cycling, but it is still assessing elite athletes, and therefore it holds that in the current study with an injury incident rate of 5.9 per 1000 training exposures, and with missing only 1.6% of training exposures due to injury this reflects not only a low incidence but also a low impact of injury in terms of effect on training and competition in elite New Zealand track cyclists.

Injuries in the current research were classified as acute, overuse or recurrent. Barrios (2015) and Clarsen (2010, 2014)'s studies largely only reported overuse injuries, whereas the current research had no injuries recorded which were classified as overuse, with 36 of the 44 (82%) were recorded as being acute, and eight recurrent (18%). No participants reported overuse injuries, describing all injuries as the aggravation of an old injury or a new injury altogether. Initial baseline survey results indicated that 15% of participants had shoulder symptoms at the initiation of the research, 39% had lower back symptoms, and 21% reported knee symptoms using the OSTRC overuse injury

surveillance questionnaire. It is unclear whether these symptoms continued during the study and weren't reported or whether they had resolved. This should be an area of development for future research, either in the wording of the questions used in the injury surveillance tool used, or in the classification methods and tools used by the researcher, or both. In the PILLS injury surveillance tool utilised in this study the questions in the survey ask for a date upon which the injury occurred which did not allow for description of a steadily building event.

Alternatively, another theory for this result of no overuse injuries could be due to the centralised environment that these athletes live and train in. In this environment all athletes and support staff (Coaching, Physiotherapy, Medical, Strength and Conditioning staff and more) are required to work and train together at the Avantidrome Velodrome – the "Home of Cycling" in Cambridge, New Zealand. Athletes are able to present early with small niggles rather than injuries (tension or stiffness rather than a tear or strain), which means that they receive medical and physiotherapy treatment and advice early, that they can have bike set up changes to offload any effected area, and that gym and cycling load training can be adapted quickly to decrease stress on a particular body part. This may be evidenced in the high number of treatments received by some participants without any record of injury on the PILLS app for the same timeframe. Therefore, the question can be raised - do regular maintenance therapies by the onsite therapists (i.e. physiotherapy and massage for areas of soft tissue tightness or joint stiffness) have a preventative, protective effect and help to reduce rates of injury? Another theory proposed (or question to ask) is that the variety of training that a track cyclist is exposed to (track training and competition, road cycling, ergometer training, strength and conditioning gym load) is actually protective for injuries, and overuse injuries in

particular. It could be that this variety of training plays a role in the reduction of overuse injuries, and an increased availability to train (minimisation of time lost to training) in comparison with previous road cycling studies. These are all questions that require further investigation in future studies to gain any definitive answer.

5.4 Statistical analysis

No relationships or associations were found between injury incidence and the age, gender or squad discipline of the participants, or in relation to previous injury history. Nor was any relationship found between the number of treatments received and number of injuries sustained. When training exposures and injury prevalence were compared across the year, it indicated a possible link between training load and injury prevalence, with an increase in training exposures coinciding with an increase in injury prevalence, and vice versa (as displayed in Figure 4.9.1 in Chapter 4). There was no statistical relationship found between these variables in this study, but this should be investigated further in future research. These results were incomparable to previous research as there are no published studies available on comparable cohorts (elite track cyclists) in the literature. The lack of statistical significance with these variables is due to small sample size and also the low frequency of injuries sustained during the period of the study. Continuing to capture injury data with this cohort over a longer period of time may allow for better assessment of relationships and risk factors, however this is not possible with this current data set.

5.5 Limitations of the study

When investigating elite populations, the sample size is often limited because of squad selection, as was the case in this research, which is the main limitation of this study. This, when combined with the small number of injuries sustained during this study produced results that can only be presented as descriptive data, with no relationships or associations able to be detected. To detect moderate to strong associations 20-50 injury cases are needed, whereas moderate to small associations would need approximately 200 injured participants (Bahr & Holme, 2003). There were 33 participants, with a total of 53 injuries recorded from 44 events during the research collection. Therefore, the current study had enough power to detect moderate to strong associations with injury, but not to detect small to moderate associations. The sample size and power can be addressed by continuing to collect such data in future research and therefore increase both the sample size and the volume of injury surveillance data.

