QUANTIFICATION OF PRE-COMPETITIVE SLEEP/WAKE BEHAVIOUR IN A SAMPLE OF SOUTH AFRICAN CYCLISTS

BY

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ABSTRACT

The quantification of athlete pre-competitive sleep behaviour is of interest owing to the possibility that sleep loss may have a negative effect on health and performance. The purpose of this study was to monitor and quantify the sleep/wake patterns of South African cyclists prior to competitive races. A total of 336 cyclists, male and female and of differing competition levels, cycling in either the 2015 Tsogo Sun Amashova or the 2016 Telkom 94.7 Cycle Challenge completed an altered version of the Competitive Sports and Sleep Questionnaire. The questionnaire asked cyclists to report on pre-competitive sleep over the past year. A subset of 92 cyclists also recorded a Core Consensus Sleep Diary for the three nights leading up to the races. The questionnaire showed that 67% of the cyclists reported worsened sleep at least once prior to competition within the past 12 months. The sleep diary found that the cyclists' average sleep duration the night before the races was 6h19min (±1h38min), which was significantly less than two and three nights prior to the races. Sleep quality was also shown to deteriorate significantly the night before the races. The contributing factors leading to worsened pre-competitive sleep were the time the cyclists had to wake-up as well as perceived increases in sleep latency and awakenings after sleep onset. Anxiety was found to be the major cause of sleep disturbances.

While females were found to be significantly more likely to report having experienced poorer sleep before competition in the past year, the sleep diary showed no difference in sleep the night before the races between the sexes. Females were significantly more likely to report instances of unpleasant dreams and waking up during the night. Again, the sleep diary data did not corroborate these findings. Females were also found to report significantly more accounts of nervousness or thoughts about competition as being the cause of sleep problems.

There was no difference in sleep loss the night before competition when comparing competition-level groups. The only significant difference was that recreational cyclists were more likely to report sleeping in foreign environments as a cause of sleep disturbances.

Despite a large percentage of cyclists experiencing pre-competitive sleep loss, over half (55%) perceived sleep loss to have no impact on their performance. Analysis of pre-sleep behaviour also revealed that the cyclists engaged in several practices that

may have a negative effect on subsequent sleep. The vast majority of the cyclists (61%) indicated having no specific strategy to help them sleep the night before competition. Fifteen percent of cyclists reporting using media devices to help them fall asleep, a practice that has been shown to disrupt sleep.

In conclusion, most cyclists, regardless of sex and level of competition experience pre-competitive sleep loss attributed largely to anxiety but with the perception that this loss in sleep does not negatively impact their performance.

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CHAPTER I

1 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Sleep is an important biological process which aids the body in recovery and preparation through the processes of development, growth, optimal metabolic and immune function, and energy conservation (Mignot, 2008; Halson, 2014; and Lastella *et al.,* 2014). Sleep loss, therefore, can have both short-term and long term pathological effects on the human body (Killgore, 2010; Hirshkowitz *et al.,* 2015; and Watson, *et al.*, 2015). Acute sleep loss can lead to, but is not limited to, negative mood states (Scott *et al.*, 2006; and Killgore, 2010), reductions in motor function and reaction time (Bonnet & Arand, 2003; Rogers *et al.*, 2003; Durmer *et al.*, 2005; Schmidt *et al.,* 2007; and Killgore, 2010), increased pain sensations (Killgore, 2010), reductions in short-term memory (Bonnet & Arand, 1995), and increased distractibility (Bonnet & Arand, 2003). Of greater concern are the health implications associated with chronic sleep loss among the general public which include an increased risk of obesity (Sekine *at al.*, 2006; Cappuccio *et al.*, 2007; Yu *et al.*, 2007; and Gangwisch *et al.*, 2009); and cardiovascular disease (Meier-Ewert *et al.*, 2004) as well as psychological disorders (Liu, 2004; and Wong *et al.,* 2004). There is some evidence which suggests that athletic performance could also be compromised by inadequate sleep (Oliver *et al.,* 2009; Skein *et al.*, 2011; and Temesi *et al.*, 2013). There is mounting empirical evidence which suggests that athletes are likely to experience sleep loss during training as well as directly before competition (Erlacher *et al.*, 2011; Leeder *et al.*, 2012; Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; Lastella *et al.*, 2014; Lastella *et al.*, 2015a; Lastella *et al.*, 2015b; and Juliff *et al.*, 2015). This is despite athletes and coaches viewing good sleep as an important factor for enhanced performance and recovery (Oliver *et al.,* 2009; Lastella *et al.*, 2014; and Sargent *et al.*, 2014a).

Sixty to seventy percent of elite athletes, regardless of sex and sporting code, report worse sleep the night before competition (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). Elite athletes have also been found to get approximately 6h of sleep the night before competition (Lastella *et al.*, 2014; and Lastella *et al.*, 2015b). This shows a sleep reduction of nearly an hour as compared to baseline sleep (Lastella *et al.*, 2014; and

Lastella *et al.*, 2015b) and is lower than the recommended sleep range for healthy adults (Hirshkowitz *et al.*, 2015; and Watson *et al.*, 2015). Individual sport athletes, such as cyclists, have been shown to be more prone to experiencing sleep loss during both periods of training and competition (Erlacher *et al.*, 2011; and Lastella *et al.*, 2015a). Cyclists in particular have shorter average sleep periods when compared to other endurance athletes (Erlacher *et al.*, 2011). Only swimmers and triathletes have been shown to record less average sleep length (Erlacher *et al.*, 2011).

Biological sex differences have been found with regards to sleep/wake regulation (Santhi *et al.*, 2016). These differences include earlier timing of sleep onset (Wever, 1984; Djik *et al.*, 1989; Roennenberg *et al.*, 2004; and Ma *et al.*, 2011); earlier and larger amplitude in melatonin peaks (Cain *et al.*, 2010); earlier timing of rhythms in the brain related to clock genes (Lim *et al.*, 2013); and a shorter intrinsic period of the body temperature and melatonin rhythms in females (Wever, 1984; and Duffy *et al.*, 2011). There are also proposed behavioural differences between the sexes which may cause differences in sleep (Hislop & Arber, 2003). Co-rumination, for instance, has been shown to correlate with the increase in sleep problems in females as compared to males (Chow *et al.*, 2017). The traditional gender roles of males and females may also contribute to the finding of increased sleep problems in females (Hislop & Arber, 2003). The traditional (although antiquated and changing) gender role of females places an increased burden on them including dealing with domestic chores and mothering (Hislop & Arber, 2003). Coping with the higher domestic burden may lead to the increase in worsened sleep as seen in previous findings (Groeger *et al.*, 2004; Tsai & Li, 2004; Landis & Lent, 2006; Sekine *et al.*, 2006; Zhang & Wing, 2006; Lund *et al.*, 2010; and Petrov *et al.*, 2014).

Thus far, only three known studies have quantified pre-competitive sleep of both male and female athletes (Erlacher *et al.*, 2011; Lastella *et al.*, 2014; and Juliff *et al.*, 2015). Only two, however, presented a comparison of sleep/wake behaviour between the sexes (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). Neither study found differences between males and females with regards to the incidence rate of pre-competitive sleep loss (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). Furthermore, the majority of studies have all been conducted on elite athletes (Erlacher *et al.*, 2011; Lastella *et al.*, 2014; Lastella *et al.*, 2015b; Juliff *et al.*, 2015; Romyn *et al.*, 2016; and Ehrlenspiel *et al.*, 2017). No known data which demonstrates the pre-competitive sleep behaviour of recreational or sub elite athletes are available. Furthermore, no data on athlete pre-competitive sleep/wake patterns are available from South Africa.

Previous quantification studies have endeavoured to identify the aetiology of pre-competitive sleep loss where it has been found to occur (Erlacher *et al.*, 2011; Lastella *et al.*, 2014; Juliff *et al.*, 2015; Romyn *et al.*, 2016; and Ehrlenspiel *et al.*, 2017). Findings suggest that problems falling asleep (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015) as a result of pre-competitive anxiety (Erlacher *et al.*, 2011; Lastella *et al.*, 2014; Juliff *et al.*, 2015; Romyn *et al.*, 2016; and Ehrlenspiel *et al.*, 2017) is the main cause of sleep loss the night before competition.

Another area of interest is the extent of sleep-hygiene knowledge amongst athletes (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). This is because it is unknown whether athletes who do not experience pre-competitive sleep loss have coping methods which they use to avoid disrupted sleep. When elite athletes have been asked about strategies used to promote sleep, the results suggest a clear lack of basic sleep-hygiene education (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). Half of all athletes report having no special strategy to aid sleep and a quarter of athletes watch television or use media devises to help them sleep (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015).

With sleep being recognised as an important component of optimal human functioning and athletes being identified as a possible at risk group, more research into this area is clearly warranted.

1.2 STATEMENT OF THE PROBLEM

While there is a growing body of evidence which shows that athletes are susceptible to experiencing sleep loss the night prior to competition, there is still a need to replicate these findings. There is also a need to understand why pre-competitive sleep loss occurs in an effort to find preventative measures. Cyclists are a group of particular interest for this study. Research within this area has also largely focused on international athletes with no evidence to suggest these findings are generalizable to a South African population. There is also a clear need to add to the existing pre-competitive sleep data with regards to sex differences and comparisons of athletes of differing skill level. Little research has focused on the pre-sleep practices of athletes prior to competition. This is important to understand in order to identify intervention methods for when pre-competitive sleep loss is an issue.

1.3 AIMS AND OBJECTIVES

The primary aim of this study was to document the sleeping patterns of a population of cyclists the nights prior to cycling races. This included identifying sex and competition-level differences to identify sub categories of cyclists who may be at a higher risk of experiencing sleep loss. A secondary objective was to document self-reported problem areas of sleep. This was in an effort to further the understanding of the aetiology of sleep loss in cyclists. Lastly, this study aimed to document pre-sleep practices of cyclists the night before competition. This aimed to identify successful sleep strategies already used by the population as well as to note those pre-sleep routines which correlate to poor sleep.

1.4 RESEARCH HYPOTHESIS

1.4.1 General

With the previous literature in mind, it is expected that cyclists will experience pre-competitive sleep loss before competition.

1.4.2 Sex and competition-level differences

It is expected that there will be a difference found for the incidence rate of pre-competitive sleep loss between the sexes and between elite and recreational athletes.

CHAPTER II

2 REVIEW OF RELEVANT LITERATURE

The following chapter aims to outline and inform the argument that there is a need for the sleep/wake behaviour of South African cyclists to be investigated. First and foremost, the fundamentals of sleep and sleep/wake regulation will be outlined and explained. Next, the status of sleep attainment and sleep need will be addressed followed by an analysis of sleep/wake behaviours within athlete populations. Lastly, techniques and methods used to measure sleep in athlete populations will be reviewed.

2.1 SLEEP

A purely behavioural definition of sleep would be the reversible state in which one is unresponsive and disengaged from the environment (Carskadon & Dement, 2011). From a physiological standpoint, sleep is recognised as being essential for recovery from the previous period of wakefulness whilst at the same time preparing the body for the upcoming time spent awake (Halson, 2014).

2.2 SLEEP-WAKE REGULATION

The traditional postulation of how sleep is regulated involves two separate biological mechanisms which, while working in synchrony, have opposing effects (Borbély & Achermann, 1999; Dijk & Lockley, 2002; and Schmidt *et al.*, 2007). This two process model of sleep regulation was first proposed by Borbély (1982) and Daan, Beersma, & Borbély (1984). The first of these processes is the circadian rhythm, which is also known as process C (Borbély & Achermann, 1999; and Schmidt *et al.*, 2007). The second is the homeostatic sleep process, which is also referred to as process S (Borbély & Achermann, 1999; and Schmidt *et al.*, 2007).

2.2.1 Circadian rhythm

The circadian rhythm, or rather rhythms, are variations within the biology of most mammalians which are cyclical, with one cycle in human beings equating to roughly 24 hours (Dijk & Lockley, 2002; and Hayes *et al.*, 2010). These cycles are controlled by an endogenous pacemaker within the suprachiasmatic nucleus in the anterior hypothalamus (Schwartz *et al.*, 1986; Cohen & Albers, 1991; Duffy *et al.*, 2001; Dijk & Lockley, 2002; and Hayes *et al.*, 2010). As the suprachiasmatic nucleus acquires sensory inputs from the environment, it communicates with the endocrine system as well as other centres within the hypothalamus to stimulate and regulate behavioural and physiological processes (Hayes *et al.*, 2010). Amongst these processes are those which control the oscillating variation in sleep and wakefulness propensities (Dijk & Lockley, 2002; and Schmidt *et al.*, 2007). In human beings, this variation sees wakefulness or arousal levels increasing in strength throughout the biological day and peaking in the early evening (Dijk & Lockley, 2002) (Figure 1). Arousal levels and wakefulness are then down-regulated and decrease during the biological night culminating in a minimum being reached in the early hours of the morning (Dijk & Lockley, 2002) (Figure 1).

2.2.1.1 Factors affecting the circadian rhythm

Sensory inputs from the environment, termed "zeitgebers" meaning time-givers or synchronisers, are relied upon heavily by the suprachiasmatic nucleus for the regulation of the above systems (Schmidt *et al.*, 2007). These "zeitgebers" entrain the human body (and mammalians in general) to the rotation of the earth, and by extension, the day-night cycle (Daan, 2000). The major "zeitgeber" informing the suprachiasmatic nucleus which regulates sleep-wake propensity is thought to be light from the environment (Czeisler & Wright, 1999; Dijk & Lockley, 2002; Schmidt *et al.*, 2007; and Hayes *et al.*, 2010). This entrainment is partly what keeps human beings (under normal conditions) awake during the day, with habitual sleep occurring during the night, as can be seen in Figure 1 (Daan, 2000; and Dijk & Lockley, 2002).

2.2.1.1 Systems affected by the suprachiasmatic nucleus

The suprachiasmatic nucleus modulates numerous efferent systems which include the adrenergic, histaminergic, serotonergic, melatonin and orexin systems (Lavie 1997; Djik *et al.*, 2000; Lu *et al.*, 2000, Abrahamson *et al.*, 2001; Aston-Jones *et al.*, 2001; Lu *et al.*, 2001; and Moore *et al.*, 2001). All of these systems are implicated in circadian arousal and/or circadian hypnotic processes (Dijk & Lockley, 2002). Orexin, for example, is a neuropeptide which has been found to stimulate wakefulness (Peyron *et al.*, 2000; and Overeem *et al.*, 2001). This is owing to a correlation between orexin defficiencies and the sleep disorder narcolepsy (Peyron *et al.*, 2000; and Overeem *et al.*, 2001). Melatonin, on the other hand, is a circadian hypnotic hormone as plasma melatonin fluctuations are closely correlated to sleep propensity, as seen in Figure 1 (Lavie 1997; Djik & Cajochen, 1997; and Crowley *et al.*, 2007).

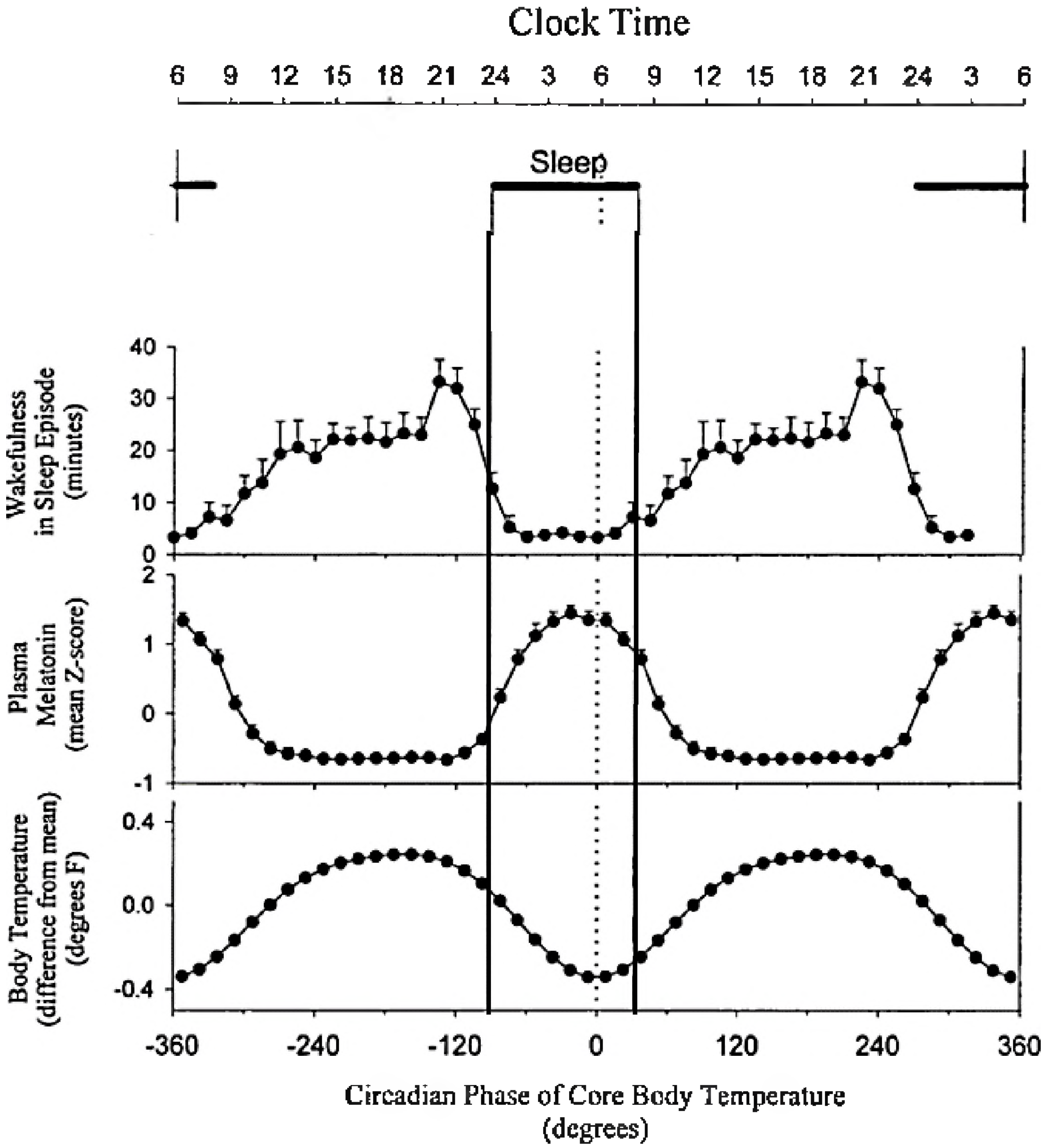

Figure 1. Representation of a typical sleep period in relation to the circadian rhythm of core body temperature, plasma melatonin, wake propensity, and the responsiveness to light. Taken from Dijk & Lockley (2002).

2.2.2 Homeostatic sleep process

The homeostatic sleep process differs from the circadian rhythm since it works as a pressure system (Borbély & Achermann, 1999; Durmer *et al.*, 2005; and Crowley *et al.*, 2007). The longer an individual is awake, the more sleep pressure accrues as a function of time, and thus, sleepiness and the likelihood of sleep increases (Schmidt *et al.,* 2007). This increase in sleep pressure is also accompanied by decreases in alertness and cognitive performance (Schmidt *et al.,* 2007). This sleep pressure is only relieved during sleep and particularly during stages 3 and 4 of non-rapid eye movement sleep (Borbély and Achermann, 1999; Durmer *et al.*, 2005; and Schmidt *et al.,* 2007).

2.2.3 Interaction between the circadian rhythm and the homeostatic sleep process

Under normal circumstances, people fall asleep when the circadian rhythm promotes sleep in conjunction with an elevated sleep pressure from the homeostatic sleep process (Dijk & Lockley, 2002; and Schmidt *et al.,* 2007) (Figure 2). People then wake-up when the circadian rhythm promotes wakefulness in coincidence with reduced levels of sleep pressure from the restorative night's sleep (Dijk & Lockley, 2002; and Schmidt *et al.,* 2007) (Figure 2). The two systems also interact in opposition to maintain sustained and optimal periods of sleep and wakefulness (Schmidt *et al.,* 2007). For instance, sleep pressure is building towards its highest during the early hours of the evening (Schmidt *et al.,* 2007). The circadian rhythm, however, dictates a low propensity for sleep at this time, ensuring wakefulness despite the pressure from the homeostatic sleep process (Schmidt *et al.,* 2007) (Figures 1&2). Similarly, sleep pressure is mostly reduced within the first 3-4 hours of sleep (Schmidt *et al.,* 2007) (Figure 2). After this period, the circadian rhythm enters its nadir, that is, the point within the rhythm when sleep is most promoted physiologically. This high circadian-based propensity for sleep is what ensures that waking within the early hours of the morning does not occur (Schmidt *et al.,* 2007). It is, thus, via the interaction and the opposition of these two processes that the cycles of sleep and wakefulness are regulated.

Figure 2 illustrates how the circadian rhythm and homeostatic sleep process interact to promote an overall state of wakefulness or sleepiness.