Although weekly reporting via the PILLS injury questionnaire application was good for reducing recall bias, it may be that there is a more effective tool that could be used for this research, or that the PILLS questions need to be altered. During the study no injuries were recorded as overuse type injuries. This was despite knee, shoulder and lower back overuse symptoms being reported in high numbers (21%, 15% and 39% respectively) in the baseline OSTRC questionnaires. This may have been because the PILLS questionnaire doesn't allow for an overuse option in that it asks for a specific date of injury. Therefore, all injuries were classified as new events and it was up to the lead researcher to then code if they were acute or subsequent injuries.

Eighty-one percent of all members of the elite New Zealand track cycling squad (33 of 41) consented to participate in the research, which indicates that this study is a good representation of the available cohort. However, with a smaller total cohort, as is the case of the elite New Zealand track cycling group, greater initial consent to participate and preferably close to 100% uptake would be the ideal. This is also the case for overall survey completion compliance, whereby the recorded 75% compliance indicates a quality study, but in such a small cohort, a higher compliance rate would garner the most accurate results.

The second limitation with using the PILLS survey for gathering data on injury surveillance is the lack of information collected around training load. The PILLS survey purely collects the number of training exposures planned with no detail on the breakdown or duration of that training. Recent studies suggest that changes in training load may affect injury risk, where training is measured as a combination of exposure (training duration) and either internal (for example rate of perceived exertion) or external (for example distance travelled) load. Hulin, Gabbett, Blanch et al (2014) determined that in the cricket bowling population, an increase in acute (7 day) workload of >1.5 ratio (or >150% increase) compared to their chronic (28 day rolling average) load resulted in a greater than two-fold increase in risk of injury in the following week, and those with a workload ratio increase >2 (200%) had a relative risk of 4.5 for subsequent injury compared with those with a .5-.99 acute: chronic ratio (Hulin et al, 2014; Gabbett et al, 2016). Although this is not specifically in the cycling cohort it is a notable change in risk based on change in training load, and therefore it follows that detailed load measurements should be recorded in any future injury surveillance research. Although this means the researcher in the future may be able to compare purely based on

exposure and therefore possibly compare results across different sporting disciplines, if only one sport is the key focus, as in the case of track cycling, then more detail around the nature of load (Rate of Perceived Exertion, and training duration as possible measures) is required for improved accuracy and applicability of the results (Gabbett, 2016; Herman et al., 2006).

5.6 Conclusions

This research provides the first descriptive injury profile for the elite New Zealand track cycling cohort. Sixty-four percent of participants sustained an injury over the 12-month period. Injury incidence and prevalence was low with rapid return to training and competition. The greatest number of injuries were seen in the lower back, the hip/buttock/pelvis region and the knee, which may reflect the biomechanics of cycling and therefore biomechanical load on the body, and also the nature of the training required for this sporting group. This is comparable with previous research into the road cycling cohort who found the lower back, knee and shoulder to be the most frequently injured/involved body regions. However, these results differ to road studies whereby a greater proportion of those injuries are classified as overuse and no overuse injuries were recorded in this study. Possible explanations for this are the nature of the surveillance tool used, the nature of track cycling and the training required, or the centralised environment in which this cohort lives and trains in which athletes are able to seek advice and treatment early. Alternatively, there may be another explanation which is as yet unidentified. Further research is required in this area.

5.7 Future research

Ongoing data collection in subsequent years is required in order to increase sample size and power of the data collected and determine what if any relationships exist between the participants and the injuries they sustain. This would enable a possible assessment of an athlete's injury risk, and also provide a more robust baseline measure upon which changes can be tracked over time, and which would allow subsequent injury prevention measures to be introduced and assessed in this cohort, which would enable progression of the research from purely injury surveillance into injury prevention.

Future research of this nature should look at improved collection of training load either via the modification of the PILLS injury surveillance application questions, or via other collection measures, be that a different self-reporting tool which better captures this data, or utilisation of other support staff involved with the cyclists' training programs versus solely the medical support team and athlete self-reporting. Improving detail around training exposures and load will improve the accuracy and therefore applicability of the study results.

APPENDICES

Appendix 1 Ethics approval

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

AUTEC SECRETARIAT

14 May 2015

Duncan Reid
Faculty of Health and Environmental Sciences

Dear Duncan

Re Ethics Application: **15/108 Prospective cohort study of injury incidence in NZ elite track cyclists.**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 14 May 2018.

As part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/researchethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 14 May 2018;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/researchethics. This report is to be submitted either when the approval expires on 14 May 2018 or on completion of the project.

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to obtain this. If your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply there.

To enable us to provide you with efficient service, please use the application number and study title in all correspondence with us. If you have any enquiries about this application, or anything else, please do contact us at ethics@aut.ac.nz.

All the very best with your research,

Kate O'Connor
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Helene Barron helene.barron@hpsnz.org.nz

Appendix 2 Participant Information sheet

Participant Information Sheet

Date Information Sheet Produced:

14 April 2015

Project Title

Injury incidence in elite New Zealand Track Cyclists: A prospective cohort study.

An Invitation

My name is Helene Barron and I am a Physiotherapist currently undertaking a Masters in Health Science.

I am looking for track cyclists carded with High Performance Sport NZ to participate in this study.

To take part in the study you should be: A member of the 2015-16 New Zealand Track Cycling squad – defined as all those athletes listed as "carded" track cycling athletes with High Performance Sport New Zealand (HPSNZ) as selected March 2015.

The aim of this study is to investigate injury rates in elite track cyclists over a full training and competition year

If you agree to take part in this research:

1. Any injury data and questionnaire data will be confidential.

2. You will in no way be personally identified in the study

3. Participation in this research is voluntary and you shall in no way be disadvantaged/advantaged if you choose to participate or not.

4. You may withdraw yourself or any information at any time prior to the completion of the study without being disadvantaged in any way.

What is the purpose of this research?

The aim of this study is to investigate injury rates in elite track cyclists over a full training and competition year.

Injury surveillance is an essential component in injury prevention. Little research is available on injury and illness rates in track cyclists, with the majority of cycling research focussed on road cycling alone. Understanding the injury profile of specific track cycling subgroups may provide the base from which screening tools, interventions and training can be monitored.

This research will be my Thesis and will contribute to the Completion of my Masters in Health Science qualification. As part of this research I may be required to provide a summary of my findings for publication in research journals or conference paper.

How was I identified and why am I being invited to participate in this research?

You were selected because as a member of the NZ Track Cycling Squad and therefore being registered as "carded" with HPSNZ you are deemed to be "elite" and therefore fit the criteria for this study. All carded track cyclists will be invited to participate in this study.

You may not be able to participate in the study if:

- You choose to withdraw from the squad
- You lose your carding status
- No phone / computer access

What will happen in this research?

If you choose to participate in this study you will be asked to:

- Complete an initial injury questionnaire, which will provide us with background information ie gender, age, squad group. You will also complete the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire which will ask for information on previous and or current injuries.

- You will receive a unique code. This means your data is linked to a code rather than your name and hence you will not be identified personally to this information.

- Complete weekly injury status questionnaires (one per week) over a full training and competition year, available to you via the iSurvey Application.

- If you attend physiotherapy for treatment and assessment your physiotherapist will record details of any injuries utilizing the Orchard Coding system.

What are the discomforts and risks?

No injury risk is anticipated as you are not being asked to do anything over and above your normal training and competition. The only requirement is for you to honestly complete the initial and weekly surveys given to you.

What are the benefits?

The principle benefit of this study is that you will contribute (via your participation) to the cycling community by increasing our understanding of injury incidence and risk factors. This information can then be utilized to focus on injury prevention strategies. By minimising injury risk it is hoped to positively influence your ability to participate in training and competition and therefore have secondary performance benefits.

How will my privacy be protected?

Data collected from you will only be used for the study to determine injury incidence in track cyclists.

Data will be coded and therefore you will not in any way be personally identifiable.

Only the investigators and administrators of the study will have access to your personal information and this will be kept secure and strictly confidential.

All raw data on which the results of this study depend will be retained in secure storage for 10 years after which it will be destroyed.

What are the costs of participating in this research?

Participation in this research will require you to

1. Complete an initial injury questionnaire - this will take approximately 15 minutes.

2. Complete weekly injury surveillance questionnaires for 52 consecutive weeks – this will take 3-5minutes per week

What opportunity do I have to consider this invitation?

You will be invited to attend an information session in the pre-season of 2015 (May 2015).