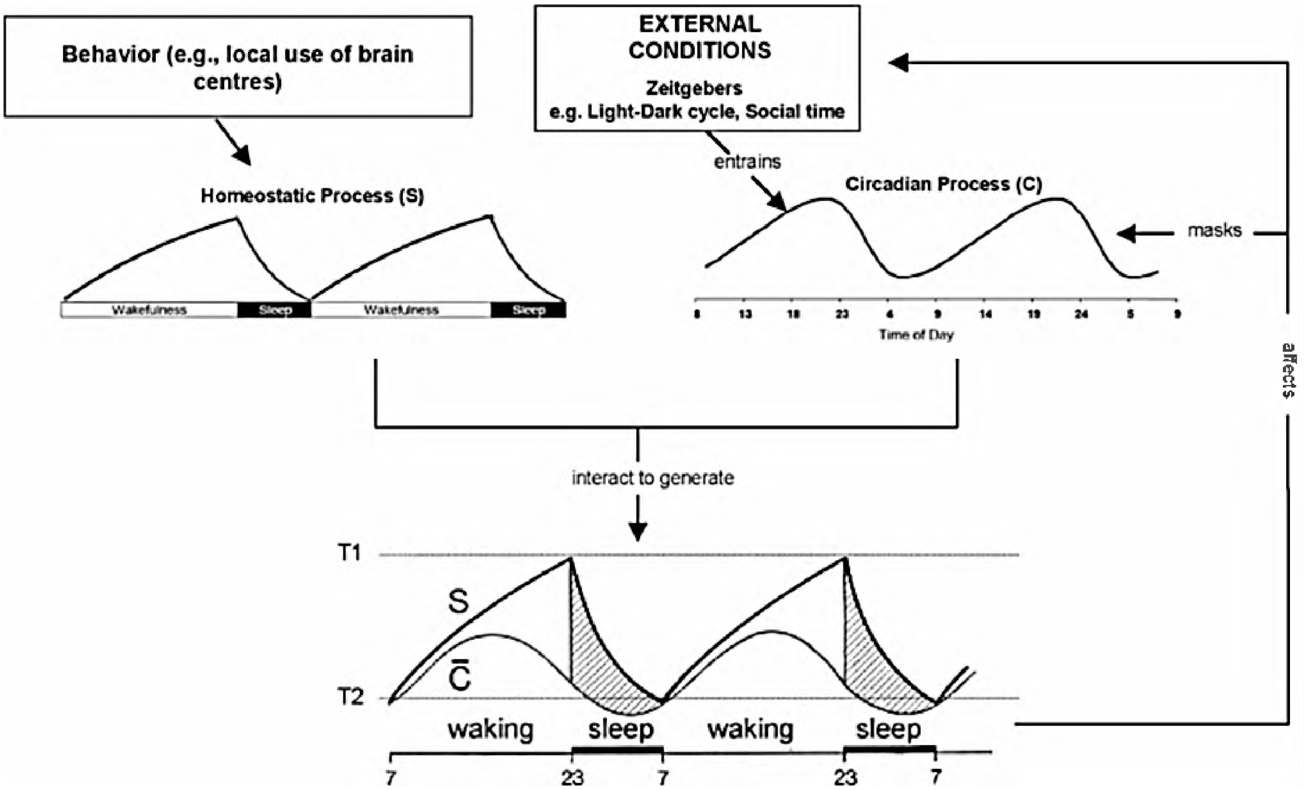

Figure 2. Representation of the interaction between the homeostatic sleep process and the circadian rhythm as proposed by Borbely (1982) and Daan *et al.* (1984). Image taken from (Schmidt *et al.*, 2007).

2.3 GENERAL SLEEP NEED

The optimum sleep length for the general public has been identified as being between 7 and 9hrs based on extensive observational and epidemiological evidence (Balkin *et al.*, 2008; Bixler, 2009; Carskadon & Dement, 2011; Hirshkowitz *et al.*, 2015; and Watson *et al.*, 2015). The variability within this range exists owing to fluctuating sleep need from person to person and night to night (Carskadon & Dement, 2011). Average sleep need is predominantly based on the genetic make-up of the individual (Karacan & Moore, 1979; and Watson *et al.*, 2015). Sleep need for any given night is, however, also determined by the accrued homeostatic sleep pressure since the last period of sleep, as well as the stage of the circadian process in which the individuals happen to find themselves (Carskadon & Dement, 2011). Falling both above and below the recommendation for optimal sleep length is correlated with numerous health, cognitive and performance decrements (Killgore, 2010). With respect to general health, there is evidence that inadequate sleep length is correlated with increased morbidity (Hall *et al.,* 2008; Van Cauter *et al.*, 2008; & Gangwisch, 2009;) and mortality (Kripke *et al.,* 2002; Patel, 2006; Hublin *et al.*, 2007; Kronholm *et al.,* 2008; and Patel *et al.,* 2008) in the form of increased risk of obesity (Sekine *et al.,* 2006; Cappuccio *et al.*, 2007; Yu *et al.*, 2007; and Gangwisch *et al.*, 2009), cardiovascular disease (Meier-Ewert *et al.*, 2004), alcohol and drug abuse (Wong *et al.*, 2004) as well as suicide in adolescents (Liu, 2004). Other health decrements associated with sleep reduction include negative metabolic functioning (Van Cauter *et al.*, 2008) and the general impairment of the immune system (Sekine *et al.*, 2006). Despite the evidence of these risks being clearly and extensively documented, sleep loss is a common problem within most societies (Ferrara & De Gennaro, 2001; Cappuccio *et al.*, 2007; Yu *et al.*, 2007; and Jean-Louis *et al.*, 2014). It is speculated that this may be a function of sleep being viewed as a perfunctory chore (Killgore, 2010; and St-Onge *et al.*, 2016). If the benefits of sleep are not truly considered by the individual, it is highly possible that sleep will be seen as a waste of time, with the time rather being spent on entertainment, work or any activity deemed more lucritive than going into a seemingly unproductive state for 8hrs (Killgore, 2010; and St-Onge *et al.*, 2016).

2.3.1 Common causes of sleep loss in society

With sleep loss having extensive physiological consequences, understanding what causes sleep loss is of utmost importance (Potter *et al.,* 2016; and *St*-Onge *et al.*, 2016). The factors that follow are over and above the biological and pathological sleep disturbances that can arise from genetic and diseased states.

2.3.1.1 Sleep/wake disorders

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) there are eight sleep/wake disorder groups (American Psychiatric Association, 2015). The International Classification of Sleep Disorders (ICSD-3) identifies 80 specific sleep/wake disorders which fall into the eight categories (American Academy of Sleep Medicine, 2014). Providing a full review of the myriad of sleep disorders members of the general public may encounter would detract from the primary focus of the current research. It should be noted that sleep disorders are highly prevalent in general society (American Psychiatric Association, 2015). Up to 33% of general populations have been found to exhibit symptoms of insomnia, 5-15% experience restless leg syndrome and 5% of individuals suffer from sleep apnea (American Psychiatric Association, 2015).

2.3.1.2 The working world

A major cause of sleep loss in modern society is the nature of the working world (Potter *et al.,* 2016). Shift workers, in particular, are at risk of circadian and sleep disruptions owing to the need to work during the typical rest phase for diurnal creatures (Axelsson *et al*., 2004; Arendt *et al*., 2006; Folkard, 2008; and Arendt, 2010). The consequences of chronic circadian and sleep disruption can be seen in dose-response relationship between shift work and diseases such as breast cancer and the metabolic syndrome (Wang *et al*., 2013; and Wang *et al*., 2014). Even working "normal" hours during the day can result in less obvious circadian disruptions (Potter *et al.,* 2016). Sleep on work days is usually shorter by an hour compared to sleep on non-work days (Potter *et al.,* 2016). Chronically restricting sleep during the week and "catching up" on the weekends causes a phenomenon known as "social jetlag" (Wittmann *et al*., 2006; and Roenneberg *et al*., 2012). As the term suggests, this is comparable to the circadian disruption that would be indicative of trans-meridian travel, only it is caused by chronically short sleep duration and altered sleep wake patterns during the weeks in comparison to the weekends (Wittmann *et al*., 2006; and Roenneberg *et al*., 2012). Social jetlag has been found to be correlated to increased risk of obesity as well as increased alcohol and nicotine dependencies (Wittmann *et al*., 2006; and Roenneberg *et al*., 2012).

Jetlag itself seems to only induce short-term and reversible effects on the circadian rhythm (Hammer *et al*., 2014). That being said, the issue of jetlag may become a larger problem as the world moves more and more towards a global society (Potter *et al.,* 2016). For example, 831 million more people were shown to travel via aeroplane in 2016 compared to 2011 (Annual Review, 2013; and Potter *et al.,* 2016). With more people travelling across time zones and travelling more frequently, jetlag may become a real concern in the future (Potter *et al.,* 2016).

2.3.1.3 Light exposure

Artificial light is perhaps the most pervasive cause of circadian and sleep disturbance, and by extension the pathologies they cause (Ferrara & Gennaro, 2001; Eisenstein, 2013; and Potter *et al.,* 2016).

Receptors in the human eye, known as melanopsin receptors, are stimulated by light (Eisenstein, 2013). These receptors feed this light information to the suprachiasmatic nucleus which regulates circadian functions (Eisenstein, 2013). Light is an important "zeitgeber" upon which the suprachiasmatic nucleus relies in order to synchronise the body clock with the day-night cycle. It has also been found that light with a wavelength between 460 and 480 nanometres, the blue frequency light, is the strongest stimulator of melanopsin receptors (Eisenstein, 2013). Blue frequency light is common with most light emitting diode (LED) screens found in cell phones, televisions and other media devices (Minors *et al.*, 1991; Khalsa *et al.*, 2003; and Eisenstein, 2013). Multimedia device usage at night can, therefore, disrupt the body clock and delay the body's propensity for falling asleep (Minors *et al.*, 1991; Kubota *et al.*, 2002; Khalsa *et al.*, 2003; Higuchi *et al.*, 2005; Gellis & Lichstein, 2009; and Eisenstein, 2013). This is owing to the suprachiasmatic nucleus being fed information suggesting daytime has not yet ended and thus it delays the onset of 'biological' night (Eisenstein, 2013). Indeed, multimedia devices have already been shown to be a significant contributor to disturbed sleep in the general population (Ferrara & Gennaro, 2001; Van den Bulck, 2004; and Fossum *et al.*, 2014). Apart from the stimulation from the light itself, the stimulating nature of the media being consumed could compound the arousal effects of media device usage (Van den Bulck, 2004).

2.3.1.4 Anxiety

Stress and anxiety have also been identified as possible reasons for altered sleep patterns in the general public (Reilly & Edwards, 2007; Spiegelhalder *et al.*, 2013 and Horváth *et al.*, 2016). Psychological stress produces a chemical response in the human body to try to prepare itself to cope or deal with this stress (Taylor *et al.*, 2008). This is commonly known as the 'fight or flight' response (Taylor *et al.*, 2008). There are two categories of anxiety which are commonly accepted in the field of psychology. Trait anxiety is a chronic pathology of the personality while state anxiety is an acute experience of arousal by feelings of tension, apprehension and fear (Endler & Kocovski, 2001). Both types of anxiety have been found to alter non-rapid eye movement sleep (Horváth *et al.*, 2016). Furthermore, trait anxiety seems to correlate to alterations in rapid eye movement sleep structure as well, while state anxiety seems to lead predominantly to increases in sleep onset latency, nightmares and feeling unrefreshed in the morning (Papadimitriou & Linkowski 2005; and Horváth *et al.*, 2016).

2.3.1.5 Lifestyle of an athlete

There is now also evidence which suggests that athletes are at risk of experiencing sleep loss owing to the very nature of training and competition (Erlacher *et al.*, 2011; Leeder *et al.*, 2012; Sargent *et al.*, 2012; Lastella *et al.*, 2014; Sargent *et al.*, 2014; Juliff *et al.*, 2015; Lastella *et al.*, 2015a; and Lastella *et al.*, 2015b). This risk of sleep loss is over and above all of the factors that would affect the general population. The following section will be an in depth review of athlete sleep and the factors that make athletes in particular prone to sleep loss.

2.4 SLEEP LOSS IN ATHLETES

The purpose of the current study is to quantify athlete sleep. This is owing to the fact that previous literature has shown a possible negative relationship between sleep loss and athletic performance (Oliver *et al.,* 2009; Skein *et al.*, 2011; and Temesi *et al.*, 2013). It would detract from the purpose of the study to review in depth the relationship between sleep and performance which has been detailed elsewhere (Killgore, 2010; and Fullagar *et al.*, 2015). It must be noted, however, that sleep loss has been shown to affect visuospatial perception in terms of judging distance, lower pain thresholds for temperature, cause general states of hyperalgesia and increase negative emotional states to name but a few (Killgore, 2010). Sleep loss has also been shown to diminish recovery after exercise bouts (Skein *et al.*, 2011), decrease reaction time (Bonnet & Arand, 1995; and Killgore, 2010), executive attention (Durmer & Dinges, 2005; and Killgore, 2010), short-term memory (Bonnet & Arand, 1995), working memory (Durmer & Dinges, 2005), and vigilance (Bonnet & Arand, 1995; and Killgore, 2010). All of these factors are intrinsic to central theories of exercise induced fatigue and performance enhancement (Tucker, 2009). It is because of the effects that sleep loss has on these factors of human performance that makes it a variable of interest in athlete populations. Sleep loss is a modifiable factor in terms of athlete performance making sleep quantification a priority for maintaining athlete wellbeing and performance (Lastella *et al.*, 2014).

Table 25 in Appendix A summarises the studies that were both sourced by and available to the author with regards to the quantification of athlete sleep.

2.5 SLEEP LOSS PRIOR TO TRAINING

Athletes have been consistently shown to experience poor sleep on nights that precede training days (Leeder *et al.*, 2012; Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; and Lastella *et al.*, 2015a). Australian Olympic swimmers reported sleeping 5h24min on nights prior to training days compared to 7h06min on nights prior to rest days (Sargent *et al.*, 2014a). Similar findings have been reported where 70 nationally competitive athletes slept significantly less (6h30min) on nights prior to training days when compared to nights prior to rest days (6h48min) (Sargent *et al.*, 2014b). Poor sleep has also been found in a cohort of 124 elite athletes who were noted to obtain an average of 6h48min sleep per night (Lastella *et al.*, 2015a). All three of these studies attributed the pre-training sleep loss largely to early morning training schedules (Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; and Lastella *et al.*, 2015a).

Some studies have, however, failed to show that athletes lose sleep during training (Leeder *et al.,* 2012; Romyn *et al.*, 2016; and Knufinke *et al.,* 2017). In the case of Leeder *et al.* (2012), this was attributed to the fact that athlete sleep was compared to a non-athlete control group. A population of 47 Olympic athletes was found to sleep an average of 6h55min during training (Leeder *et al.*, 2012). This sleep duration was statistically similar to that of the matched control (7h11min). It must be noted that this duration would be regarded as being just under the National Sleep Foundation's minimum recommendation of 7h00min of sleep for a healthy adult (Hirshkowitz *et al.*, 2015; and Watson *et al.*, 2015) and well below the recommendation of sleep (8h00min) required to minimise reductions in neuro-behavioural performance (Belenky *et al.*, 2003; and Van Dongen *et al.*, 2003).

That being said, the athlete group experienced significantly reduced sleep quality and sleep efficiency (Leeder *et al.*, 2012). The athlete group spent, on average, 30min longer in bed despite sleeping for the same amount of time (Leeder *et al.*, 2012). Furthermore, athletes had longer sleep latencies and higher rates of restlessness throughout the night (Leeder *et al.*, 2012). Knufinke *et al.* (2017) found average sleep durations of 8h11min in 98 elite youth athletes aged 18.8 (±3 years) during training phase. The study does not, however, seem to have differentiated between pre-training day and pre-rest day sleep making it unclear whether this result is a true reflection of athlete sleep during training phase. That being said, 41% of the athletes were classified in the study as 'poor sleepers' and 12% were diagnosed with one or more sleeping disorders (Knufinke *et al.,* 2017). Romyn *et al.* (2016) did, however, find comparable training phase sleep durations (8h11min) for a group of netball players of a similar age (19.6 ± 1.5 years) as the population in Knufinke *et al.* (2017). With the sample size of 8 athletes in the Romyn *et al.* (2016) study and the methodological inconsistency in Knufinke *et al.* (2017), however, further research is needed to establish whether young athletes are less prone to sleep loss or whether there are other reasons for these results.

2.5.1 Sex differences and sleep loss before training

Only one known study has reported on sex differences with regards to training phase sleep (Leeder *et al.*, 2012). Males were found to have lower average sleep efficiency scores than females (Leeder *et al.*, 2012). Male athletes also spent a significantly greater amount of time awake after sleep onset compared to females (Leeder *et al.*, 2012). The poorer sleep quality measured in the study corresponds with a single study's finding within the general public where females have been found to have better sleep quality than a comparable male group (Goel *et al.*, 2005). In contradiction to this finding, however, are several studies which have found that females have higher incidence rates of sleep disturbances than males (Groeger *et al.*, 2004; Tsai & Li, 2004; Landis & Lent, 2006; Sekine *et al.*, 2006; Zhang & Wing, 2006; Lund *et al.*, 2010; and Petrov *et al.*, 2014). Despite these noted sex differences, no difference in sleep duration between the sexes was found prior to athletic training (Leeder *et al.*, 2012).

2.5.2 Type of sport and sleep loss before training

There is evidence to suggest that the type of sport in which an athlete participates may also contribute to or be a factor in sleep loss and the intensity of the sleep loss prior to training. Individual sport athletes tend to obtain significantly less sleep than team sport athletes (6h30min vs 7h00min) and have poorer sleep efficiency (Lastella *et al.*, 2015). Sleep quality, however, has not been shown to differ with sport type (Lastella *et al.*, 2015). Breaking sporting codes down even further, cyclists reportedly slept, on average, for 6h42min; mountain bikers for 7h00min; race walkers for 7h06min; swimmers for 6h24min and triathletes slept on average 6h06min during a typical training phase (Lastella *et al.*, 2015).

When considering the team sport athletes, the following has been found: Australian Rules Football players sleep on average for 6h42min, basketball players for 7h30min, rugby union players for 6h54min and football players for 6h54min (Lastella *et al.*, 2015). This illustrates how different sports may place different demands on athletes and how some athletes in specific sporting codes may be more susceptible to sleep loss than others. This may also illuminate a possible link between training and sleep loss. Sports with high training demands such as cycling, swimming and triathlon often require athletes to train multiple times during the day which can often include morning sessions (Taylor, Rogers, & Driver, 1997).

Early morning training sessions seem to play a large role in sleep loss for athletes (Sargent *et al.*, 2014a; and Sargent *et al.*, 2014b). For example, swimmers have been shown to exhibit a systematic pattern in terms of the amount of sleep lost relative to the time they started training in the morning (Sargent *et al.*, 2014a). For every start time earlier than 8am in one hour increments towards 5am, there was an exponential relationship observed with respect to sleep loss (Sargent *et al.*, 2014a). On average, 6min of sleep was lost if the start time was at 7am, 48min was lost when training started at 6am and 102min was lost for a 5am training session (Sargent *et al.*, 2014a). Importantly, these results echo those from the working context. Results from studies within the work sectors of aviation and railway suggest that, on average, 30min of sleep tends to be lost for every hour that the start of work is earlier than 9am (Kecklund & Akerstedt, 1995; and Akerstedt *et al.*, 2008). It should also be noted that early morning training sessions may also be a tradition born from the need for non-professional athletes to train before work or school (Sargent *et al.*, 2014a). This may serve as evidence that training schedules and times are possibly the greatest cause of sleep loss for athletes during their training phases.

2.6 SLEEP LOSS PRIOR TO COMPETITION

The end goal for any athlete is achieving optimal performance and the notion that sleep loss prior to competition may, in some way, negatively affect performance has made the quantification of athlete sleep a priority. Sixty-eight percent of marathon runners surveyed on the morning of a race reported having slept worse than usual during the previous night (Lastella *et al.*, 2014). A similar trend was found where 65.8% of elite German athletes retrospectively reported having slept worse during the night(s) preceding competitions at least once in their careers, with 62.3% reporting the same within the previous 12 months (Erlacher *et al.*, 2011). In a comparable retrospective survey, 64% of elite Australian athletes indicated sleeping worse on at least one night preceding an important competition (Juliff *et al.*, 2015). These results are not isolated to survey studies.

Through the use of sleep diaries, marathon runners have been shown to sleep an average of 5h52min the night before a race (Lastella *et al.*, 2014). This value is much lower than even the lowest limit of the recommended range for healthy adults (Hirshkowitz *et al.*, 2015; and Watson *et al.*, 2015). Actigraphy data has also shown that cyclists get an average 6h48min sleep on the night prior to the start of an endurance race, nearly a whole hour less than that recorded on baseline nights (7h24min) (Lastella *et al.*, 2015b). Studies using more objective means of data collection (Lastella *et al.*, 2015b) have criticised the use of retrospective techniques such as surveys (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). That being said, the data obtained through these methods are consistent with the findings of the more objective methods used to monitor sleep (Lastella *et al.*, 2014; and Lastella *et al.*, 2015b).

2.6.1 Aetiology of pre-competitive sleep loss

Quantifying sleep before competitions has not been the sole objective of researchers in this area of inquiry. After establishing that athletes do suffer from sleep loss before competitions, the next step is finding the factors that may affect sleep prior to competition. Survey studies have all included items to identify the reasons for the accrued sleep loss experienced by athletes prior to competition (Erlacher *et al.*, 2011; Lastella *et al.*, 2014; and Juliff *et al.,* 2015). Trouble falling asleep has been noted as the most cited problem attributed to pre-competition sleep loss by athletes (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). German athletes report waking early in the morning to be the second biggest issue related to sleep loss while Australian athletes' second most common problem was waking up during the night (Juliff *et al.*, 2015). Anxiety was also a major contributor to the occurrence of these issues with sleep (Lastella *et al.*, 2014; Romyn *et al.*, 2016; and Ehrlenspiel *et al.*, 2017). Athletes who reported higher anxiety levels 4 days prior to competition were also found to be more likely to show pathological sleep/wake behaviours the night before competition (Ehrlenspiel *et al.*, 2017). This suggests that anxiety in general as well as anxiety directly preceding competition may influence pre-competitive sleep loss. The possible link between anxiety and stress and pre-competitive sleep loss seems plausible, considering that cognitive stress can be a major reason for altered sleep patterns (Reilly & Edwards, 2007).

Sleeping in foreign environments, trans-meridian travel, noise both inside and outside the room, familial issues, dreaming and need for the toilet have all been cited as additional reasons for why athletes lose sleep before competition (Erlacher *et al.*, 2011; Lastella *et al.*, 2014; and Juliff *et al.,* 2015). These are cited far less frequently, however, than pre-competitive anxiety (Erlacher *et al.*, 2011; Lastella *et al.*, 2014; and Juliff *et al.,* 2015).