Data collection for this study will commence following the release of information.

How do I agree to participate in this research?

If you agree to participate in this research you will be ask to complete a Consent form. These have been included in this information pack.

Once you have agreed to participate you will need to complete the enclosed consent form

If you are aged between 16 -20 years old we need parental/guardian consent also. These forms are also included in this pack with a self -addressed envelope.

Once you have completed these forms you can use the enclosed envelope to return these to my Supervisor at AUT University.

Will I receive feedback on the results of this research?

You can choose if you wish to receive feedback on the results of this research. Those participants who wish to receive feedback will be emailed a summary of the research findings at the conclusion of the study.

Any possible conflict of interest?

Helene Barron – the primary researcher – currently work with Cycling New Zealand(CNZ)'s track athletes. Although I work with CNZ, I am employed by High Performance Sport NZ. I am conducting this research as part of my individual Master's Study and not because of any influence by either HPSNZ or Cycling New Zealand. I have applied for and received a Prime Minister's Scholarship to undertake my Master's study – this research is endorsed by Cycling New Zealand and the scholarship is managed by HPSNZ but the research is not influenced by either organisation.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Duncan Reid , dreid@aut.ac.nz, +64 9 9219999 ext 7806

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, Kate O'Connor, *ethics@aut.ac.nz* , +64 9 921 9999 ext 6038.

Whom do I contact for further information about this research?

Researcher Contact Details:

Helene Barron
Physiotherapist – High Performance Sport NZ – Avantidrome, Hanlin Road, Cambridge, NZ
helene.barron@hpsnz.org.nz
+64 21 242 2572

Project Supervisor Contact Details:

Duncan Reid
AUT University
dreid@aut.ac.nz
+64 09 9219999 ext 7806

Approved by the Auckland University of Technology Ethics Committee on 14 May, 2015, AUTEC Reference number 15/108

Appendix 3 Parent Guardian Information sheet

Parent/Guardian Information Sheet

Date Information Sheet Produced:

14/04/2015

Project Title

Injury incidence in elite New Zealand Track Cyclists: A prospective cohort study.

An Invitation

My name is Helene Barron and I am a Physiotherapist with High Performance Sport NZ.

I am inviting your son/daughter to take part in a study that will look at injury rates in elite NZ track cyclists. I would like to collect information on any injuries they may have suffered in the past and then collect injury data from them over the next year.

To take part in the study they should:

1. Be current elite track cyclists – as recognized through their carding status with High Performance Sport NZ.

If you agree for them to take part in this research:

5. Any data captured will be confidential.

6. They will in no way be personally identified in the study.

7. Participation in this research is voluntary and they will in no way be disadvantaged/advantaged if they choose to participate or not.

8. Your child may withdraw themselves or any information at any time prior to the completion of the study without being disadvantaged in any way.

What is the purpose of this research?

This research aims to establish the baseline prevalence of injury, and its effect on training and competition for elite New Zealand track-cyclists. Injury characteristics and training exposure will be established over a twelve month period utilising the Programme for Injury and Illness Surveillance (PILLS) smart phone or tablet application which has been developed by High Performance Sport New Zealand (HPSNZ).

As part of this research I may be required to provide a summary of my findings for publication in research journals or a conference paper.

How were they identified and why are they being invited to participate in this research?

They were identified for the study by Cycling NZ.

What will happen in this research?

If they choose to participate in this study they will be asked to:

- Complete an initial injury questionnaire, which will provide us with background information ie gender, age, squad group. They will also complete the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire which will ask for information on previous and or current injuries.

- They will receive a unique code. This means their data is linked to a code rather than their name and hence they will not be identified personally to this information.

- Complete weekly injury status questionnaires (one per week) over a full training and competition year, available to them via the PILLS tool on the iSurvey Application.

- If they attend physiotherapy for treatment and assessment with HPSNZ, their physiotherapist will record details of any injuries utilizing the Orchard Coding system.

What are the discomforts and risks?

No injury risk is anticipated as they are not being asked to do anything over and above their normal training and competition. The only requirement is for them to honestly complete the initial and weekly surveys given to them.

What are the benefits?

While there are no immediate benefits to them personally, their participation will however be contributing knowledge about injuries in track cycling. The principle benefit of this study is that they will contribute (via their participation) to the cycling community by increasing our understanding of injury incidence and risk factors. This information can then be utilized to focus on injury prevention strategies. By minimising injury risk it is hoped to positively influence their ability to participate in training and competition and therefore have secondary performance benefits in the future.

How will their privacy be protected?

Data collected from your child will only be used for the study to assess their injury status.

Only the investigators and administrators of the study will have access to your child's personal information and this will be kept secure and strictly confidential.

Each participant will be allocated a unique code and therefore they will not in any way be personally identifiable.

All raw data on which the results of this study depend will be retained in secure storage for 10 years after which it will be destroyed.

No information that could identify them as an individual participant will be used in any of the research reports or papers written from this research.

What are the costs of participating in this research?

Participation in this research is voluntary and the only cost anticipated is the time taken to complete the surveys. The initial survey should take 10 minutes to complete. Subsequent weekly surveys are estimated to take 2-3 minutes to complete.

What opportunity do I have to consider this invitation?

Your child will be invited to attend an information session in the week beginning 4th May 2015.

How do I agree to participate in this research?

If you agree for them to participate in this research you will be ask to complete a Consent and or Assent Form attached to this information sheet.

Once you have agreed for them to participate you will need to complete the consent and or assent form and return this to the research team once you have had a chance to have any questions answered. This will most likely be at the information session as stated above.

The completed forms will then be given to Dr Duncan Reid at AUT University.

Will I receive feedback on the results of this research?

You can choose if you wish to receive feedback on the results of this research please indicate this in the box provided on the consent and assent forms.

Those participants who wish to receive feedback will be emailed a summary of the research findings at the conclusion of the study.

Any possible conflict of interest?

Helene Barron – the primary researcher – currently work with Cycling New Zealand(CNZ)'s track athletes. Although I work with CNZ, I am employed by High Performance Sport NZ. I am conducting this research as part of my individual Master's Study and not because of any influence by either HPSNZ or Cycling New Zealand. I have applied for and received a Prime Minister's Scholarship to undertake my Master's study – this research is endorsed by Cycling New Zealand and the scholarship is managed by HPSNZ but the research is not influenced by either organisation.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Duncan Reid, dreid@aut.ac.nz, 09 9219999 ext 7806

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, Kate O'Connor, *ethics@aut.ac.nz* , 921 9999 ext 6038.

Whom do I contact for further information about this research?

Researcher Contact Details:
Helene Barron
High Performance Sport New Zealand
helene.barron@hpsnz.org.nz
021 242 2572

Project Supervisor Contact Details:
Duncan Reid
AUT University
dreid@aut.ac.nz
09 9219999 ext 7806

Approved by the Auckland University of Technology Ethics Committee on 14 May, 2015, AUTEC Reference Number 15/108

Appendix 4 Consent Form

Consent Form

Injury Data Collection

Project title: Injury incidence in elite New Zealand Track Cyclists: A prospective cohort study.
Project Supervisor: Duncan Reid
Researcher: Helene Barron

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 14 April 2015.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that if I receive treatment from the Physiotherapist at HPSNZ details of my injury will be recorded utilizing the OSICS-10 system (Orchard Codes)
- ○ I understand that I will be asked to complete an initial injury surveillance questionnaire to establish my baseline characteristics – this is in the form of the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire
- ○ I understand that I will be asked to complete a weekly injury questionnaire for 52 consecutive weeks which I will complete via the iSurvey application on a smart phone or tablet.
- ○ All my personal details, injury data and questionnaire answers are confidential and I will in no way be personally identified.
- ○ I understand that the results of this study may be published/reported at conferences however that I will not be identified individually
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If I withdraw, I understand that all relevant information collected or parts thereof, will be destroyed.
- ○ I agree to take part in this research.
- ○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

Participant's signature:.....

Participant's name:.....

Participant's Contact Details

Address :……..

Phone : ……..

Email : ……

Approved by the Auckland University of Technology Ethics Committee on 14 May 2015 AUTEC Reference number 15/108

Note: The Participant should retain a copy of this form

Appendix 5 Parent Guardian Consent Form

Parent/Guardian Consent Form

For use in conjunction with either an appropriate Assent Form when legal minors (people under 16 years) are participants in the research or a Consent Form when involving participants aged 16-20 years whose age makes them vulnerable as concerns consent.