2.6.2 Sex differences and sleep loss before competition

In terms of sex differences, only three of the eight studies that researched pre-competitive sleep/wake behaviour in Table 25 considered both male and female athletes. Only two of the three reported on sex differences (Erlacher *et al.*, 2011; and Juliff *et al.,* 2015). Both studies found no significant differences between males and females with regards to the incidence rate of poorer reported sleep prior to competition (Erlacher *et al.*, 2011; and Juliff *et al.,* 2015). That being said, females reported double the amount of unpleasant dreams and were found to be significantly more likely to report thoughts and nervousness about the competition in one of the studies (Erlacher *et al.*, 2011). While the one study did find that women were more likely to report unpleasant dreams, no difference in the frequency of reports of thoughts and nervousness about the competition between the sexes was found (Juliff *et al.,* 2015). A possible explanation for the dream findings may be that women have generally been found to have better dream recall than men (Schredl & Reinhard, 2008) as well as being more likely to report dreams that have negative connotations (Schredl, 2009). The evidence thus suggests that even though males and females seem to lose sleep ubiquitously before competition, the reasons for or aetiology of the sleep loss may be different (Erlacher *et al.*, 2011; and Juliff *et al.,* 2015).

2.6.3 Type of sport and sleep loss before competition

Individual sport athletes have been found to report a greater incidence of sleep loss compared to team sport athletes (Erlacher *et al.*, 2011). It is suggested that because team athletes share the burden of competition, there are lower reported anxiety levels among them when compared to individual athletes (Erlacher *et al.*, 2011). Another possible reason may be related to early morning start times for individual sport competitions. Individual sport athletes may experience higher instances of pre-competitive sleep loss if their start times are early in the morning as is the case with their training sessions (Sargent *et al.*, 2014a; and Sargent *et al.*, 2014b). The major cause of pre-competitive sleep loss in a cyclist population has been found to be the early morning start time of the race which lends support to this theory (Lastella *et al.*, 2015b). This may also be a possible explanation for why reduced pre-competition sleep was not found in a group of netball players whose competition start times were later than those of the cyclists (Romyn *et al.*, 2016). Indeed, the study linked later bed times and wake-up times found during competition phase to the tournament schedule (Romyn *et al.*, 2016). This trend has not been shown, however, by all sleep quantification studies (Juliff *et al.,* 2015). One of the studies found no significant differences regarding team and individual athletes with regards to total sleep duration or reportedly poorer sleep prior to competition (Juliff *et al.,* 2015). This contradictory finding could be explained by the differing samples of the various studies. The individual sport athlete sample was a third of the team sport sample (n=73 vs n=210) in the study that reported no differences (Juliff *et al.,* 2015). This may be a possible reason for why the finding of this study is inconsistent with Erlacher *et al.* (2011) and the theory that team sport athletes have fewer pre-competitive sleep disturbances than individual athletes (Juliff *et al.*, 2015). Perhaps the division of team sport and individual sport athletes is unhelpful in identifying at risk groups in terms of pre-competitive sleep loss. Dividing athletes into early morning competitors and late competitors may be more useful in identifying poor sleepers as the evidence suggests a link to match/competition scheduling rather than the sporting code (Erlacher *et al.*, 2011; Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; Juliff *et al.*, 2015; and Romyn *et al.*, 2016).

2.6.4 Pre-sleep behaviours prior to competition

Only two studies have investigated the pre-sleep practices of athletes on nights prior to competition (Erlacher *et al.*, 2011; and Juliff *et al.,* 2015). Athletes in both studies were asked to identify the strategies, if any, that they used in an effort to achieve restful sleep (Erlacher *et al.*, 2011; and Juliff *et al.,* 2015). Of the athletes who participated in the Erlacher *et al.* (2011) study, 34% claimed to watch television before bed to relax and 16.6% preferred to read. Only 9.2% indicated that they used some form of relaxation technique and 1.3% resorted to taking sleeping pills (Erlacher *et al.*, 2011). Over half the athletes in the study (56.6%) indicated using no special strategy (Erlacher *et al.*, 2011). The responses from the athletes in the Juliff *et al.* (2015) study do not reflect those of Erlacher *et al.* (2011). Only 19.3% of athletes indicated watching TV as a method to promote the onset of sleep before competition (Juliff *et al.*, 2015). Reading was reported as a pre-sleep strategy by 26.1%, while 21% engaged in relaxation techniques (Juliff *et al.*, 2015). Sleeping pills were reportedly used by 13.1% the night before competition to assist with sleep and the remaining 51.7% athletes indicated having no specific strategy that they used to try to and promote sleep (Juliff *et al.*, 2015). These findings show inconsistencies as well as a lack of knowledge of appropriate and healthy sleep-hygiene practices within athlete populations.

2.6.5 Athlete sleep improvement

There is recent evidence that would suggest that just because athletes are prone to sleeping poorly does not mean that their sleep cannot be improved (Tuomilehto *et al.*, 2017; and Van Ryswyk *et al.*, 2017). Sleep counselling and the detection of undiagnosed sleep disorders was found to improve 83% of elite ice hockey players' sleep 12 months after the intervention (Tuomilehto *et al.*, 2017). An intensive six-week intervention where daily sleep feedback was given in conjunction with a mid-intervention sleep education program was found to significantly improve multiple aspects of athlete sleep (Van Ryswyk *et al.*, 2017). Elite athlete sleep duration as well as sleep efficiency were improved significantly by the intervention (Van Ryswyk *et al.*, 2017). Furthermore, the intervention was also successful in increasing participants' levels of vigour while reducing fatigue scores (Van Ryswyk *et al.*, 2017).

From these studies it would seem that with the appropriate intervention athlete sleep can be improved.

2.7 THE SOUTH AFRICAN CYCLIST'S CONTEXT

No known large-scale sleep quantification study could be identified that focused on South African athletes. It may be worthwhile engaging with the South African context and identifying why it could be argued that results from other populations may differ to a South African sample. As this review has identified cyclists as a possible group at risk of experiencing sleep loss, this section explores the South African cyclist's context.

In 2013, the South African cycling community mourned as under-23 men's cross-country world champion, Burry Stander was killed while training (Koyana, 2015). The South African mountain biker was struck by a minibus taxi while cycling (Koyana, 2015). The high profile accident was a stark reminder of road traffic accidents that frequently take place on South African roads. Indeed, traffic related fatalities in South Africa have been recorded as twice the world's average (WHO, 2002) and have been shown to be increasing further still (Wright & Ribbens, 2016). Vulnerable commuters such as cyclists and pedestrians constitute a large percentage of these statistics, especially in low – middle income countries such as South Africa (Mabunda *et al.*, 2008).

Road safety in South Africa is compromised by several factors ranging from poor infrastructure to high crime rates (Wright & Ribbens, 2016). Some infrastructure issues which could impact cyclists in South Africa include: faulty or lack of street lighting; stolen or vandalised street signs; and livestock on, or next to, the road (Wright & Ribbens, 2016). Cases of robbery have been shown to increase in recent years with cyclists being identified as a population needing protection from cycle theft and muggings (Wright & Ribbens, 2016). With decreased reaction time (Bonnet & Arand, 1995; and Killgore, 2010), reduced executive attention (Durmer & Dinges, 2005 and Killgore, 2010), and vigilance (Bonnet & Arand, 1995; and Killgore, 2010) being shown to be consequences of sleep loss, these safety concerns make sleep loss in cyclists even more important to investigate.

With anxiety being mentioned as a major cause of sleep disturbances in athletes (Lastella *et al.*, 2014; Romyn *et al.*, 2016; and Ehrlenspiel *et al.*, 2017), it may be important to note general anxiety levels in South Africa. The South African Stress and Health study found that the most prominent mental disorder, over 12 month prevelance and life time prevelance, was anxiety specific (Stein *et al.,* 2008; and Herman *et al.*, 2009). Higher occurences of anxiety disorders were also associated with females more than males (Stein *et al.,* 2008). South Africa ranks within the top ten countries with high occurences of anxiety disorder out of all countries participating in the World Mental Health Survey Initiative (Herman *et al.*, 2009). Possible reasons for high anxiety in the country may have to do with high crime and civil unrest (Wright & Ribbens, 2016). For instance, the homicide rate in South Africa is five times more than the world average (WHO, 2002). In terms of civil unrest, there are an average of 25 civil protests a month, majority of which relate to service delivery, in South Africa (Wright & Ribbens, 2016). While definitive links between the social turbulence in the country and anxiety cannot be made, it is clear that the general population shows signs of heightened anxiety (Stein *et al.,* 2008; and Herman *et al.*, 2009). With anxiety being linked with athlete sleep loss, this further warrants investigation into the sleeping habits of South African specific populations.

2.8 MEASURING SLEEP IN ATHLETE POPULATIONS

2.8.1 Polysomnography

The “golden standard” for measuring and assessing sleep is polysomnography (Halson, 2014; and Tuomilehto *et al.*, 2017). Polysomnography encompasses the measurement of several bodily functions including brain activity, muscle activity, cardiac activity, and eye movements (Jacobs *et al.* 1988; Douglas *et al.* 1992; Reite *et al.* 1995; Ryan *et al.* 1995; Halson, 2014; and Tuomilehto *et al.*, 2017). Polysomnography offers information on, but is not limited to, a participant’s total time spent asleep, sleep latency, time spent in various sleep stages, number of awakenings and sleep efficiency (Halson, 2014; and Tuomilehto *et al.*, 2017). The downfall of polysomnography is that it is time consuming, labour intensive, very costly and can only really be applied in a laboratory setting (Halson, 2014). Participants also require significant habituation to the equipment and the laboratory settings where sleep would be required to take place (Halson, 2014). Additionally, the operation of polysomnography equipment and the subsequent data analysis requires significant expertise. For these reasons, this method is often reserved for assessing clinical disorders related to sleep (Halson, 2014). Only two studies could be found where polysomnography was used in athlete populations during quantification research (Sargent *et al.* 2013; and Tuomilehto *et al*. (2017).

2.8.2 Actigraphy

An alternative method for tracking sleep is the use of actigraphy (Sadeh & Acebo, 2002). This method records body movement continuously via an accelerometer (Ancoli-Israel *et al*., 2003; and Halson, 2014). Actigraphs can be worn comfortably on the wrist, ankle or the trunk making them non-invasive as well as allowing for full range of movement to be unobstructed 24hrs a day (Ancoli-Israel *et al*., 2003; and Halson, 2014).

Actigraphy has been compared to polysomnography in an attempt to validate it. With correlations of 0.97, actigraphy has been shown to correlate highly with polysomnography with respect to differentiating sleep from wakefulness (Blood *et al*., 1997; and Girardin *et al*., 1996). Slater *et al*. (2015), however, found that when compared to polysomnography, the sensitivity, specificity and accuracy of wrist actigraphy were 90%, 46% and 84%, respectively; and of hip actigraphy were 99%, 14% and 86%. It was also concluded that wrist worn actigraphy was a more valid sleep measure than hip worn actigraphy even though it has a limited ability to discern wakefulness during a given sleep period (Slater *et al*., 2015). It must be noted that this study was conducted using GTX3+ Actigraphs and whether these findings will prove indicative of all actigraphs is unknown.

While actigraphy is not as accurate as polysomnography, it still has some significant advantages. Actigraphs can record data continuously, for days or even weeks, which is an advantage over polysomnography as it can be used in field studies or to track a participant during her normal routines (Ancoli-Israel *et al*., 2003; and Halson, 2014). Actigraphy has been widely used in sleep quantification studies in athlete populations (Leeder *et al*., 2012; Sargent *et al*., 2014a; Sargent *et al*., 2014b; Lastella *et al*., 2015a; Romyn *et al*., 2016; and Staunton *et al*., 2017). Actigraphy does, however, have its limitations. In order to monitor multiple participants in a single night, multiple actigraphs are needed. The researcher also needs consistent contact with the participants to get the actigraph back for analysis. Mass sleep quantification is, therefore, impractical if trying to monitor large samples during a single night or participants not in the immediate vicinity.

2.8.3 Self-reported sleep tools

Subjective sleep assessment tools are regarded as being the cheapest and most practical way to collect sleep/wake information on large population samples (Carney *et al.,* 2012; and Girschik *et al.*, 2012). The golden standard of self-reported sleep measurement tools is sleep diaries (Bootzin & Nicassio 1978; Bootzin & Engle-Friedman, 1981; Buysse *et al.*, 2006; and Carney *et al.,* 2012). Sleep diaries can yield information regarding sleep onset, sleep onset latency, wakefulness after sleep onset, final awakening, total sleep duration as well as total time in bed (Carney *et al.,* 2012).

One issue that has made sleep diary research difficult to standardise is the fact that no set sleep diary is used by the majority of sleep researchers (Carney *et al.*, 2012). For example, in Carney *et al.* (2012), 16 unique sleep diaries, which varied in terminology and format, were identified as being used out of a group of 22 sleep experts. The same group of experts developed a standardised sleep diary, the Consensus Sleep Diary, which aimed to address this problem (Carney *et al.*, 2012). A core set of questions that were deemed the minimum required for a self-reported sleep diary were collated. Additions to these core items were made for specific sleep/wake concerns (Carney *et al.*, 2012). Sleep diaries have been used in previous athlete sleep quantification research (Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; Lastella *et al.*, 2014; and Lastella *et al.*, 2015a) and the Consensus Sleep Diary specifically has also been used (Knufinke *et al.*, 2017). Some of these studies, however, used sleep diaries only to inform actigraphy analysis (Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; and Lastella *et al.*, 2015a).

Another form of self-reported sleep assessment is that of retrospective questionnaires and surveys. The Competitive Sports and Sleep Questionnaire, for example, has been used in previous research to document very large samples of athlete sleep/wake behaviour (Erlacher *et al.*, 2011; and Juiliff *et al.*, 2015). This questionnaire in particular investigates pre-competitive sleep patterns over a 12-month retrospective period (Erlacher *et al.*, 2011). While the accuracy of such a tool is not equal to any tool mentioned thus far in this section (Lastella *et al.,* 2014; and Lastella *et al.,* 2015b), it does offer advantages that other sleep assessments do not. The retrospective nature of the Competitive Sports and Sleep Questionnaire allows for athletes to provide pre-competition data without necessarily needing to be in competition phase at the time of the study (Erlacher *et al.*, 2011). This allows for multiple sporting codes and athletes to be studied simultaneously regardless of whether the athletes are in-season, out of season or if they have a competition coming up soon.

To the knowledge of the author, only two other self-reported tools have been used to assess athlete sleep. The first is the survey used by Lastella *et al.* (2014) and the second is the Athlete Sleep Screening Questionnaire as developed by Samuels *et al.* (2015). Unfortunately, the author could not gain access to either of these tools to review them appropriately. The Athlete Sleep Screening Questionnaire seems to be primarily focused on identifying sleep disorders and assessing sleep rather than merely quantifying sleep (Samuels *et al.*, 2015).

2.9 SUMMARY AND RATIONALE

The current state of the literature indicates that sleep is important for a healthy lifestyle as well as for optimal athletic performance. For this reason, sleep quantification is important within athlete populations. Athlete sleep during both training and competition phases has been shown to fall below recommendations for health and functioning. As sleep is theorised to alter performance, sleep quantification prior to competition should be a priority as this could be a modifiable factor for performance. To date, only two large pre-competition sleep quantification studies have been conducted, neither of which has focused on a single sporting code and neither is applicable to a South African population. In terms of sporting codes, there is reason to believe that individual sport athletes are at the highest risk of experiencing pre-competitive sleep loss. While not the most accurate measuring tools, subject sleep surveys seem the most practical when collecting data on large athlete populations. With these factors in mind, the methodology in the subsequent chapter was designed.

CHAPTER III

3 METHODOLOGY

3.1 RESEARCH DESIGN

The study was designed as a retrospective, cross-sectional, survey-based investigation. Cyclists taking part in the 2015 Tsogo Sun Amashova or the 2016 Telkom 94.7 Cycle Challenge were recruited over the three-day registration period prior to each race. Pre-race sleeping patterns for the preceding 12 months were measured via questionnaire as was the sleep behaviour of the cyclists immediately prior to each races.

3.1.1 The races

Both races were chosen for the large and diverse sample they would attract. The Tsogo Sun Amashova is the oldest classic cycle race in South Africa and draws over 10 000 cyclists to enter each year (http://www.shova.co.za/history/). One of the reasons the Tsogo Sun Amashova boasts such large involvement is because it offers three different distances; a fun ride of 35km, a 65km half challenge and a 106km Classic (http://www.shova.co.za/history/). In addition, the year that data collection took place, 2015, the Amashova's full distance was the sole African qualifying race for the World Championships in Perth 2016 (http://www.sport.be/uciworldcyclingtour/2015/eng/news/article.html?Article_ID=744398). The Amashova typically starts at 06h45 in the morning with batch gaps of between three and five minutes (http://www.shova.co.za/approach-to-106km-start/).

The Telkom 94.7 Cycle Challenge had similar desirable attributes that made it ideal for the current study. The Telkom 94.7 Cycle Challenge is also an old race with a 20-year history (http://www.cyclechallenge.co.za/). In addition, it is the largest race in Johannesburg, welcoming an annual field of over 30 000 cyclists to compete (http://www.cyclechallenge.co.za/). The size of the field also makes it the second largest cycling event in the world in terms of participation (http://www.bicycling.co.za/race-news/947-cycle-challenge/history-947-cycle-challenge/). The Telkom 94.7 Cycle Challenge, like the Amashova, has an early morning start time as well. The first batch of riders start at 05h30 with batch gaps of between two and seven minutes (Gouws, 2016). The final start time can be as late as

09h56 if a rider is in the final batch to be released (Gouws, 2016). The above characteristics of both races allowed for a broad spectrum of athletes at various levels of competition to be included in the study.

The Registration Expo of the Tsogo Sun Amashova cycling race took place on Thursday the 15th, Friday the 16th and Saturday the 17th of October 2015 at Sun Coast Casino in Durban, South Africa. The Telkom 94.7 Cycle Challenge Registration Expo on the other hand, took place on Thursday the 17th, Friday the 18th and Saturday the 19th of November 2016 at the Ticketpro Dome, Johannesburg South Africa. These were the venues at which potential participants were recruited for the study.

3.1.2 Questionnaires

3.1.2.1 The Competitive Sports and Sleep Questionnaire

The Competitive Sports and Sleep Questionnaire (Erlacher *et al.*, 2011), was selected as it contained several items that were relevant to the study (Appendix B). That being said, there were also several items, particularly those related to assessing dream patterns, which were not important for the study. For this reason, The Competitive Sports and Sleep Questionnaire was shortened in order to make it as concise and relevant to the research objectives of the current study as possible. The adaptations that were made are as follows:

The original questionnaire as created by Erlacher *et al.* (2011) is comprised of five sections:

1. Demographic data
2. Questions about your sport
3. Questions about sleep habits prior to important competitions or games
4. Questions about dreaming and sport
5. Questions about lucid dreaming

For the purpose of the current study only sections 1-3 were used (Appendix B). The sections devoted to dream information were beyond the scope of the current study. Sections 1 and 2 were essential in profiling the population of participants who were recruited (Appendix B). Age, sex, experience level and competition-level of the cyclists were determined in these sections (Appendix B). Section 3 was devoted to sleep and sleep loss experience. The first three questions identified average sleep length and sleep quality while out of competition phase (Appendix B). The fourth question was a comparison of general sleep quality and pre-competition sleep quality (Appendix B). Question five asked whether or not they had experienced sleep loss prior to a race within the past year (Appendix B). If the cyclists answered yes, they had a further four questions to answer:

- "What kind of problems did you experience with your sleep prior to an important competition or game?"
- "What reasons were responsible for your sleeping problems prior to an important competition or game?"
- "In what manner did the sleeping problems influence your performance during the competition or game?"
- "Which strategies do you use to sleep well in the night(s) prior to an important competition or game?"

Each of these questions had a selection of phrases that could be used to answer. If none of the phrases applied to them, there was an option to input their own answer (Appendix B).

If they answered no to question five, they skipped straight to the question "Which strategies do you use to sleep well in the night(s) prior to an important competition or game?". Irrespective of whether they experienced sleep loss or not, they were asked this question. This was in an effort to identify whether athletes who did not experience pre-competition sleep loss were doing something different that may explain their avoidance of sleep loss.

While this questionnaire has not yet been validated, it has been used in published studies investigating the sleep patterns of athletes including cyclists (Erlacher *et al.,* 2011; and Juliff *et al.*, 2015) and was deemed to be the best available survey for the current research at the time of its conception (Appendix B).

3.1.2.2 The Consensus Sleep Diary

An unaltered version of the Core Consensus Sleep Diary including instructions, as described by Carney *et al.* (2012), was chosen as the items on the questionnaire were appropriate and sufficient to answer the primary research question (Appendix C). The

Core Consensus Sleep Diary included a set of nine items considered to be minimally necessary for sleep-diary based research (Carney *et al.*, 2012). These questions were:

1. “What time did you get into bed?”
2. “What time did you try go to sleep?”
3. “How long did it take you to fall asleep?”
4. “How many times did you wake-up, not counting your final awakening?”
5. “In total, how long did these awakenings last?”
6. “What time was your final awakening?”
7. “What time did you get out of bed for the day?”
8. “How would you rate the quality of your sleep?”
9. “Comments (if applicable)”

Each question had a written description explaining the question (Appendix C). The Core Consensus Sleep Diary has been validated in terms of construct validity (Carney *et al.*, 2012).

Owing to the fact that cyclists attended the Registration Expos over three separate days, not all participants were recruited with three nights left before race day. Table 1 indicates for how many nights cyclists would have recorded sleep diaries according to when they were recruited for the study.

Table 1. Number of sleep diary entries required by participants who were recruited for the study on various days of the Registration Expos.

	Number of nights a sleep diary was recorded
Recruited Thursday	3
Recruited Friday	2
Recruited Saturday	1

3.1.3 Participants

A total of 336 cyclists completed the Competitive Sports and Sleep Questionnaire. Of the cyclists who completed the questionnaire, 92 also recorded Core Consensus Sleep Diaries. Cyclists under the age of 18 years and cyclists who had diagnosed sleeping disorders were excluded from the study. Cyclists were asked to confirm the above to the researcher verbally before being allowed to participate in the study. Apart from these parameters, all other cyclists taking part in either race of any distance were deemed eligible to participate in the current study. Cyclists who took part in both races were only allowed to participate once in the study.

3.2 PRE-EXPERIMENTAL PROCEDURES

3.2.1 Ethical considerations

A formal ethical application was completed in compliance with the requirements of the Rhodes University Ethics Committee and the Department of Human Kinetics and Ergonomics Ethics Committee (application number RU-HSD-15-08-0005). Clearance was received prior to any participant recruitment.

3.2.2 Recruitment

To recruit participants, leaflets advertising the study were distributed at the Registration Expos (Appendix D). A stall was set up where testing could take place and the study could be advertised. In addition, cyclists were approached and asked to consider participating. If interested, the risks and benefits of participation were fully explained verbally. Volunteers, who confirmed verbally that they were above the age of 18 years and had no diagnosed sleep pathology, were then given an information letter and consent form to sign (Appendix E and F). The letter reiterated what had been verbally explained and could be taken home by volunteers. During the informed consent process, it was also made clear that any and all data collected for research purposes would be kept strictly confidential with anonymity being ensured at all times. Participants were also made aware and reminded of the fact that they could withdraw from the study at any time without prejudice.

3.3 EXPERIMENTAL PROCEDURE

3.3.1 Data collection

Athletes who were willing to participate in the study were requested to complete the Competitive Sports and Sleep Questionnaire and a three-day Core Consensus Sleep Diary. Both documents were offered to all participants in electronic and hardcopy formats.

The athletes were encouraged to complete the questionnaire at the Expos. The questionnaire could be completed on laptops set up at the researcher's stall or on hardcopies if participants preferred not to use a computer. The addition of the online option, which was in the form of a Google Form, was included to allow for athletes who had extraneous time constraints to still be afforded the opportunity to participate in the study. That being said, none of the participants chose to complete the questionnaire at a later date online and all completed it at the Expos.

It was explained to the athletes that they were under no obligation to fill in a sleep diary even if they had filled in the questionnaire. The diary was explained in detail to all athletes and those interested were given further instruction on how to complete it. Each participant was given a hardcopy of the sleep diary. Athletes were asked to record all the necessary information on this hardcopy. The participants were then asked to transfer the data from their hardcopy into an online version of the diary (also a Google form), which would then be automatically sent to the author without any added administrative duties on the part of the participants. The hardcopy allowed for participants to make daily recordings without having to do multiple online submissions. This was done to try and streamline the data capturing process for both the participants as well and the primary researcher.

3.4 POST-EXPERIMENTAL PROCEDURES

3.4.1 Feedback

Participants could offer personal email addresses if they indicated that they would like feedback from the study. The email addresses were only used for these purposes and for no further correspondence after the completion of the study. Feedback from the study included sleep-hygiene infographics (Appendix G) directly after the races as well as a copy of the results once shortened into journal format. The feedback was disseminated to interested participants as a thank you for participating in the study with the hope that it would aid participants' future sleep patterns.

3.4.2 Statistical analyses

All data were transcribed in to Microsoft Excel spreadsheets where measures of central tendency were determined. All statistical analyses were performed on

Statistica software package, version 12 (Statistica, Statsoft, Inc.; Tulsa, Oklahoma, USA). Normality was assessed using a Shapiro-Wilk W test. Statistical significance for all the tests to follow was set at $p \leq 0.05$.

Questionnaire response differences were calculated by running Mann-Whitney tests. These comparisons were made to identify differences in the pre-competition sleep behaviour between sub groups of cyclists. Male/female differences and competition-level differences were calculated. All questionnaire statistical files are presented in Appendix H.

The statistical analyses for the sleep diary data comprised of three factorial analysis of variance (ANOVA) to compare the data of male and females as well as competition-level groups for the three nights leading up to the race. The p-value, degrees of freedom, the F statistic and observed power were calculated by the ANOVAs. Tuckey Post Hoc tests were run to identify specific between and within effects where general and interaction effects were found from the three-way ANOVAs. All sleep diary statistical files are presented in Appendix I. Cohen's d effect sizes were calculated manually for all sleep diary variables over all nights with regards to total participant responses. Effect sizes for sex and competition-level comparison were only calculated for the night before the race. The strength of effect sizes was determined as in Cumming, 2014: d: 0.2–0.49, small effect; 0.5–0.79, moderate effect; ≥0.8, large effect. Effect sizes were considered for reporting in the results if statistical significance was found between variables. Effect sizes of non-significant results were only considered if moderate, or above, in magnitude. Cohen's U_3 and the probability of superiority were also calculated where effect sizes were calculated. Cohen's U_3 was calculated to derive the percentage of cyclists who fell above or below the mean of baseline sleep variables the night before the races. The probability of superiority was calculated to find the chance, given as a percentage, that a cyclist picked at random would exhibit a value on the night before the races falling above or below the mean derived from two and three nights before the races.

Equations used for Cohen's d; Cohen's U_3; and probability of superiority:

$$Cohen's\ d = \frac{\mu_2 - \mu_1}{SD_2 - SD_1}$$

Where μ_n is the mean of the respective population and SD_n is the standard deviation of the respective population.

$$U_3 = \Phi\,(\mathrm{d})$$

Where Φ is the cumulative distribution function of the standard normal distribution.

$$Probability\ of\ superiority = \Phi(\frac{d}{\sqrt{2}})$$

Finally, Spearman Rank R correlations were applied to identify items on both the sleep diary and questionnaire that correlated significantly with sleep length and sleep quality the night before the races. This was in an effort to find predictive questions that may be used to identify sleep loss in athlete populations where the use of sleep diaries may not be appropriate. Statistical files for the correlation data can be seen in Appendix K.

It should be noted that owing to sample size, competition level comparisons were different with regards to the questionnaire and sleep diary data. For the questionnaire data, competition levels were divided into three groups; international/national, provincial and recreational. Sleep diary data comparison, however, was split into two groups; competitive (international, national and provincial) and recreational. This was done in an effort to allow for the statistical tests that were run to have stronger power based solely on the lack of sample numbers in the competitive athlete groups.

CHAPTER IV

4 RESULTS

4.1 RESPONSE RESULTS

A total of 336 cyclists completed the Competitive Sports and Sleep Questionnaire. The breakdown of the participants' age, years of cycling experience, sex and competition-level can be found in Table 2 below.

Table 2. Demographics of participants who filled out the questionnaire as well as participant age and years of experience. Values given are averages with brackets indicating standard deviation.

Participants	No. of responses for questionnaire	Age (years)	Years of experience (Years)
Male	230	36.5 (11.6)	8.8 (8.6)
Female	106	33.2 (9.9)	6.2 (6.2)
International athletes	7	25.7 (7.1)	9.3 (5.9)
National athletes	27	35 (10.7)	10.4 (8.1)
Provincial athletes	26	33.7 (9.5)	12.1 (11.2)
Recreational athletes	276	35.9 (11.3)	7.3 (7.6)
All participants	336	35.5 (11.2)	7.9 (8)

Only 27% of participants completed both the Competitive Sports and Sleep Questionnaire and the Core Consensus Sleep Diary. A total of 92 cyclists recorded a sleep diary for the night before the races. Table 3 shows the breakdown of the number of sleep diary responses for the different nights by males and females as well as cyclists of different competition levels.

Of the participants who filled in the questionnaire, 96% were South African nationals. Similarly, 93% of the cyclists who completed the sleep diary were South Africans.

Table 3. Demographics of participants that completed the sleep diary as well as participant age and years of experience. Values given are averages with brackets indicating standard deviation.

Participants	No. of responses for sleep diary			Age (Years)	Years of experience (Years)
	3 nights before the race	2 nights before the race	Night before the race	(Night before the race)	
Male	52	61	66	36 (11.6)	9 (8.9)
Female	22	24	26	29.5 (7.4)	2.2 (2.9)
International athletes	1	1	1	28	20
National athletes	8	7	8	36.1 (12.8)	10.3 (6.9)
Provincial athletes	5	6	6	32.3 (11.1)	16.6 (10.7)
Recreational athletes	60	71	77	34 (11)	6.4 (7.6)
All participants	74	85	92	34 (11)	7.5 (8.1)

4.2 QUESTIONNAIRE

4.2.1 All participant responses

4.2.1.1 Sleep loss in the past 12 months

As can be seen in Table 4, the questionnaire revealed that 67% of cyclists in the current study felt that they had experienced worsened sleep prior to competition within the past year.

Table 4. Number of cyclists indicating whether or not they have experienced worse than normal sleep the night before competition within the past year.

	All participants	
	Absolute	**Frequency %**
Overall	**n=336**	**100%**
Cyclists reporting worse sleep	n=188	67%
Cyclists not reporting worse sleep	n=148	33%

4.2.1.2 Perceived problem areas of sleep

Reasons for sleep loss included problems with falling asleep (71%), waking up during the night (35%) and waking up earlier than usual in the morning (34%) (Table 5). Unpleasant dreams were reported by 9% of participants followed by 'other' responses of "irritability" and "restless sleep – not deep sleep" (Table 5).

Table 5. Problems encountered by those participants in Table 4 who experienced worsened sleep.

What kind of problems did you experience with your sleep prior to an important competition or game?		
Overall	**188**	**100%**
Problems falling asleep	134	71%
Waking up at night	66	35%
Waking up early in the morning	64	34%
Not feeling refreshed in the morning	52	28%
Unpleasant dreams	17	9%
Other	2	1%

4.2.1.3 Reasons for sleep disruptions

The most common reasons for sleep disruptions included thoughts (71%) and nervousness (70%) about the upcoming race (Table 6). Foreign environments (15%) and noise (11%) were cited less frequently (Table 6). The list of 'other' responses was as follows: "light", "fear of being late", "anxiety that I'll miss the start", "general restlessness" (reported by two participants), "not sure", "afraid of oversleeping", "excitement", "final race preparation", and "fear of having an accident on my bike".

Table 6. Reasons provided as the cause of sleep loss by those cyclists in Table 4 who reported worsened sleep.

What reasons were responsible for your sleeping problems prior to an important competition or game?		
Overall	**188**	**100%**
Thoughts about the competition	105	71%
Nervousness about the competition	131	70%
Not used to surroundings	28	15%
Noises in the room or from outside	17	11%
Other	11	6%

4.2.1.4 Impact of sleep loss on performance

More than half (55%) of those reporting worsened sleep felt that it had no influence on their athletic performances (Table 7). The remaining participants reported that sleep loss increased daytime sleepiness (24%) and worsened their mood the next day (17%). Only 16% felt that it had a direct negative influence on their performance (Table 7). The ‘other’ responses that were not left blank and were applicable to the question included “poor concentration”, “no reference to a race following good sleep” (suggesting that the participant has never slept well before competition) and “I don’t know”.

Table 7: The perceived effects of sleep loss on race performance as reported by the cyclists.

In what manner did the sleeping problems influence your performance during the competition?		
Overall	**188**	**100%**
No influence	104	55%
Increased daytime sleepiness	45	24%
Bad mood the following day	32	17%
Worse performance in competition	23	16%
Other	8	4%

4.2.1.5 Methods used to promote sleep before competition

Over half (52%) of the cyclists reported not using any specific strategy to promote sleep (Table 8). Watching TV before going to bed was reported by 18% while 15% reported using specific relaxation methods (Table 8). A further 15% reported the use of reading as a sleep promoting aid and 10% admitted resorting to sleeping pills to try improve pre-competitive sleep (Table 8). The ‘other’ reports from the cyclists were: “muscle relaxers” (reported by two participants), “go to sleep early” (also reported by two cyclists with one of them adding “usually never works”), “try to get a good night’s rest two nights before the race”, “drink milk”, “alcohol”, “breathing exercises”, “coffee”, “stick to my routine”, and “listen to beta wave piece”. One other response, “natural sleeping pills” was included in the sleeping pills category and the last response was applicable to the question that was asked.

Table 8. Methods used by cyclists, from Table 4 who reported worsened sleep, to try to promote sleep the night before competitions.

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists reporting worse sleep)		
Overall	**188**	**100%**
No special strategy	97	52%
Watching TV/ using media devices	33	18%
Methods to relax	29	15%
Reading	28	15%
Sleeping pills	18	10%
Other	12	6%

Of the athletes who did not report experiencing worsened sleep prior to competitions (Table 4), 72% said that no special method was used to promote sleep (Table 9). The next highest cited method was watching television or using media devices (13%) followed by reading (7%), relaxation techniques (6%) and sleeping pills (5%) (Table 9). “Alcohol”, “green tea”, “drink lots of water” and “slow mag” (magnesium tablets) were the ‘other’ responses.

Table 9. Strategies used to promote sleep the night before competitions by the cyclists from Table 4 who did not report worsened sleep.

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists not reporting worse sleep)		
Overall	**148**	**100%**
No special strategy	107	72%
Watching TV/ using media devices	19	13%
Reading	11	7%
Methods to relax	9	6%
Sleeping pills	8	5%
Other	4	2%

4.2.1.6 Comparison of strategies used to promote sleep by cyclists reporting sleep loss and cyclists not reporting sleep loss

A significantly larger ($p<0.01$) proportion of cyclists who did not report worsened sleep also used no special strategy to try to fall asleep as compared to cyclists who did report sleep loss (Table 10). Those cyclists who did not report experiencing sleep loss also reported significantly fewer accounts of using relaxation methods ($p=0.01$) and reading to fall asleep ($p=0.03$) compared to cyclists who did report sleep loss (Table 10).

Statistically, there was no significant difference in the frequency of watching television/using media devices and the use of sleeping tablets between those reporting and not reporting sleep loss (Table 10). There was also no statistically significant difference between cyclists reporting and not reporting sleep loss with regards to the citation of ‘other’ responses (Table 10).

Table 10. Statistical comparison of sleep promoting strategies used by cyclists reporting sleep loss and those not reporting sleep loss. Red values denote p values meeting the set alpha of 0.05.

	All cyclists		Cyclists				
	Absolute	Frequency %	Sleep loss		No sleep loss		
Which strategies do you use to sleep well in the night(s) prior to an important competition?							
Overall	**336**	**100%**	**188**	**100%**	**148**	**100%**	**p value**
No special strategy	204	61%	97	52%	107	72%	<0.01
Methods to relax	38	11%	29	15%	9	6%	0.01
Reading	39	12%	28	15%	11	7%	0.03
Watching TV/ using media devices	52	15%	33	18%	19	13%	0.24
Sleeping pills	26	8%	18	10%	8	5%	0.16
Other	15	4%	12	6%	3	2%	0.06

4.2.2 Male – female questionnaire response comparison

4.2.2.1 Sleep loss in the past 12 months

A significantly higher (p=0.04) percentage of females (as compared to males) experienced worsened sleep before competition at least once within the past 12 months (Table 11).

Table 11. Comparison of the number of male and female cyclists indicating whether they have experienced worse than normal sleep the night before competition within the past year. Red values denote p values meeting the set alpha of 0.05.

	Gender				p value
	Male		Female		
Overall	**n=230**	**100%**	**n=106**	**100%**	
Cyclists reporting sleep loss	n=120	52%	n=68	64%	0.04
Cyclists not reporting sleep loss	n=110	48%	n=38	36%	

4.2.2.2 Perceived problem areas of sleep

Pre-competitive sleep loss in both men and women was attributed to problems with falling asleep (Table 12). The second highest reason reported by men was the issue of waking up early in the morning whereas the second most reported problem by women was waking up during the night (Table 12). Females were, in fact, significantly more likely than males to report accounts of waking up during the night (p=0.01) and having unpleasant dreams (p=0.04) (Table 12).

Table 12. Problems causing sleep loss cited by male and female cyclists who reported having experienced pre-competitive sleep loss in Table 11. Red values denote p values meeting the set alpha of 0.05.

What kind of problems did you experience with your sleep prior to an important competition or game?					
	Gender				
	Male		Female		
Overall	**120**	**100%**	**68**	**100%**	**p value**
Problems falling asleep	85	70%	49	72%	0.86
Waking up at night	34	28%	32	47%	0.01
Unpleasant dreams	7	6%	10	15%	0.04
Waking up early in the morning	44	37%	20	29%	0.32
Not feeling refreshed in the morning	32	27%	20	29%	0.69
Other	2	2%	0	0%	0.29

4.2.2.3 Reasons for sleep disruptions

Both males and females attributed any sleep disruptions to thoughts and nervousness related to the upcoming race (Table 13). Females were, however, significantly ($p<0.01$) more likely than males to link sleep disruptions to nervousness about the race (Table 13).

Table 13. A comparison of reasons reported by male and female cyclists as the cause of their sleep loss. Red values denote p values meeting the set alpha of 0.05.

What reasons were responsible for your sleeping problems prior to an important competition or game?					
	Gender				
	Male		**Female**		
Overall	**120**	**100%**	**68**	**100%**	**p value**
Not used to surroundings	18	15%	10	15%	0.96
Noises in the room or from outside	8	7%	9	13%	0.13
Nervousness about the competition	72	60%	59	87%	<0.01
Thoughts about the competition	73	61%	32	47%	0.07
Other	10	8%	1	1%	0.06

4.2.2.4 Impact of sleep loss on performance

Over half the male (53%) and female (60%) cyclists felt that sleep disruptions had no impact on subsequent cycling performances (Table 14). The only difference between the sexes was that males were significantly ($p=0.03$) more likely than females to report the influence of sleep disruption on performance as 'other'.

Table 14. The relationship between sleep loss and cycling performance during a race as identified by both the male and female cyclists. Red values denote p values meeting the set alpha of 0.05.

In what manner did the sleeping problems influence your performance during the competition?					
	Gender				
	Male		**Female**		
Overall	**120**	**100%**	**68**	**100%**	**p value**
No influence	63	53%	41	60%	0.30
Worse performance in competition	17	14%	6	9%	0.29
Bad mood the following day	20	17%	12	18%	0.87
Increased daytime sleepiness	29	24%	16	24%	0.92
Other	8	7%	0	0%	0.03

4.2.2.5 Methods used to promote sleep before competition

With regards to methods used to try to promote sleep the night before competitions (Table 15), there were no significant differences between the males and females who reported sleep loss (Table 11).

Table 15. A comparison of the strategies used by the male and female cyclists who reported sleep loss in Table 11 to try to promote sleep the night before competitions.

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists reporting sleep loss)					
	Gender				
	Male		**Female**		
Overall	**120**	**100%**	**68**	**100%**	**p value**
No special strategy	62	52%	35	50%	0.98
Methods to relax	14	12%	15	31%	0.06
Reading	14	12%	14	25%	0.10
Watching TV/ using media devices	25	21%	8	6%	0.12
Sleeping pills	12	10%	6	6%	0.79
Other	8	7%	4	9%	0.84

Amongst those cyclists who reported no sleep loss, however, females reported a significantly higher use of sleeping pills (p=0.01) before competition than males (Table 16).

Table 16. A comparison of the methods employed by the male and female cyclists who did not report sleep loss in Table 11 in an effort to promote sleep the night before competitions. Red values denote p values meeting the set alpha of 0.05.

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists not reporting sleep loss)					
	Gender				
	Male		**Female**		
Overall	**120**	**100%**	**68**	**100%**	**p value**
No special strategy	83	75%	24	63%	0.15
Methods to relax	7	6%	2	5%	0.81
Reading	7	6%	4	11%	0.40
Watching TV/ using media devices	15	14%	4	11%	0.63
Sleeping pills	3	3%	5	13%	0.01
Other	1	1%	2	5%	0.10

4.2.3 Competition-level questionnaire response comparison

Owing to the low sample numbers in the elite athlete groups (see Table 2), the competition-level categories were divided into three groups as follows: international/national, provincial and recreational.

4.2.3.1 Sleep loss in the past 12 months

While the percentage of cyclists who indicated experiencing pre-competitive sleep loss within the last year varied between different competition levels, no statistical difference ($p>0.05$) was found between the groups (Table 17).

Table 17. Number of cyclists from different competition levels indicating whether they have experienced worse than normal sleep the night before competition within the past year

	Competition level of athletes					
	Internation/national		**Provincial**		**Recreational**	
Overall	**n=34**	**100%**	**n=26**	**100%**	**n=276**	**100%**
Cyclists reporting sleep loss	n=21	62%	n=10	38%	n=157	57%
Cyclists not reporting sleep loss	n=13	38%	n=16	62%	n=119	43%

4.2.3.2 Perceived problem areas of sleep

Provincial level athletes were significantly ($p<0.05$) more likely to report not feeling refreshed in the morning than recreational athletes (Table 18). Elite cyclists (international/national) reported a higher percentage ($p<0.05$) of ‘other’ reasons (as opposed to the options given on the questionnaire) than recreational cyclists (Table 18).

Table 18. Problems cited by cyclists of different competition levels who reported experiencing pre-competitive sleep loss in Table 17. Red asterisks denote p values meeting the set alpha of 0.05.

What kind of problems did you experience with your sleep prior to an important competition or game?						
	Competition level of athletes					
	Internation/national		**Provincial**		**Recreational**	
Overall	**21**	**100%**	**10**	**100%**	**157**	**100%**
Problems falling asleep	13	62%	7	70%	114	73%
Waking up at night	5	24%	6	60%	55	35%
Unpleasant dreams	7	33%	4	40%	53	34%
Waking up early in the morning	6	29%	3	30%	43	27%
Not feeling refreshed in the morning	2	10%	3*	30%	12*	8%
Other	1*	5%	0	0%	1*	1%

4.2.3.3 Reasons for sleep disruptions

Recreational cyclists attributed sleep disruptions to being in a foreign environment more so ($p<0.05$) than elite cyclists (Table 19). In addition, provincial cyclists reported a higher percentage ($p<0.05$) of 'other' reasons than recreational cyclists (Table 19).