Project title: **Injury incidence in elite New Zealand Track Cyclists: A prospective cohort study.**

Project Supervisor: ***Duncan Reid***

Researcher: ***Duncan Reid, Helene Barron, Dr Bruce Hamilton***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 14 April 2015.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that I may withdraw my child/children and/or myself or any information that we have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ I understand that if my child receives treatment from the Physiotherapist at HPSNZ details of their injury will be recorded utilizing the OSICS-10 system (Orchard Codes)
- ○ I understand that my child will be asked to complete an initial injury surveillance questionnaire to establish their baseline characteristics – this is in the form of the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire
- ○ I understand that my child will be asked to complete a weekly injury questionnaire for 52 consecutive weeks which I will complete via the iSurvey application on a smart phone or tablet.
- ○ All my child's personal details, injury data and questionnaire answers are confidential and they will in no way be personally identified.
- ○ I understand that the results of this study may be published/reported at conferences however that my child will not be identified individually.
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If my child/children and/or I withdraw, I understand that all relevant information including tapes and transcripts, or parts thereof, will be destroyed.

○ I agree to my child/children taking part in this research.

○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

Child/children's name/s : ……

Parent/Guardian's signature: .....

Parent/Guardian's name: .....

Parent/Guardian's Contact Details:……..

Date: ……

Approved by the Auckland University of Technology Ethics Committee on 14 May, 2015, AUTEC Reference Number 15/108

Appendix 6 Baseline History Questionnaire

HIGH PERFORMANCE SPORT NEW ZEALAND

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

BRIEF INJURY HISTORY

DATE _____

NAME OF ATHLETE _____

SPORT_____

DISCIPLINE _____

POSITION PLAYED *(if applicable)*_____

CURRENT LEVEL OF PARTICIPATION	□ Regional	□ National	□ International
HANDEDNESS	□ Left	□ Right	□ Ambidextrous
FOOTEDNESS	□ Left	□ Right	□ Ambidextrous

EXTERNAL SUPPORT eg Foot orthotics, Braces, Strapping etc

TRAINING HOURS PER WEEK

Sport Specific _____

Cross Training _____

Any perceived areas of muscular tightness, weakness and / or fatigue associated with performance or training

---

PREVIOUS INJURIES

Date	Injury
___/___/___	_____
Date	Injury
___/___/___	_____

CURRENT INJURIES

Date	Injury
___/___/___	_____
Date	Injury
___/___/___	_____
Date	Injury
___/___/___	_____

Medication: (taken if currently have an injury)

Appendix 7 Oslo Sports Trauma Research Centre overuse Injury Questionnaire

Oslo Sports Trauma
RESEARCH CENTER

OSTRC Overuse Injury Questionnaire	
Part 1: Knee Problems	
Please answer all questions regardless of whether or not you have problems with your knees. Select the alternative that is most appropriate for you, and in the case that you are unsure, try to give an answer as best you can anyway.	
The term "knee problems" refers to pain, ache, stiffness, swelling, instability/giving way, locking or other complaints related to one or both knees.	
Question 1	
Have you had any difficulties participating in normal training and competition due to knee problems during the past week?	
☐	Full participation without knee problems
☐	Full participation, but with knee problems
☐	Reduced participation due to knee problems
☐	Cannot participate due to knee problems
Question 2	
To what extent have you reduced you training volume due to knee problems during the past week?	
☐	No reduction
☐	To a minor extent
☐	To a moderate extent
☐	To a major extent
☐	Cannot participate at all
Question 3	
To what extent have knee problems affected your performance during the past week?	
☐	No effect
☐	To a minor extent
☐	To a moderate extent
☐	To a major extent
☐	Cannot participate at all
Question 4	
To what extent have you experienced knee pain related to your sport during the past week?	
☐	No pain
☐	Mild pain
☐	Moderate pain
☐	Severe pain

Oslo Sports Trauma
RESEARCH CENTER

OSTRC Overuse Injury Questionnaire	
Part 2: Lower Back Problems	
Please answer all questions regardless of whether or not you have problems in your lower back. Select the alternative that is most appropriate for you, and in the case that you are unsure, try to give an answer as best you can anyway.	
The term "lower back problems" refers to pain, aching, stiffness or other problems in your lower back.	
Question 1	
Have you had any difficulties participating in normal training and competition due to lower back problems during the past week?	
☐	Full participation without lower back problems
☐	Full participation, but with lower back problems
☐	Reduced participation due to lower back problems
☐	Cannot participate due to lower back problems
Question 2	
To what extent have you reduced you training volume due to lower back problems during the past week?	
☐	No reduction
☐	To a minor extent
☐	To a moderate extent
☐	To a major extent
☐	Cannot participate at all
Question 3	
To what extent have lower back problems affected your performance during the past week?	
☐	No effect
☐	To a minor extent
☐	To a moderate extent
☐	To a major extent
☐	Cannot participate at all
Question 4	
To what extent have you experienced lower back pain related to your sport during the past week?	
☐	No pain
☐	Mild pain
☐	Moderate pain
☐	Severe pain

Oslo Sports Trauma
RESEARCH CENTER

OSTRC Overuse Injury Questionnaire	
Part 3: Shoulder Problems	
Please answer all questions regardless of whether or not you have problems in your shoulders. Select the alternative that is most appropriate for you, and in the case that you are unsure, try to give an answer as best you can anyway.	
The term "shoulder problems" refers to pain, aching, stiffness, looseness or other complaints in one or both of your shoulders.	
Question 1	
Have you had any difficulties participating in normal training and competition due to shoulder problems during the past week?	
☐	Full participation without shoulder problems
☐	Full participation, but with shoulder problems
☐	Reduced participation due to shoulder problems
☐	Cannot participate due to shoulder problems
Question 2	
To what extent have you reduced you training volume due to shoulder problems during the past week?	
☐	No reduction
☐	To a minor extent
☐	To a moderate extent
☐	To a major extent
☐	Cannot participate at all
Question 3	
To what extent have shoulder problems affected your performance during the past week?	
☐	No effect
☐	To a minor extent
☐	To a moderate extent
☐	To a major extent
☐	Cannot participate at all
Question 4	
To what extent have you experienced shoulder pain related to your sport during the past week?	
☐	No pain
☐	Mild pain
☐	Moderate pain
☐	Severe pain

Appendix 8 Programme for Injury and Illness Survey – Question list

Q1. Please answer all questions in relation to the last 7 days only
Q2. How many training sessions (all aspects of training) did you have planned?
Q3. How hard would you rate your training?
Q4. In training did you TRAIN FULLY ALL SESSIONS?
Q5. How many training sessions did you MISS or MODIFY due to factors OTHER THAN INJURY or ILLNESS (e.g. study, lifestyle etc.)?
Q6. Did you miss and/or modify any training sessions due to INJURY?
Q7. How many did you MISS?
Q8. How many did you MODIFY?
Q9. WHEN did the injury occur?
Q10. WHERE did the injury occur?
Q11. WHAT did you injure?
Q12. Please rate the severity of your INJURY symptoms TODAY. (You must move the slider scale 0-10)
Q13. Which side did you injure?
Q14. What type of injury do you have?
Q15. Do you have a diagnosis of your INJURY?
Q16. Do you have any other injuries impacting on your training or performance?
Q17. Did you miss or modify training sessions due to ILLNESS?
Q18. How many did you MISS?
Q19. How many did you MODIFY?
Q20. Please indicate the affected area/systems. (Note: If you have more than one illness, indicate which is the worst.)"
Q21. Do you have an infection?
Q22. Please rate the severity of your ILLNESS symptoms TODAY. (You must move the slider – scale 0-10)
Q23. Do you have a diagnosis?
Q24. Do you have any other illnesses impacting on your training or performance?
Q25. In the last 7 days did you consult a PHYSIOTHERAPIST?
Q26. In the last 7 days did you consult a DOCTOR?
Q27. In the last 7 days did you consult a MASSAGE THERAPIST?
Q28. In the last 7 days did you consult another HEALTH PROFESSIONAL?
Q29. In the last 7 days have you had any of the following:
Q30. How ready are you today to train or compete at your best? You MUST move the slider (scale 0-100%).
Q31. Do you wish to speak with your sport's Medical Director or the NSO Physiotherapist within the next few days?

Reference

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