Table 19. A comparison of the reasons cited by cyclists of different competition levels as the cause of their sleep loss. Red asterisks denote p values meeting the set alpha of 0.05.

What reasons were responsible for your sleeping problems prior to an important competition or game?						
	Competition level of athletes					
	Internation/national		Provincial		Recreational	
Overall	21	100%	10	100%	157	100%
Not used to surroundings	6*	29%	1	10%	20*	13%
Noises in the room or from outside	3	14%	0	0%	14	9%
Nervousness about the competition	15	71%	6	60%	110	70%
Thoughts about the competition	10	48%	5	50%	90	57%
Other	1	5%	3*	30%	10*	6%

4.2.3.4 Impact of sleep loss on performance

The different competition groups responded similarly ($p>0.05$) with the majority reporting no influence of sleep loss on performance (Table 20). The only significant ($p<0.05$) difference in these responses was found between the elite cyclists and the provincial cyclists (Table 20). Namely, a higher percentage of provincial cyclists reported increased daytime sleepiness the day after compared to the elite cyclists (Table 20).

Table 20. Reports from different competition groups with regards to how pre-competitive sleep loss impacts subsequent cycling performances. Red asterisks denote p values meeting the set alpha of 0.05.

In what manner did the sleeping problems influence your performance during the competition?						
	Competition level of athletes					
	Internation/national		Provincial		Recreational	
Overall	21	100%	10	100%	157	100%
No influence	13	62%	6	60%	85	54%
Worse performance in competition	3	14%	0	0%	20	13%
Bad mood the following day	4	19%	0	0%	28	18%
Increased daytime sleepiness	2*	10%	4*	40%	39	25%
Other	2	10%	1	10%	6	4%

4.2.3.5 Methods used to promote sleep before competition

For those cyclists from Table 17 who reported sleep loss, no statistical differences were found between competition-level groups with regards to the methods employed to try to promote sleep the night before competitions (Table 21).

Table 21. Strategies used to promote sleep the night before competitions by the different competition-level cyclists who reported sleep loss in Table 17.

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists reporting sleep loss)						
	Competition level of athletes					
	Internation/national		**Provincial**		**Recreational**	
Overall	**21**	**100%**	**10**	**100%**	**157**	**100%**
No special strategy	11	52%	4	40%	82	52%
Methods to relax	2	10%	3	30%	24	15%
Reading	2	10%	2	20%	24	15%
Watching TV/ using media devices	4	19%	2	20%	27	17%
Sleeping pills	2	10%	2	20%	14	9%
Other	1	5%	0	0%	11	7%

Of the cyclists who did not report sleep loss (Table 17), elite cyclists reported a significantly higher ($p<0.05$) use of relaxation methods when compared to recreational cyclists (Table 22)

Table 22. A comparison of methods used in an effort to promote sleep the night before competitions by cyclists of different competition levels who did not report sleep loss in Table 17. Red asterisks denote p values meeting the set alpha of 0.05.

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists not reporting sleep loss)						
	Competition level of athletes					
	Internation/national		**Provincial**		**Recreational**	
Overall	**13**	**100%**	**16**	**100%**	**119**	**100%**
No special strategy	9	69%	12	75%	86	72%
Methods to relax	3*	23%	1	6%	5*	4%
Reading	0	0%	0	0%	11	9%
Watching TV/ using media devices	2	15%	4	25%	13	11%
Sleeping pills	1	8%	0	0%	7	6%
Other	0	0%	0	0%	3	3%

4.3 SLEEP DIARY

4.3.1 Total sleep length - All participants

Overall, there was a significant ($p<0.01$; df=68; F=6.92; OP=0.92) reduction in total sleep length over the three nights prior to the races. Post hoc tests revealed that the shortest sleep periods occurred the night before the race. There were significantly reduced sleep durations the night prior to the race compared to two nights ($p<0.01$; d=0.62; U_3=0.73; PoS=0.66) and three nights ($p<0.01$; d=0.7; U_3=0.76; PoS=0.69) before the race (Figure 3). It should also be noted that two nights before the race there was a much larger variation in the data compared to the previous nights (Figure 3).

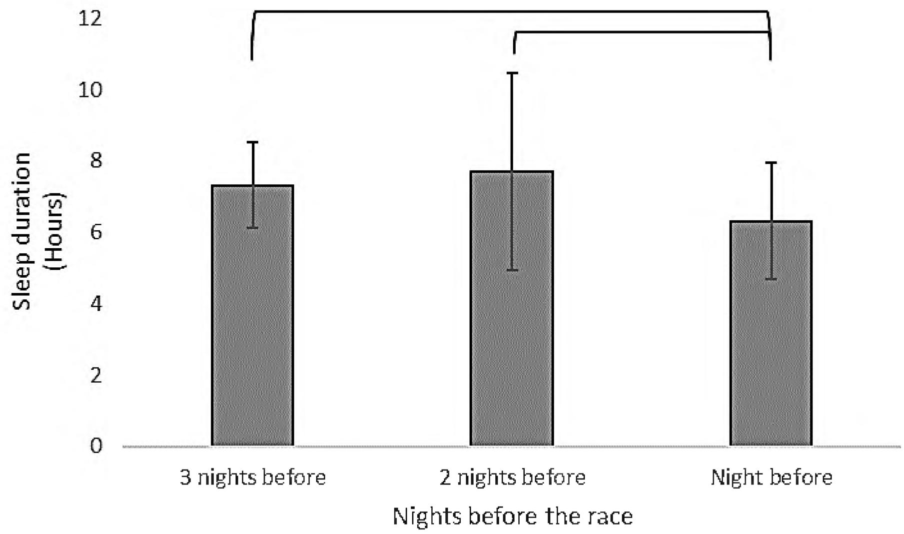

Figure 3. Total sleep duration for the three nights prior to the races. Error bars denote standard deviation. Brackets indicate statistical differences meeting the alpha level of 0.05.

4.3.2 Total sleep length - Male Female comparison

No significant effect ($p=0.29$; 68; F=1.15; OP=0.18) of sex was found for total sleep duration. Furthermore, no interaction effect ($p=0.70$; df=68; F=0.36; OP=0.11) between sex and nights was found for sleep duration either.

4.3.3 Total sleep length - Competition-level comparison

Owing to the low sample size for some of the competition levels (Table 3), it was decided that international, national and provincial athletes would be grouped into one category for the analysis of the sleep diary data.

No significant effect of competition-level (p=0.84; df=68; F=0.04; OP=0.05) was found for sleep duration. In addition, no interaction effect of competition-level and nights was found for sleep duration over the three nights (p=0.78; df=68; F=0.25; OP=0.08).

4.3.4 Sleep quality - All participants

Sleep quality significantly (p=0.02; df=70; F=4.23; OP=0.73) decreased over the three nights prior to the races (Figure 4). Post hoc tests showed significantly worse sleep quality the night prior to the race as compared to both two (p=0.04; d=0.33; U_3=0.63; PoS=0.58) and three (p=0.02, d=0.41; U_3=0.66; PoS=0.61) nights before the race (Figure 4).

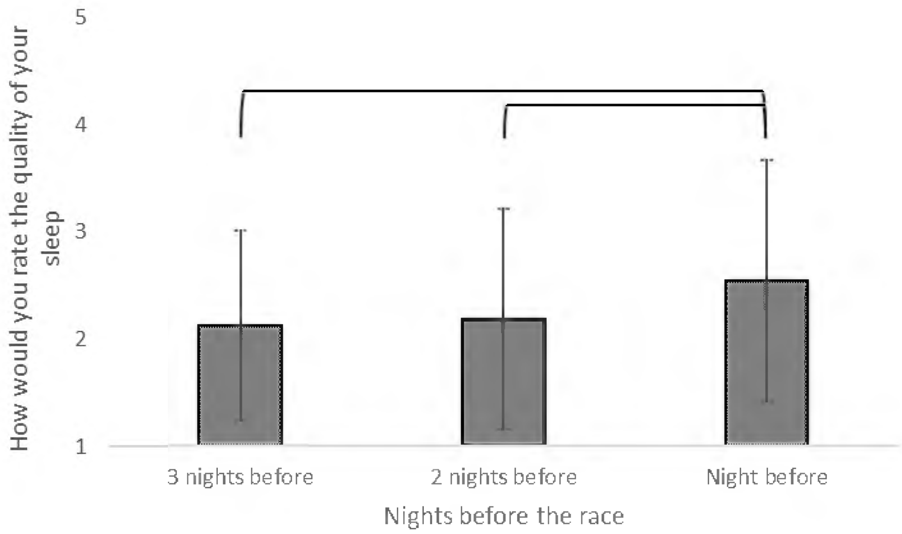

Figure 4. Sleep quality for the three nights prior to the races. Error bars denote standard deviation. Brackets indicate statistical differences meeting the alpha level of 0.05. The scale can be interpreted as follows: 1=very good, 2=good, 3=average, 4=poor, 5=very poor.

4.3.5 Sleep quality - Male Female comparison

No significant effect of sex (p=0.06, df=70; F=3.54; OP= 0.46) was found for sleep quality. Furthermore, no significant interaction effect (p=0.38; df=70; F=0.96; OP=0.21) between sex and nights was found for sleep quality.

4.3.6 Sleep quality - Competition-level comparison

No significant effect of competition-level was found for sleep quality (p=0.11; df=70; OP=0.34). No significant interaction effect (p=0.62; df=70; F=0.47; OP=0.13) of nights and competition-level was found either.

4.3.7 Bed time - All participants

There was no significant general effect (p=0.20; df=68; F=1.62; OP=0.34) with respect to the time at which participants got into bed over the three nights (Figure 5). There was also no significant difference in bed time between nights. Variation within bed times was greatest two nights prior to the race (Figure 5).

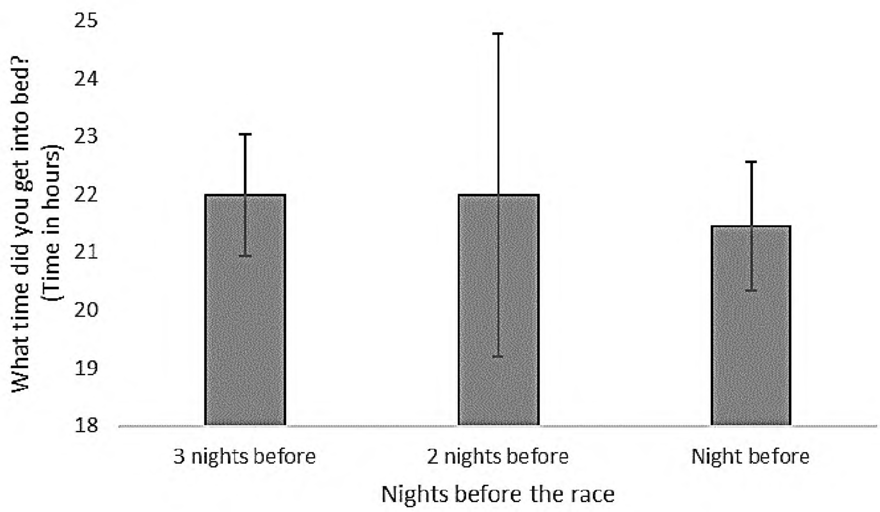

Figure 5. Time cyclists got into bed for the three nights prior to the races. Error bars denote standard deviation.

4.3.8 Bed time - Male Female comparison

No significant sex effect (p=0.49; df=68; F=0.48; OP= 0.10) was found for bed time. No significant interaction effect (p=0.70; df=68; F=0.36; OP=0.11) of sex and days was found for the time that the cyclists got into bed for the nights prior to the races. While the standard deviations for the female data set stay rather consistent over the three nights, there was large variation in the male data two nights before the race (Figure 6).

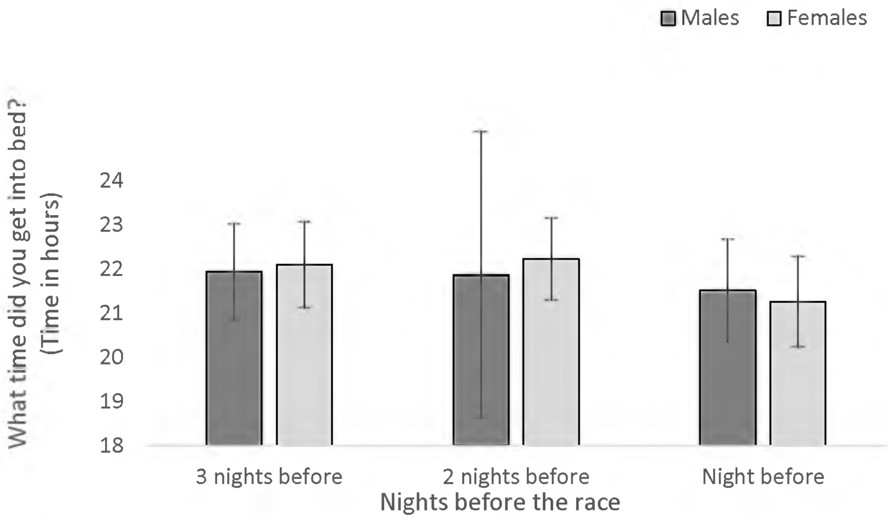

Figure 6. Comparison of the time male and female cyclists got into bed for the three nights prior to the races. Error bars denote standard deviation.

4.3.9 Bed time - Competition-level comparison

No significant effect of competition-level (p=0.28; df=68; F=1.20; OP=0.19) was found for bed time. No significant interaction effect (p=0.60; df=68; F=0.52; OP=0.13) of nights and competition-level was found for the time the cyclists went to bed. The recreational athlete data set did have a large standard deviation for two nights before the race, over double the variation of either group of cyclists on any other night monitored for both variables (Figure 7).

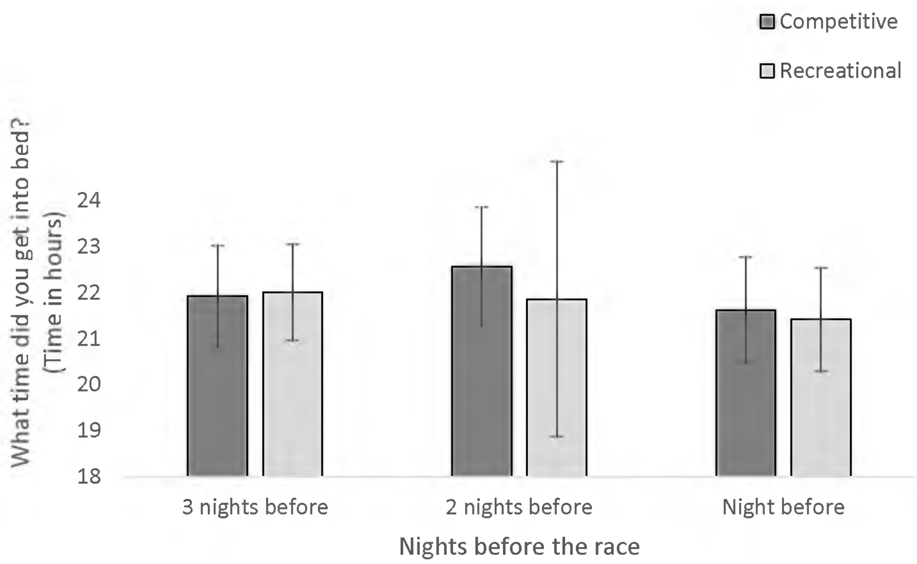

Figure 7. Comparison of the time competitive and recreational cyclists got into bed for the three nights prior to the races. Error bars denote standard deviation.

4.3.10 Time participants actively tried to go to sleep - All participants

The time that participants actively attempted to sleep did not differ significantly (p=0.22; df=68; F=1.52; OP=0.32) over the three nights (Figure 8). Variation in sleep times was highest two nights before the race (Figure 8).

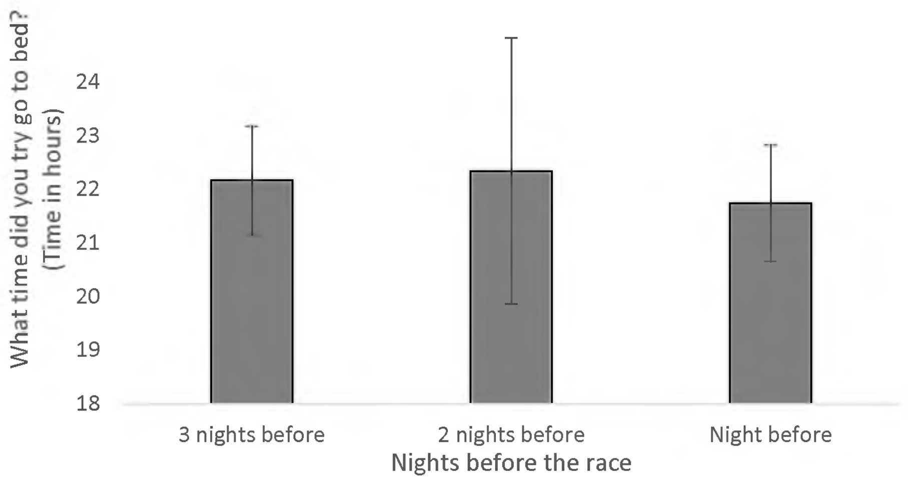

Figure 8. Time at which cyclists actively tried to go to sleep for the three nights prior to the races. Error bars denote standard deviation.

4.3.11 Time participants actively tried to go to sleep - Male Female comparison

No significant general effect of sex (p=0.56; df=68; F=0.34; OP=0.09) was found for sleep time. No significant interaction effect of sex and nights (p=0.95; df=68; F=0.05; OP=0.06) was found with respect to when cyclists actively started to try to fall asleep. The standard deviation, however, shows large variation for male data two nights before the race (Figure 9).

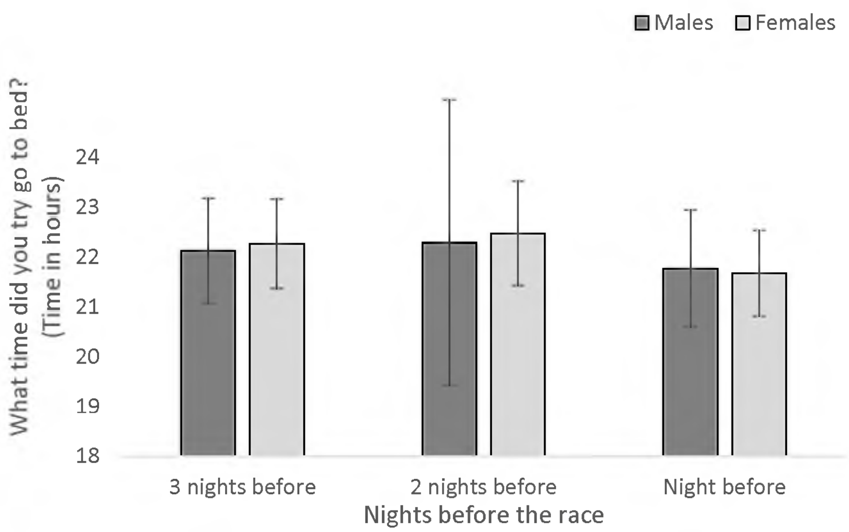

Figure 9. Comparison of the time male and female cyclists tried to fall asleep for the three nights prior to the races. Error bars denote standard deviation.

4.3.12 Time participants actively tried to go to sleep - Competition-level comparison

No significant general effect of competition-level (p=0.45; df=68; F=0.57; OP=0.12) was found for sleep time. No significant interaction effect (p=0.84; df=68; F=0.17; OP=0.08) was found between nights and competition-level with regards to the time the cyclists actively tried to go to sleep. Large variance was observed for the recreational athletes' data set two nights prior to the race (Figure 10).

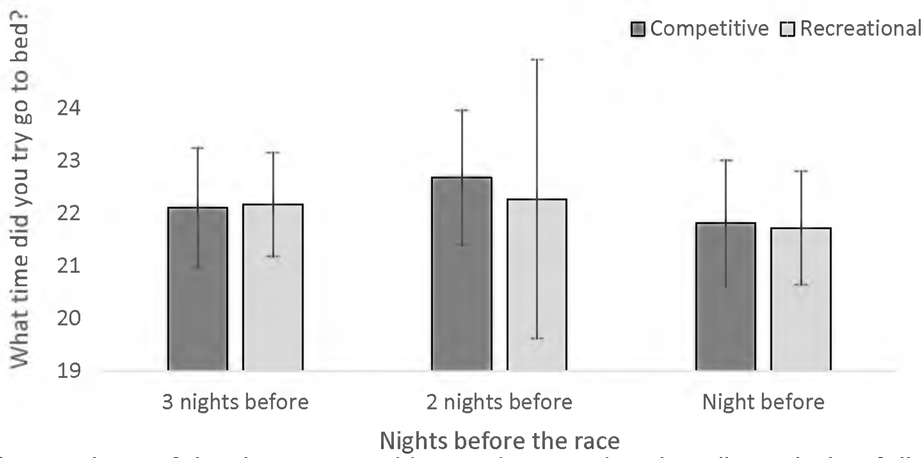

Figure 10. Comparison of the time competitive and recreational cyclists tried to fall asleep for the three nights prior to the races. Error bars denote standard deviation.

4.3.13 Sleep latency - All participants

No significant general effect (p=0.08; df=66; F=2.57; OP=0.51) was found over the three nights for the time it took cyclists to fall asleep (Figure 11). The standard deviation for sleep latency data the night prior to the race was double that of the two preceding nights (Figure 11).

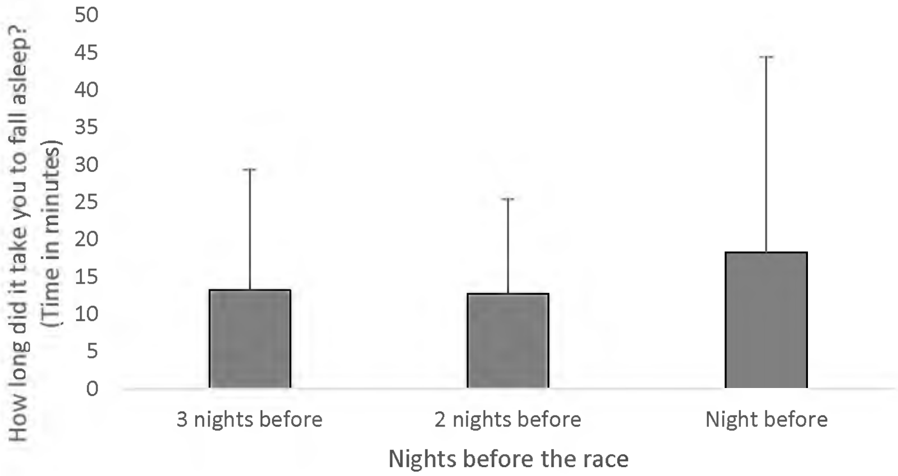

Figure 11. Sleep latency for the three nights prior to the races. Error bars denote standard deviation (one directional owing to negative overlap if displayed in both directions).

4.3.14 Sleep latency - Male Female comparison

No significant main effect of sex (p=0.17; df=66; F=1.91; OP= 0.28) was found for sleep latency. There was also no significant interaction effect (p=0.07; df=66; F=2.71; OP=0.53) for sleep latency between the sexes over the nights. It should be noted that female variance was much lower on the Thursday night before the races and then much higher the night before the races than the male data (Figure 12).

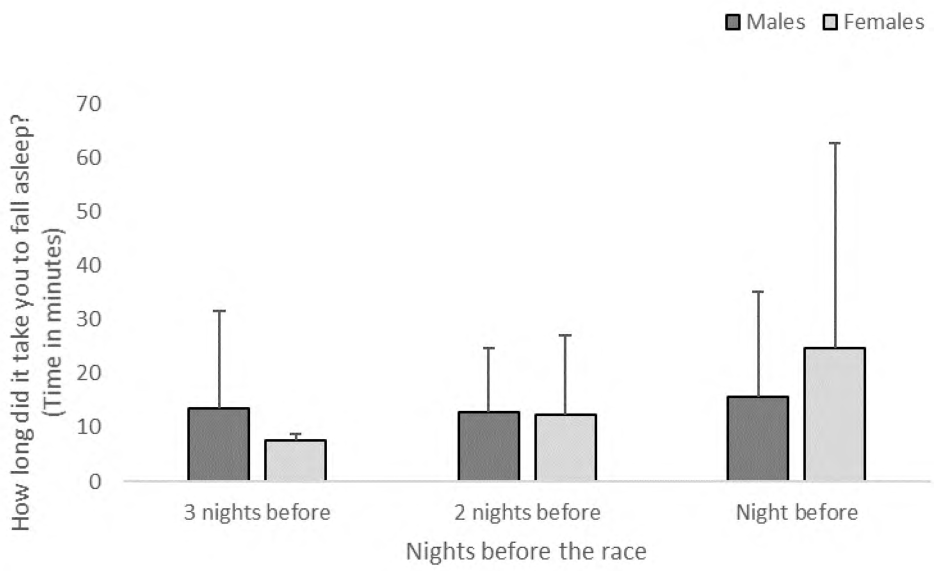

Figure 12. Comparison of male and female sleep latency for the three nights prior to the races. Error bars denote standard deviation (one directional owing to negative overlap if displayed in both directions).

4.3.15 Sleep latency - Competition-level comparison

No significant general effect of competition-level (p=0.58; df=66; F=0.30; OP=0.08) was found for sleep latency. No significant interaction effect (p=0.71; df=66; F=0.34; OP=0.15) of nights and competition-level was found for sleep latency (Figure 13). Large variation for sleep latency was found in the recreational group the night directly preceding the races (Figure 13).

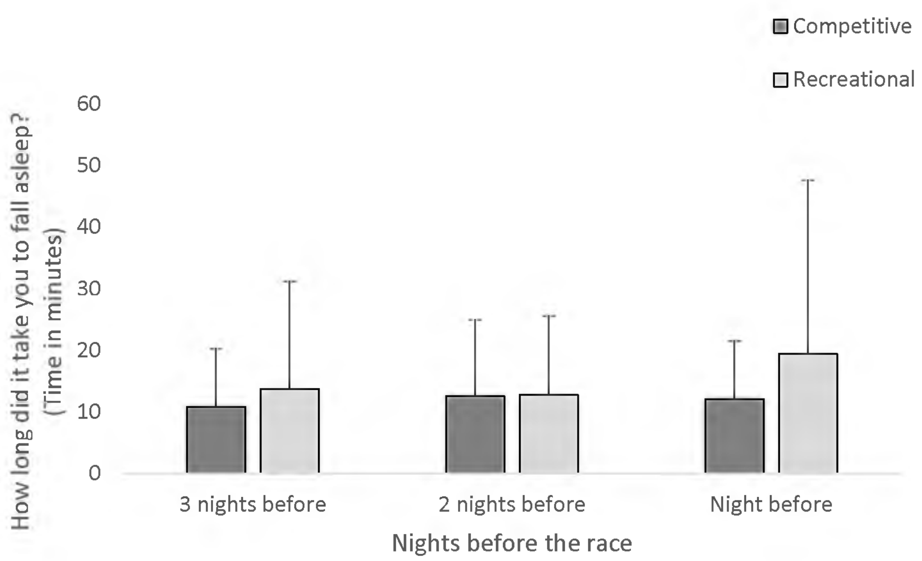

Figure 13. Comparison of the time it took for competitive and recreational cyclists to fall asleep for the three nights prior to the races. Error bars denote standard deviation (one directional owing to negative overlap if displayed in both directions).

4.3.16 Number of awakenings - All participants

The number of reported awakenings did not differ significantly (p=0.48; df=69; F=0.75; OP=0.17) over the course of the three nights for all participants.

4.3.17 Number of awakenings - Male Female comparison

No significant general effect of sex (p=0.26; df=69; F=1.31; OP=0.20) was found for the number of awakenings during the nights monitored. Furthermore, there was no significant interaction effect (p=0.12; df= 69; F=2.13; OP= 0.43) with regard to sex and nights in terms of the number of times the participants woke up.

4.3.18 Number of awakenings - Competition-level comparison

Competition-level did not significantly (p=0.54; df=69; F=0.37; OP=0.09) affect the number of awakenings. Moreover, no significant interaction effect (p=0.88; df=69; F=0.13; OP=0.07) was observed between the competition-level of the cyclists and nights for the number of awakenings.

4.3.19 Duration of awakenings - All participants

No significant general effect (p=0.20; df=67; F=1.63; OP=0.34) or between effect was found for the duration of awakenings over the three nights (Figure 14). Large variance was, however, observed for the night before the race (Figure 14).

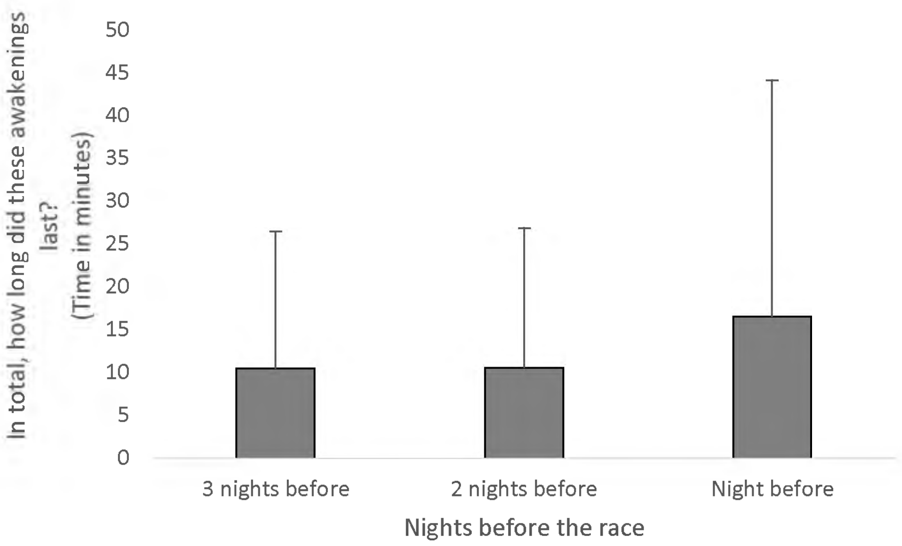

Figure 14. Accumulative durations of awakenings for the three nights prior to the races. Error bars denote standard deviation (one directional owing to negative overlap if displayed in both directions).

4.3.20 Duration of awakenings - Male Female comparison

No significant general effect of sex (p=0.75; df=67; F=0.10; OP=0.06) was found for the duration of awakenings. No significant interaction effect (p=0.82; df= 67; F=0.19; OP= 0.08) was found for the duration of awakenings between the sexes and nights.

4.3.21 Duration of awakenings - Competition-level comparison

No significant main effect of competition-level (p=0.27; df=67; F=1.25; OP=0.20) was found for the duration of awakenings. In addition, no significant interaction effect (p=0.82; df= 67; F=0.19; OP= 0.08) was found with regards to the duration of awakenings and the competition-level of the cyclists. Large variation was seen in the recreational-group data for the night before the races (Figure 15).

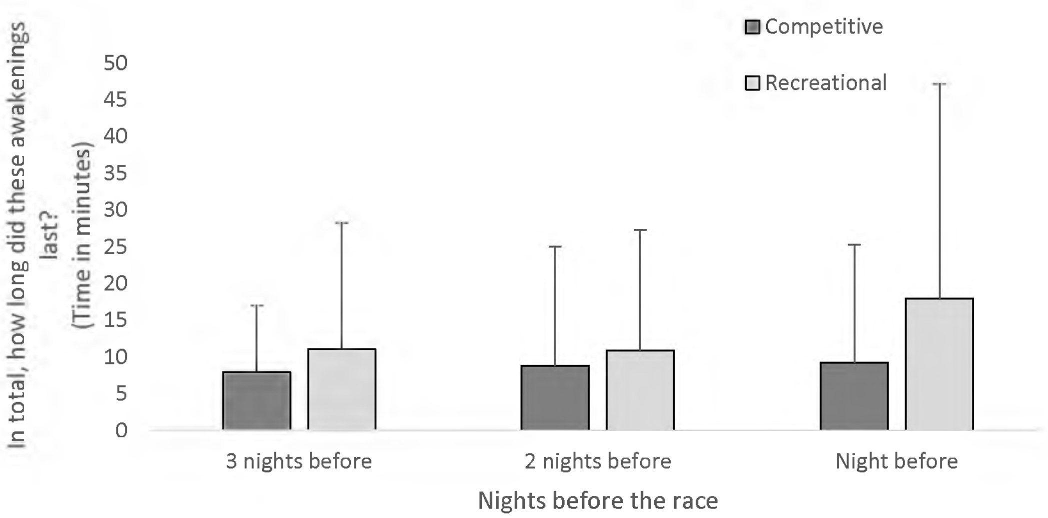

Figure 15. Comparison of the duration of awakenings between competitive and recreational cyclists for the three nights prior to the races. Error bars denote standard deviation (one directional owing to negative overlap if displayed in both directions).

4.3.22 Wake-up time - All participants

A general effect ($p<0.01$; df=68; F=41.52; OP=1.00) was found over the three mornings before the race and the time the cyclists woke up. Final awakening time the morning of the race was significantly earlier when compared to the morning of the day before the race ($p<0.01$; d=1.49; U_3=0.93; PoS=0.86) and two mornings before the race ($p<0.01$; d=1.07; U_3=0.86; PoS=0.78) (Figure 16). Final awakening time was also significantly later (p=0.01; d=0.48; U_3=0.68; PoS=0.68) one morning before the race compared with two mornings before the race (Figure 16).

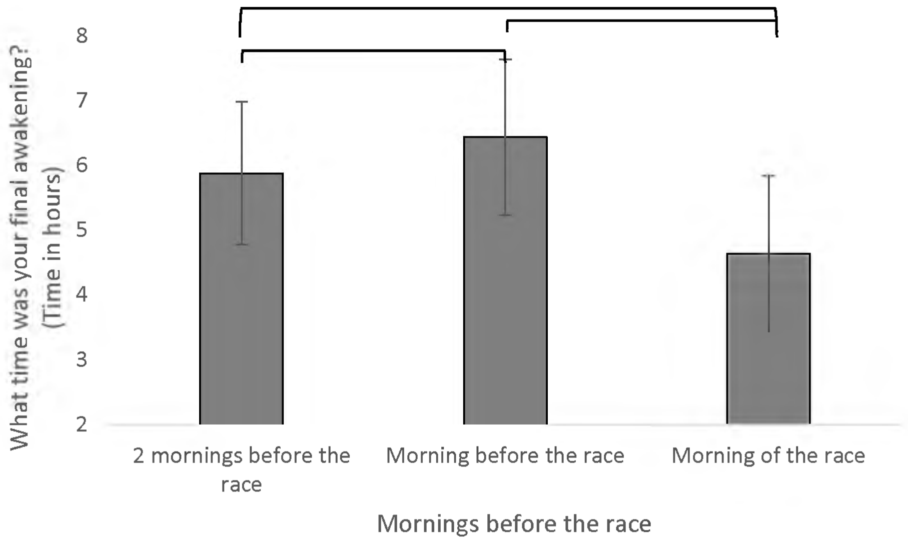

Figure 16. The time at which cyclists woke up the three mornings prior to the races. Error bars denote standard deviation.

4.3.23 Wake-up time - Male Female comparison

No significant main effect (p=0.61; df=68; F=0.26; OP=0.08) was found for sex and wake-up time. Furthermore, there was no significant interaction effect (p=0.42; df=68; F=0.87; OP=0.20) found between the sexes and the nights before the race.

4.3.24 Wake-up time - Competition-level comparison

Wake-up time did not differ significantly (p=0.87; df=68; F=0.03; OP=0.05) between cyclists in different levels of competition. Furthermore, there was no significant interaction effect (p=0.88; df=68; F=0.25; OP= 0.09) for the competition-level of the cyclists over the different nights.

4.3.25 Get out of bed time - All participants

A general effect (p<0.01; df= 69; F=6.21; OP=0.89) over the three nights was found for the time that cyclists actually got up and out of bed. Between nights, however, the only significant difference (p<0.01; d=0.46; U_3=0.68; PoS=0.64) was that cyclists woke up earlier the morning of the race compared to the morning before the race (Figure 17). In addition, large variance was found for the morning of the race.

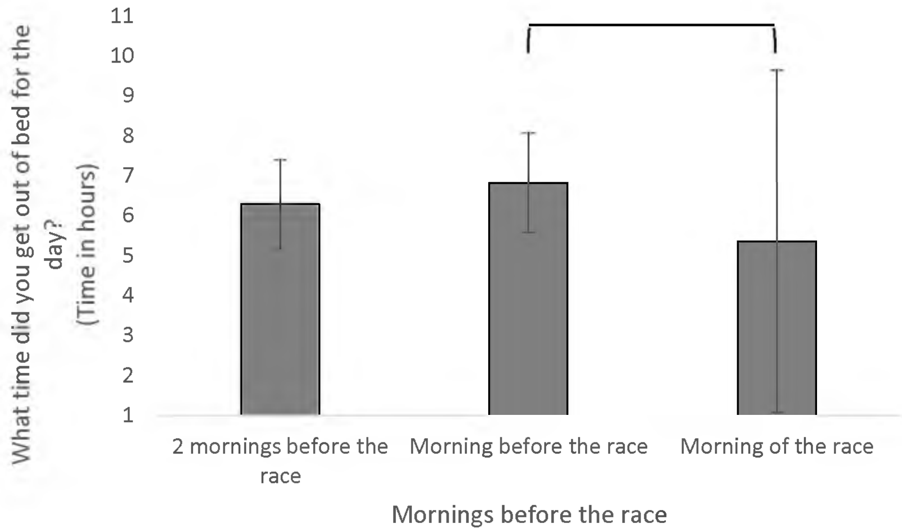

Figure 17. The time at which cyclists got out of bed the three mornings prior to the races. Error bars denote standard deviation. Brackets indicate statistical differences meeting the alpha level of 0.05.

4.3.26 Get out of bed time - Male Female comparison

No significant main effect of sex (p=0.12; df=69; F=1.00; OP=0.17) was found for the time the athletes got out of bed. Additionally, no significant interaction effect (p=0.16; df=69; F=1.88; OP=0.39) was found for the sexes and different nights. Male data did, however, show large variance for the morning of the race.

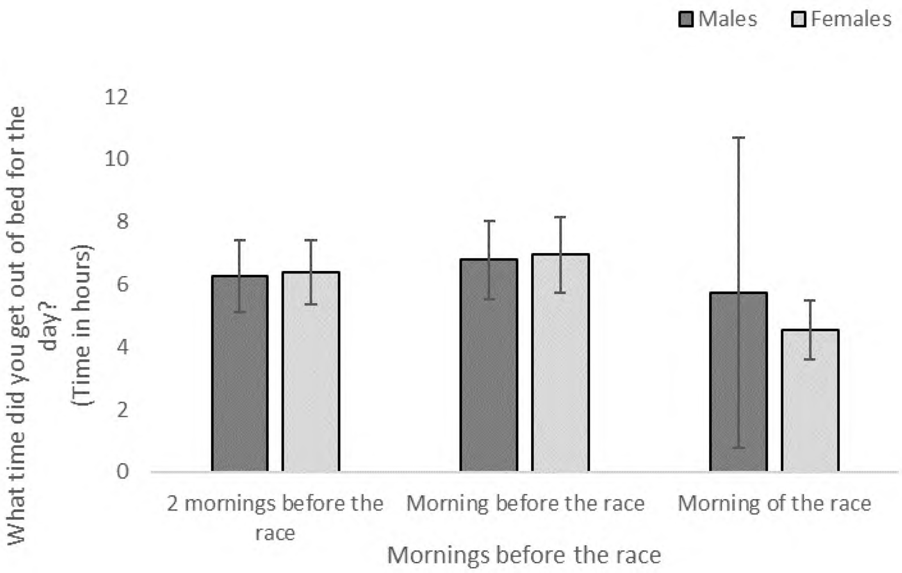

Figure 18. Comparison of the time male and female cyclists got out of bed the three mornings before the races. Error bars denote standard deviation.

4.3.27 Get out of bed time - Competition-level comparison

The time that athletes in different levels of competition got out of bed did not differ significantly (p=0.35; df=69; F=0.89; OP=0.15). No significant interaction effect (p=0.75, OP=0.10) of competition-level and nights was found. There was, however, large variance for the time that recreational cyclists got out of bed the morning of the race, more so than any other morning for either group (Figure 19).

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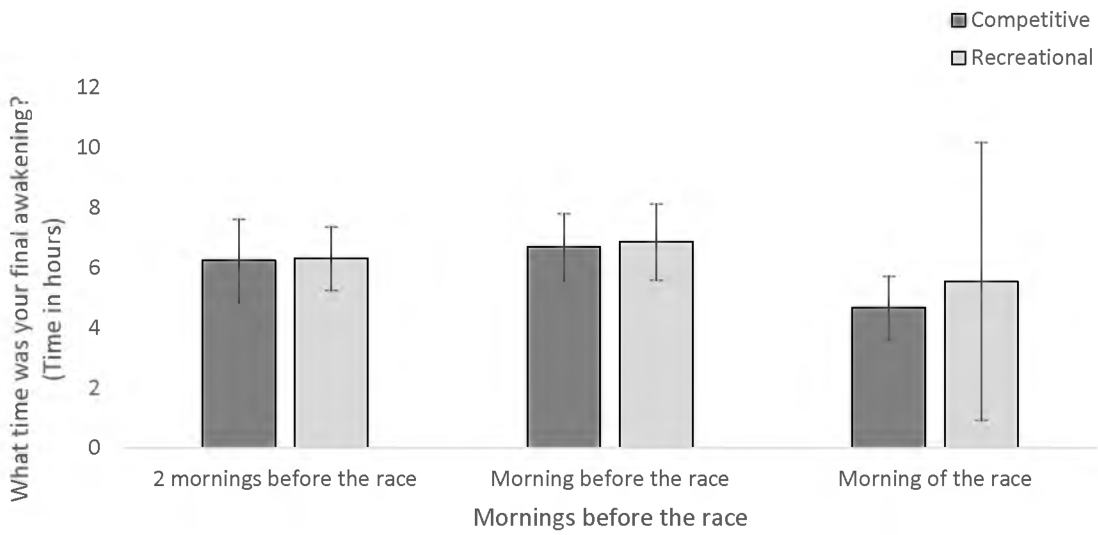

Figure 19. Comparison of the times at which competitive and recreational cyclists got out of bed for the three mornings prior to the races. Error bars denote standard deviation.

4.3.28 Comments - All participants

The comments section of the sleep diary afforded participants an opportunity to add insight into their sleep the nights leading up to the races (Appendix J). The comments section was purely qualitative and no statistical tests were applied. There are, however some trends and events from the comments that are worth noting. One such event occurred the night before the Amashova (17th of October 2015) when several participants stayed up to watch a Rugby World Cup match. Additionally, the most common comment was with regards to anxiety and nerves. Although this was mostly attributed to the races, some participants indicated anxiety unrelated to the races as well. Issues relating to family and work problems were also cited but less frequently. Travelling to the race was also reported to hinder sleep by a small number of participants.

4.4 CORRELATIONS

4.4.1 Total sleep length the night before the race

Table 23 shows all questionnaire and sleep diary item correlations to total sleep duration the night before the race. All sleep diary items are values reported for the night before the race only. The following results focus on all correlations which were found to be statistically significant regardless of the strength of the relationship. It must be noted, however, that all non-significant correlations were very weak and thus are not reported in depth.

The analyses that follow will only focus on correlations found to be significant ($p \leq 0.05$) even though the strength of the relationships was also weak (Red values in Table 23).

4.4.1.1 Questionnaire items vs total sleep length

Only a single item on the questionnaire correlated significantly ($p \leq 0.05$) with sleep duration the night before the race (Table 23).

Figure *20*0 shows the significant, negative and weak correlation (R^2=0.08; $p \leq 0.05$) that sleep duration had with cyclists' ratings of their past pre-race sleep quality. Cyclists rating typical pre-race sleep quality as better showed a slight tendency towards longer sleep durations while worse sleep quality ratings coincided with shorter pre-race sleep periods.

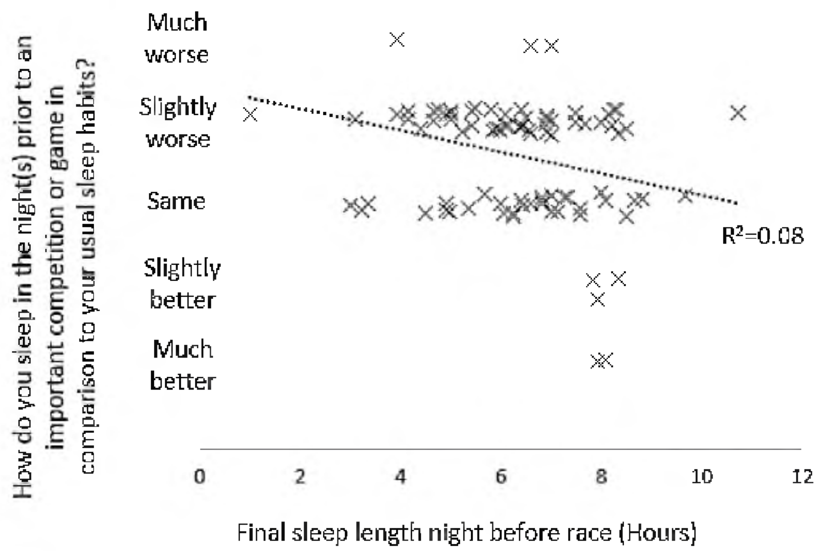

Figure 20. Correlation between final sleep duration and typical pre-race sleep quality as estimated by cyclists on the questionnaire.

Table 23. Questionnaire and sleep diary item correlations to total sleep duration the night before the races. Values in red denote correlations with significance levels p≤0.05.

Variables	Total sleep duration (Night before the race)	
Questionnaire Items	**R**	**R^2**
Age:	-0.02	0.00
Sex	-0.19	0.03
How long have you been practicing this sport?	0.01	0.00
On which level are you practicing your sport right now?	-0.03	0.00
How much time do you spend practicing per week on average?	-0.12	0.01
How often do you practice per week?	-0.13	0.02
How long do you sleep on an average night?	-0.01	0.00
How do you estimate your sleep quality in general?	-0.11	0.01
How do you sleep in the night(s) prior to an important competition or game in comparison to your usual sleep habits?	-0.27	0.08
Have you ever, compared to your usual sleep habits, slept worse in the night(s) prior to an important competition or game?	0.11	0.01
Sleep Diary Items		
What time did you get into bed?	-0.39	0.15
What time did you try go to bed?	-0.53	0.28
How long did it take you to fall asleep?	-0.23	0.05
How many times did you wake up, not counting your final awakening?	0.03	0.00
In total, how long did these awakenings last?	-0.05	0.00
What time was your final awakening?	0.63	0.39
What time did you get out of bed for the day?	0.58	0.33
How would you rate the quality of your sleep?	-0.39	0.16

4.4.1.2 Sleep diary items vs total sleep length

Total sleep duration the night prior to the race correlated with six items on the sleep diary for the same night (Table 23). Figure 21 illustrates that sleep duration significantly, weakly and negatively correlated with both the time cyclists got into bed (R^2=0.15; p≤0.05) and the time that cyclists tried to fall asleep (R^2=0.28; p≤0.05). The trend suggests that the later some cyclists got to bed and tried to fall asleep the shorter they slept (Figure 21).

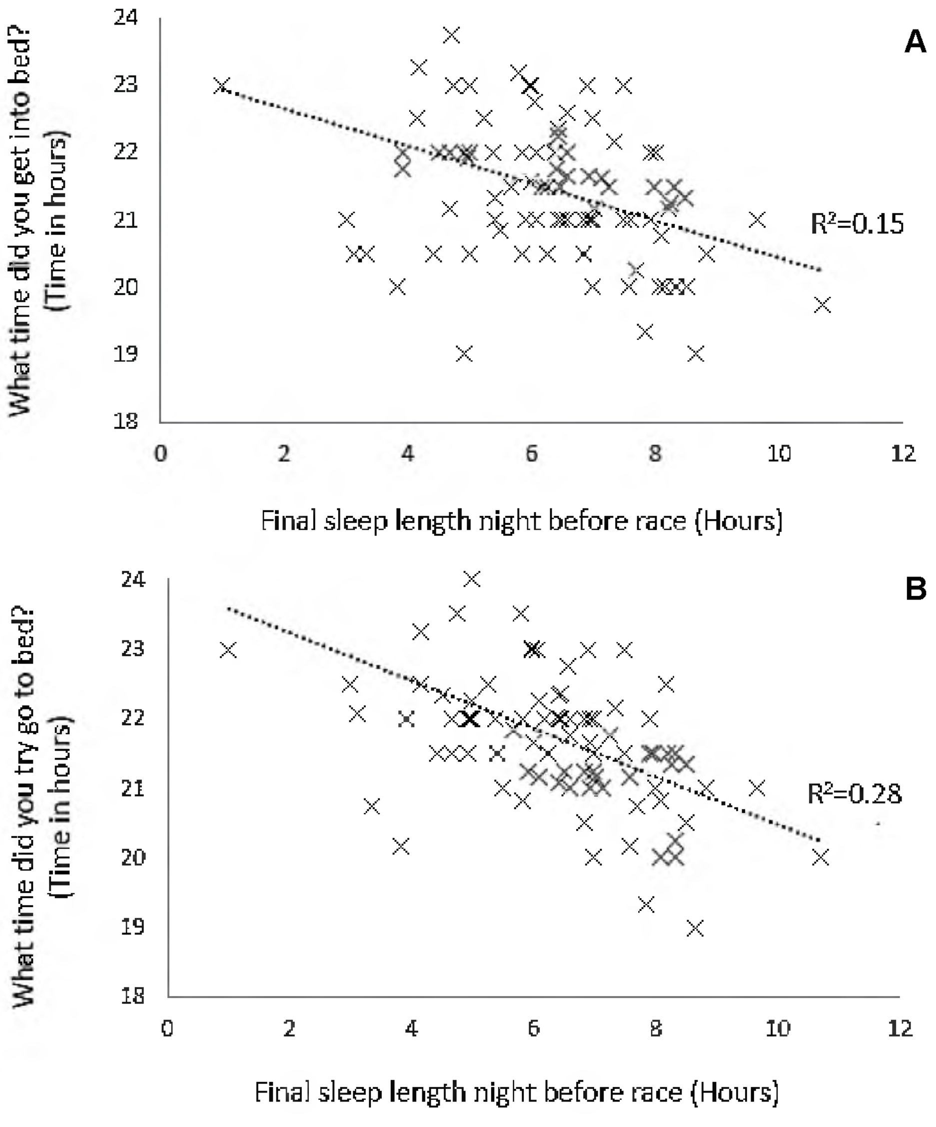

Figure 21. Correlations between sleep duration and the time cyclists got into bed (A) as well as the time they actively started trying to go to sleep (B).

Sleep latency had a significant, weak and negative correlation (R^2=0.05; p≤0.05) with total sleep duration the night before the race (Figure 22). Longer sleep latencies showed weak correlation with shorter sleep durations.

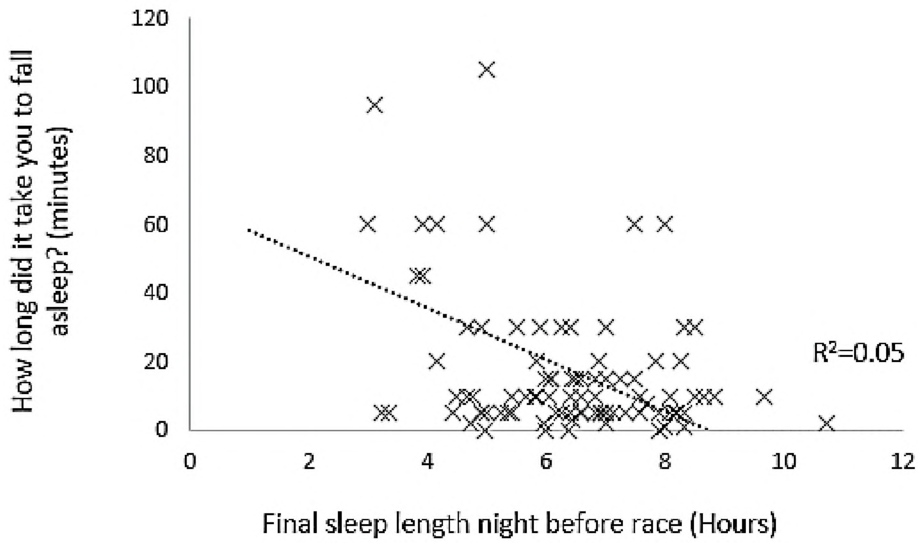

Figure 22. Correlation between sleep duration and the time it took cyclists to fall asleep.

The time the cyclists woke up in the morning was found to correlate significantly both positively and weakly (R^2=0.39; p≤0.05) with final sleep length the night before the race (Figure 23). The positive correlation, as can be seen in Figure 23, shows that earlier wake-up times tended to link with reduced sleep times.

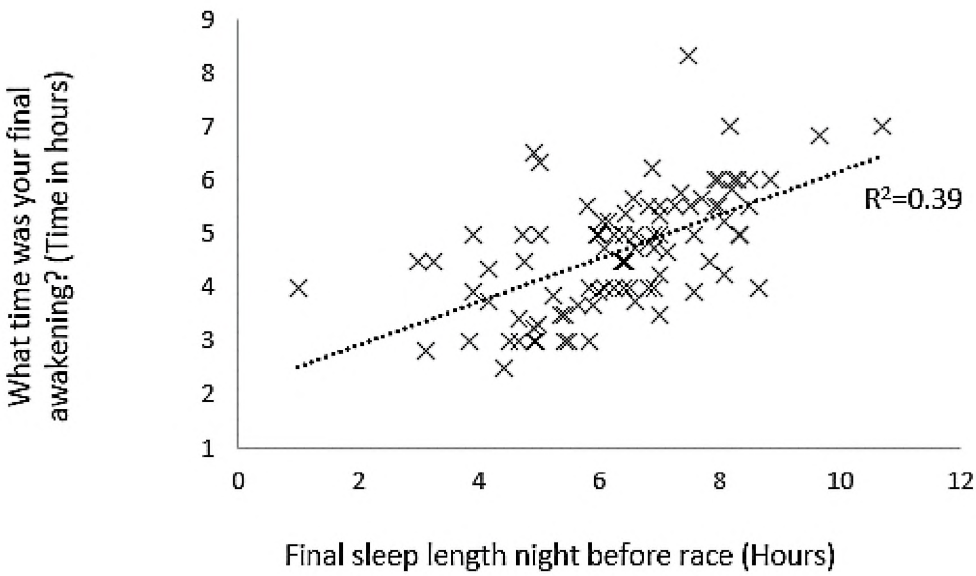

Figure 23. Correlation between final sleep duration and final wake-up time in the morning.

As can be seen in Figure 24, the correlation of the time that cyclists got out of bed the morning of the race with final sleep length was found to be significantly positive and weak (R^2=0.33; p≤0.05).

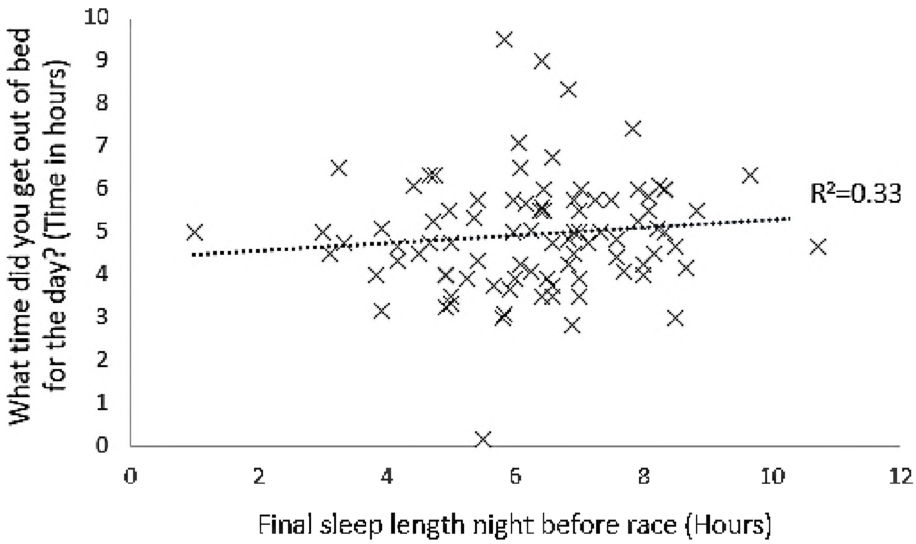

Figure 24. Correlation between final sleep duration and final wake-up time in the morning.

Total sleep length also significantly correlated (R^2=0.16; p≤0.05) with sleep quality negatively and weakly. As displayed in Figure 25, there was a weak link observed between poor sleep and shorter sleep durations while better sleep coincided with longer sleep periods.

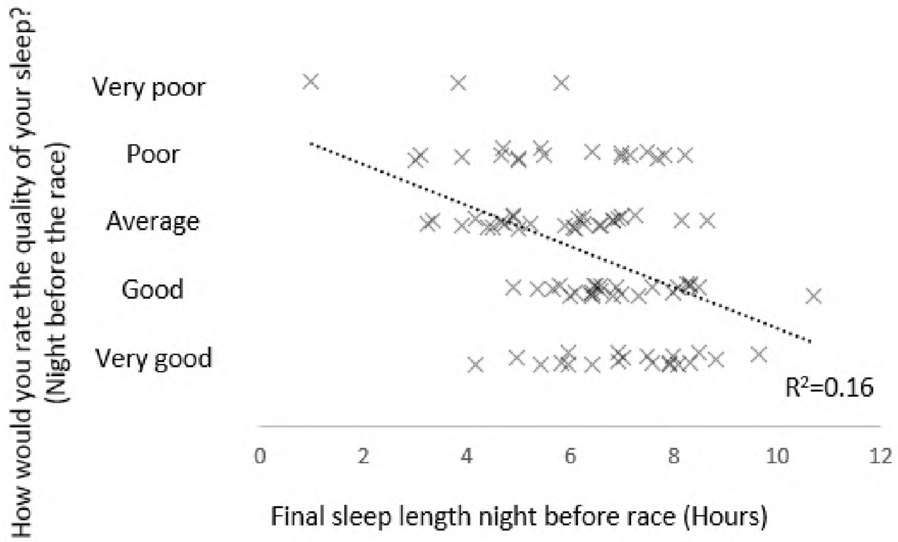

Figure 25. Correlation between final sleep duration and sleep quality for the night before the races.

4.4.2 Sleep quality the night before the race

Table 24 shows all questionnaire and sleep diary item correlations to sleep quality the night before the races. Four items on both the questionnaire and sleep diary were found to correlate with pre-race sleep quality.

Once again, the focus of the following section of this chapter will be on correlations found to be significant (p≤0.05) (Red values in Table 24).

Table 24. Correlations of items on the questionnaire and sleep diary with sleep quality the night before the races. Values in red denote correlations with significance levels p≤0.05.

Variables	Sleep quality (Night before the race)	
Questionnaire Items	**R**	**R^2**
Age:	-0.03	0.00
Sex	0.16	0.03
How long have you been practicing this sport?	-0.30	0.09
On which level are you practicing your sport right now?	-0.11	0.01
How much time do you spend practicing per week on average?	-0.03	0.00
How often do you practice per week?	0.03	0.00
How long do you sleep on an average night?	-0.03	0.00
How do you estimate your sleep quality in general?	0.32	0.10
How do you sleep in the night(s) prior to an important competition or game in comparison to your usual sleep habits?	0.29	0.08
Have you ever, compared to your usual sleep habits, slept worse in the night(s) prior to an important competition or game?	-0.27	0.07
Sleep Diary Items		
What time did you get into bed?	0.00	0.00
What time did you try go to bed?	0.14	0.02
How long did it take you to fall asleep?	0.32	0.11
How many times did you wake up, not counting your final awakening?	0.48	0.23
In total, how long did these awakenings last?	0.48	0.23
What time was your final awakening?	-0.16	0.03
What time did you get out of bed for the day?	-0.10	0.01
Total sleep duration	-0.39	0.16

4.4.2.1 Questionnaire items vs sleep quality

A significant, weak and positive correlation (R^2=0.10; p≤0.05) was found between pre-race sleep quality and general sleep quality as reported in the questionnaire. Figure 26 illustrates that poor general sleep quality was associated with poor pre-race sleep quality for a small percentage of the sample.

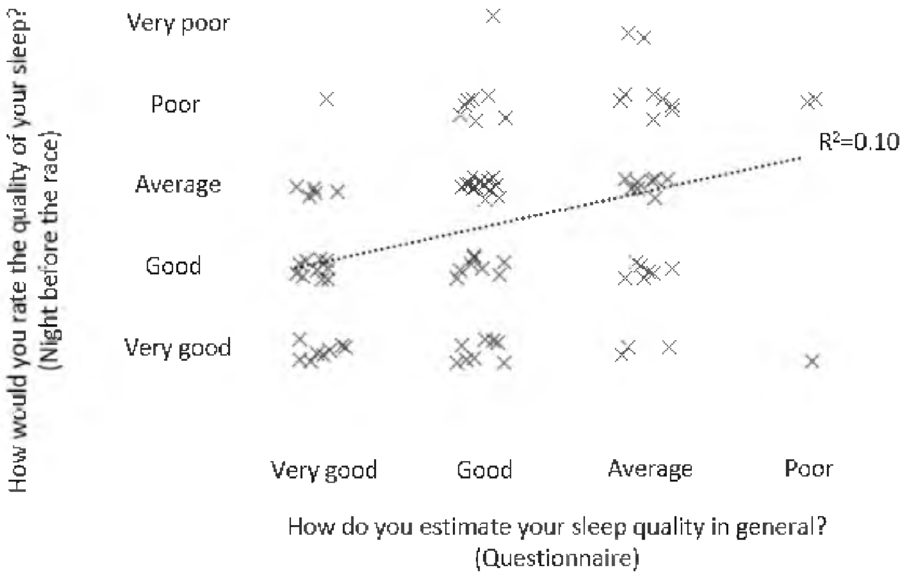

Figure 26. Correlation between general sleep quality and sleep quality for the night before the race.

Cycling experience was also found to correlate significantly both negatively and weakly (R^2=0.09; p≤0.05) with pre-race sleep quality. This weak trend suggests that the more experienced the cyclists were at the time of testing, the less likely they were to experience poor-quality sleep (Figure 27).

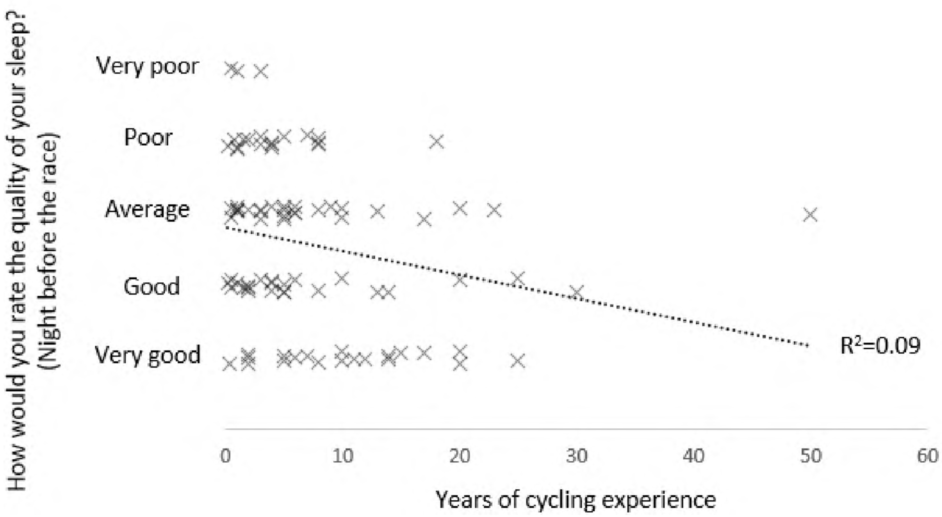

Figure 27. Correlation between sleep quality and years of cycling experience.

As was found for sleep duration, pre-race sleep quality significantly correlated positively and weakly (R^2=0.08; p≤0.05) with the cyclists rating of their typical pre-race sleep quality compared to their normal sleep. Some cyclists rating typical pre-race sleep quality as better in the questionnaire tended to rate sleep quality as better the night before the race in the sleep diary (Figure 28).

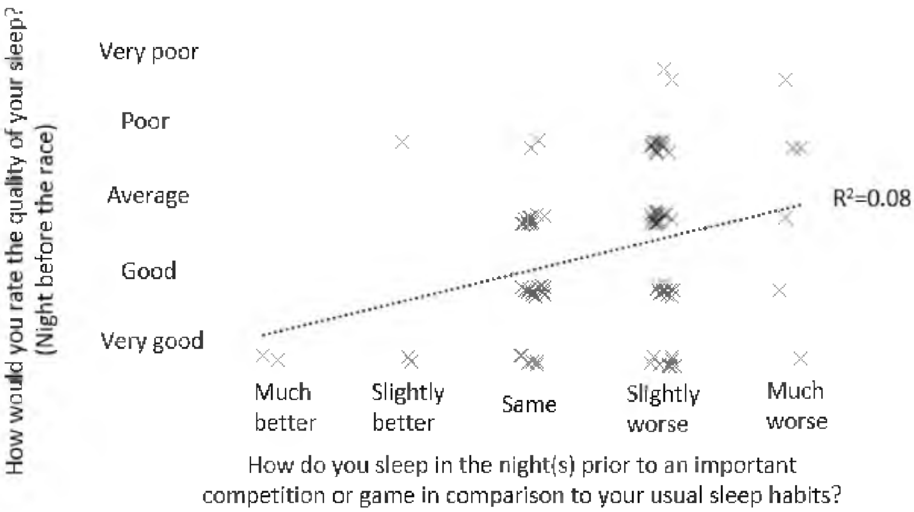

Figure 28. Correlation between sleep quality the night before the race and typical pre-race sleep quality as estimated by cyclists on the questionnaire.

Sleep quality the night before the race significantly correlated weakly and negatively (R^2=0.07, p≤0.05) with cyclists reporting of pre-competition sleep loss within the past year on the questionnaire. A small percentage of cyclists tended to rate pre-race sleep quality poorer if they had indicated that they had experienced pre-race sleep loss within the past 12 months (Figure 29).

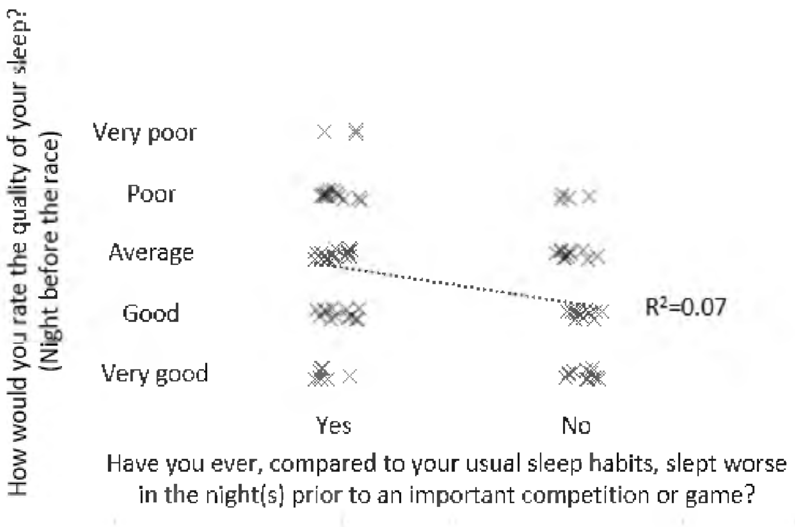

Figure 29. Correlation between sleep quality the night before the race and cyclists' reports of pre-race sleep loss within the past year on the questionnaire.

4.4.2.2 Sleep diary items vs sleep quality

Sleep latency the night before the race significantly correlated positively and weakly (R^2=0.11, p≤0.05) with sleep quality the night before the race. Lower sleep latencies tended to correlate with better self-reported sleep quality (Figure 30).

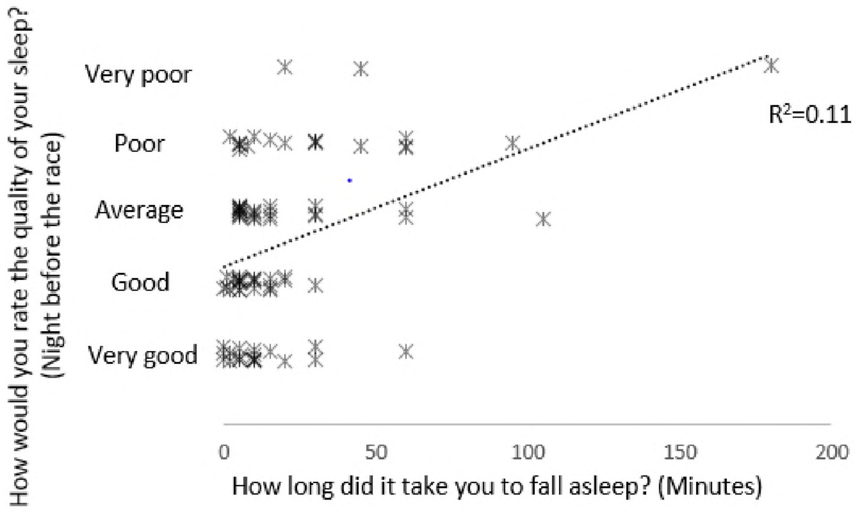

Figure 30. Correlation between self-reported sleep quality and sleep latency the night before the race.

Both the number of times the cyclists woke up the night before the race and the durations of these awakenings were found to correlate significantly both positively and weakly (R^2=0.23, p≤0.05) with self-reported sleep quality. Figure 31 (A) illustrates that some cyclists were more likely to rate sleep quality as worse the more frequently they awoke during the course of the night. The same trend was found for the duration of these awakenings in that the longer the cyclists were awake during the night, the more likely it was for them to rate their sleep quality as bad (Figure 31 (B)).

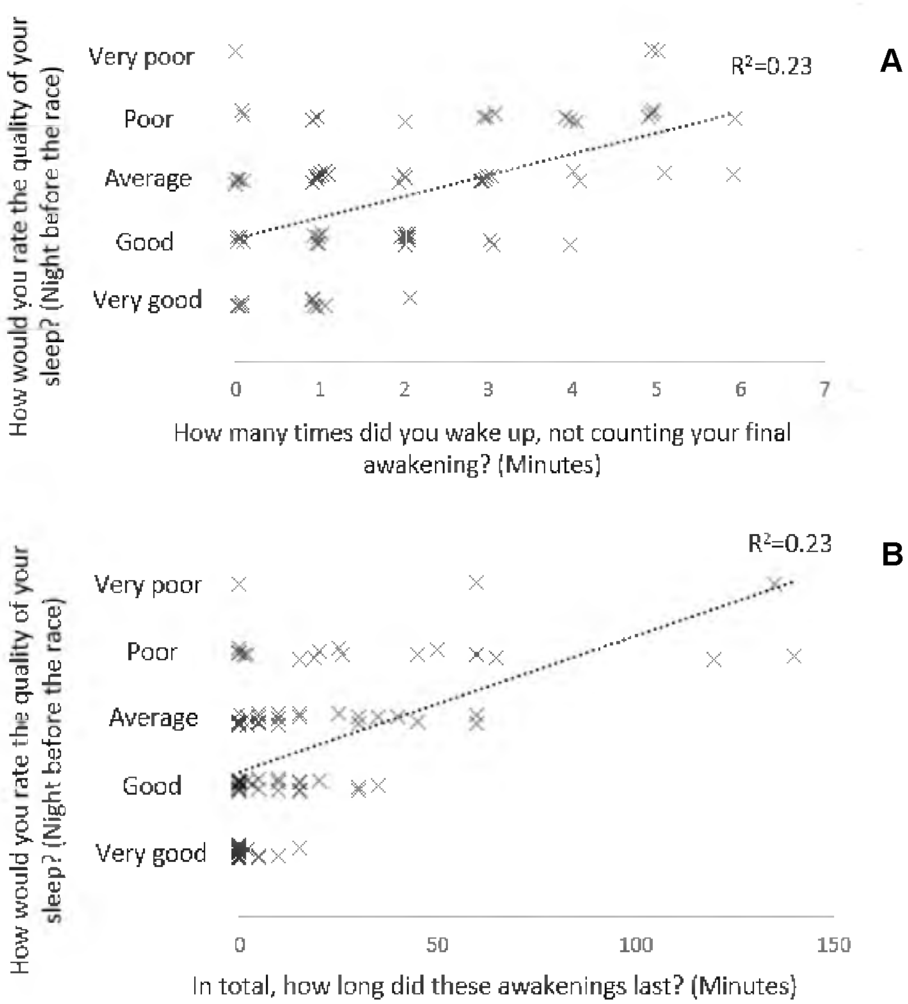

Figure 31. Correlations between sleep quality and the number (A) as well as the duration (B) of awakenings cyclists experienced the night before the race.

CHAPTER V

5 DISCUSSION

5.1 PRE-COMPETITIVE SLEEP LOSS

5.1.1 All Participants

The questionnaire findings showed that 67% of the cyclists reported having worse sleep than usual the night before a race within the past year (Table 4). This finding supports similar previous questionnaire studies which found that 60% to 70% of athletes experienced pre-competitive sleep loss (Erlacher *et al.* 2011; and Juliff *et al.* 2015).

This finding is consistent with the sleep diary data where average total sleep duration the night before races was 6h19min. This value was significantly lower than both previous nights with an average reduction in sleep duration of over an hour (Figure 3). The effect sizes suggest that the magnitude of this difference was moderate. The Cohen's U_3 suggests that over 70% of the cyclists slept less the night before the race than the mean sleep duration of two and three nights before the race. The probability of superiority also suggests that there is a 69% chance that a random cyclist picked from the sample would have slept worse the night before the race compared to other nights monitored.

The sleep reduction findings are consistent with those of previous sleep diary studies on pre-competitive sleep in athletes (Lastella *et al.*, 2014; and Lastella *et al.* 2015b). If sleep loss is considered to be sleep that is shorter than the lowest recommended sleep duration of 7hrs for healthy adults (Balkin *et al.*, 2008; and Bixler, 2009), then 66% of cyclists slept sub-optimally the night before their races.

Not only was sleep found to be diminished the night before competition but in addition, sleep quality was poorer (Figure 4), which has also been reported previously (Leeder *et al.*, 2011; Lastella *et al.*, 2014; Lastella *et al.*, 2015b; Romyn *et al.*, 2016; and Ehrlenspiel *et al.*, 2017). The effect sizes for sleep quality reduction before the races were, however, lower than the sleep duration findings. The magnitude of sleep quality reduction was found to be small. This suggests that more cyclists experienced reductions in sleep duration and a smaller percentage experienced reductions in sleep quality.

Sleep quality and sleep duration the night before the races were found to correlate significantly, albeit weakly (Figure 25). Sixteen percent of the variance in sleep quality could be explained by the sleep duration data and vice versa. This suggests that a reduction in sleep duration was linked with a poorer quality of sleep for a small percentage of the sample (Figure 25). Pre-race sleep quality was also found to correlated significantly but weakly with the years of cycling experience (Figure 27). This trend suggests that the longer some cyclists had been cycling, the more likely they were to report better pre-race sleep quality. Importantly, neither age nor competition-level were found to correlate with sleep quality. This shows that years of cycling experience and not simply years of life experience or high-tier competition experience may be linked with athlete pre-competition sleep quality. This same correlation, however, was not found for sleep duration. This could possibly mean that some experienced cyclists are conditioned to shorter sleep durations the night before competition. That is to say that despite losing sleep, they still manage to get good-quality sleep, more so than their less-experienced counterparts. A possible reason for this may be that experienced cyclists are more prepared for the race environment. Their experience may aid them in coping with what for a less-experienced rider would be an anxiety inducing lead up to the race. With anxiety being shown to impede sleep quality, this may explain why some experienced cyclists were shown to have slightly better sleep quality. The effect sizes also suggest that more cyclists experienced a reduction in sleep duration as opposed to sleep quality. No study to the author's knowledge has been conducted on the sleep efficiency before competition of athletes of different experience levels. This notion is, therefore, untested and needs to be further explored in future research.

5.1.2 Sex Differences

When comparing the sexes, females were significantly more likely to report having experienced poorer sleep before competition in the past year (Table 11). Previous sleep studies have reported tendencies for females to report poor sleep before competition more so than males (Erlacher *et al.* 2011; and Juliff *et al.* 2015). This trend has not, however, been shown to be significant in the past (Erlacher *et al.* 2011; and

Juliff *et al.* 2015). The findings of the current study, therefore, contradict the notion that males and females experience poorer pre-competitive sleep ubiquitously. Further research is needed to investigate whether there exists a true sex difference in the incidence rate of pre-competitive sleep loss in athletes.

It must be noted that the questionnaire findings are aligned to general population studies. Females have been shown to experience more occurrences of sleep disruptions compared to males (Groeger *et al.*, 2004; Tsai & Li, 2004; Landis & Lent, 2006; Sekine *et al.*, 2006; Zhang & Wing, 2006; Lund *et al.*, 2010; and Petrov *et al.*, 2014).

Despite a sex difference being found in the questionnaire data with regards to worsened pre-competitive sleep, the same was not found for the sleep diary results. No difference between the sexes was noted for either sleep duration or sleep quality. This contradicts the findings of the questionnaire which suggest that females are more prone to experiencing poorer sleep the night before competition.

The descriptive statistics suggest that females did, on average, sleep less than males the night before the race (5h52min vs 6h30min, respectively). The inferential statistics did not, however, find this difference to be significant. The observed power for the inferential tests analysing sex differences in total sleep duration was low. This, coupled with the inconsistent findings of the questionnaire, certainly warrant further investigation into sex differences in pre-competitive sleep behaviour.

5.1.3 Competition-level differences

No statistical difference was found for the incidence rate of poorer sleep before competition between different competition levels from the questionnaire. As is consistent with the questionnaire findings, no significant differences were noted between competitive levels with regards to reported sleep quality and sleep duration. As this is the first known study to investigate a competition-level difference in athlete sleep, it is unknown whether this is a representative finding. The uneven sample numbers within the various competition-level categories make the statistical inferences too weak to conclude upon with any certainty. Future research should aim to answer this question with more appropriate sample numbers.

5.2 DISCREPANCIES IN FINDINGS

At this point in the discussion, it should be noted that there are several discrepancies between the questionnaire and sleep diary data. There are also discrepancies between the findings of the current study and that of previous research. Possible reasons for these discrepancies will be outlined first and the discussion to follow should be read with these in mind.

5.2.1 Discrepancies between the questionnaire and sleep diary

The contradictory findings between the questionnaire and sleep diary could be explained by the fact that they measure different time periods. While the questionnaire is a measure of longitudinal experience, the sleep diary is a more immediate measure based on a single competition. Differences may thus be owing to the recall accuracy of the cyclists.

Inconsistent findings between the questionnaire and sleep diary data may also have to do with the uneven sample of males and females as well as competition levels. The sample of female athletes was nearly half that of the male sample which may have weakened the statistical strength. This is especially true for the sleep diary comparisons where the observed power for the statistical tests was particularly low. The same problem arose when comparing the competition-level differences. Very low observed powers were measured when comparing competition-level differences.

Other possible confounding variables are those of the age and experience differences between the sexes. For instance, while the age and experience gap between the sexes for the questionnaire sample was small, these gaps were much larger in the sleep diary sample. Males were on average 7 years older and had 7 years more experience than the females who completed the sleep diary. The correlation data showed a significant link between years of experience and pre-race sleep quality for a small percentage of the cyclists. The age and experience gap between the sexes for the sleep diary sample may, therefore, have skewed the data. The discrepancies in the samples with regards to the comparability of the male and female groups limit the generalisability of the findings.

5.2.2 Discrepancies between current and previous findings

The inconsistencies between the current findings and previous studies may have to do with the samples of athletes. The current study's sample was largely comprised of recreational cyclists. Previous similar investigations have focused on mainly elite athletes from multiple sporting codes (Erlacher *et al.,* 2011; and Juliff *et al.,* 2015). Inconsistencies with previous findings may, therefore, be a result of competition-level differences or the difference between individual and team sport athletes.

Furthermore, all three studies using the same questionnaire were conducted in different geographical areas, namely Germany, Australia and South Africa. Environmental, social and cultural differences associated with these geographical differences could be a source of variability in sleep (Potter *et al*., 2016; and Eliasson *et al*., 2017).

Another possible inconsistency, specifically for sex differences, is that previous studies did not report on whether male and female participants were equally distributed between individual- and team-sport classifications (Erlacher *et al.,* 2011; and Juliff *et al.,* 2015). If one sex comprised the majority of either of the classifications, it could have skewed the results of these studies. When comparing sex difference findings with previous studies, it is thus unclear as to whether any observed differences are owing to sex differences or whether they are an artefact of sporting code differences.

5.3 POSSIBLE PROBLEM AREAS OF SLEEP

5.3.1 Sleep problems for all participants

A disconnect between the questionnaire and sleep diary results was found for reported sleep problems prior to the races. The most commonly reported reason for pre-competitive sleep loss from the questionnaire was related to issues falling asleep. The same finding has been recorded when the Competitive Sports and Sleep Questionnaire has been used on athlete populations in the past (Erlacher *et al*., 2011; and Juliff *et al*., 2015). The second and third most commonly reported sleep problems were related to waking up during the night and waking earlier than usual in the morning.

The sleep diary findings, however, do not align with this. While the questionnaire data suggested that sleep latency was perceived as the biggest hindrance to good-quality sleep, no general effect was found from the sleep diary that would indicate an increase in sleep latency the night before the races. The sleep diary data instead suggests that the time cyclists woke up was the major contributing factor to pre-competitive sleep loss - an observation that has also been reported previously (Lastella *et al.,* 2014; Lastella *et al.,* 2015b; and Romyn *et al.*, 2016). This aligns with the fact that the races started early in the morning. The sleep diary effect sizes also suggest waking up earlier to be a problem experienced by more participants than an increase in sleep latency. A large effect was found for earlier wake-up times the morning of the races. A small effect was noted for an increase in sleep latency the night before the races. Cohen's U_3 suggests that 92% of the cyclists woke up earlier the morning of the races than the mean wake-up time for both previous mornings. The Cohen's U_3 for sleep latency suggests, however, that only 60% of the cyclists would have taken longer to fall asleep the night before the races than the mean sleep latency times from the previous two nights. Wake-time was, however, only the third most cited issue on the questionnaire. This is in spite of wake-time being shown to be significantly earlier the morning of the race, have higher effect magnitudes and maximal observed power according to the sleep diary. Owing to the questionnaire being a 12-month recall method while the sleep diary was a single day recall tool, the question of memory recall needs to be addressed. Human beings are susceptible to false and inaccurate episodic memory recall over long periods of time (Aki l & Zaragoza, 1995; Lindsay, 1990; Loftus, Miller & Burns,1978; Zaragoza & Koshminder, 1989; Zaragoza & Lane, 1994). It is necessary to consider, therefore, that the difference in findings between the questionnaire and sleep diary may be as a result in poor memory recall.

The correlation results seem to align with the sleep diary findings when it comes to sleep duration. Both sleep latency and morning wake-up time were found to correlate significantly to total sleep duration the night before the race. Wake-up time, however, was found to explain 39% of the variance seen in sleep duration data while sleep latency could only explain 5% of the variance (Table 23). The correlation data found wake-up time to correlate neither strongly nor significantly to sleep quality (Table 24). Longer sleep latency on the other hand was found to correlate significantly but weakly with worsened sleep quality (Table 24). Indeed, an increased number of awakenings during the night was also found to correlate significantly with poorer ratings of sleep quality (Table 24).

In summary, the questionnaire's top two cited sleep problems, trouble falling asleep and waking up during the night, were found to have the most profound effect on sleep quality. The questionnaire's third most cited problem, and the sleep diary's only significant issue with the largest effect size, waking up early in the morning, seems to be the major cause of reduced sleep durations.

5.3.2 Causes of sleep problems

In the current study, all issues with sleep were reported as being largely caused by thoughts and nervousness about the upcoming races. Heightened anxiety levels have been noted in athletes the night before competition in several previous studies (Erlacher *et al.,* 2011; Lastella *et al.*, 2014; Juliff *et al.,* 2015; Romyn *et al.*, 2016; and Ehrlenspiel *et al.,* 2017). It should be noted, however, that in both Erlacher *et al.* (2011) and Juliff *et al.* (2015) more athletes reported thoughts about competition as the reason for poor sleep than nervousness unlike the findings of the present study. This may in part be explained by the evidence which suggests South Africans have a general tendency to be anxious (Stein *et al.,* 2008; and Herman *et al.*, 2009). The role of anxiety may explain why the cyclists listed sleep latency as the number one cause of sleep loss before a race and not waking up early in the morning. The 'fight or flight' response associated with anxiousness is a process by which the body mobilises energy by means of elevating the body's cortisol levels (Taylor *et al.*, 2008). This anxiety-induced arousal has been postulated to be a cause for alterations in sleep patterns (Reilly *et al.*, 2007). This may be the reason for the perceived increases in sleep latency and sleep fragmentation by the cyclists, as suggested by the questionnaire data (Table 5). This same arousal effect may be the reason why athletes do not consider waking up early in the morning to be problematic. As seen in the comments section of the sleep diary, the excitement and anticipation of competition on the morning of a race may have caused an arousal effect (Taylor *et al.*, 2008). This may have aided in waking the participants up, and thus, making the chore of waking earlier than usual less of a perceived issue (Taylor *et al.*, 2008). The anxiety felt before competition may be causing a chemical response, which in turn may extend sleep latency while making it easier to wake up and stay awake (Taylor *et al.*, 2008). The disconnect between the questionnaire and sleep diary findings may be explained by the athletes' perceptions being distorted by the chemical response to physical or psychological stress in the body (Reilly *et al.*, 2007). This is, however, speculation and requires further investigation. Studies investigating biochemical changes in anticipation of exercise have consistently shown increases in cortisol before competition (Urhausen & Kindermann, 1987; Suay *et al.,* 1999; Salvador *et al.*, 2003; and Kivilighan *et al.*, 2005). To test this theory, future research should investigate whether there is a correlation between pre-competition anxiety, biochemical response, problems related to sleep and arousal the morning of competition.

5.3.3 Sex differences in sleep problems and causes of sleep loss

The questionnaire revealed that females were more likely to report waking up during the night and also to experience unpleasant dreams before the races. These findings are not consistent with the sleep diary data or with previous studies. Both Erlacher *et al.* (2011) and Juliff *et al.* (2015) had similar findings, with females reporting more accounts of unpleasant dreams than males. Neither study, however, found a difference in the frequency of reported awakenings between the sexes. The sleep diary data suggests that females did not experience more sleep disturbances than males before the race. No sex effects were found for any of the sleep diary variables.

The cause for increased sleep disturbances reported by females on the questionnaire may be related to the anxiety theory outlined earlier. This is because female cyclists reported more accounts of nervousness the night before competition than males in this study and in previous literature (Erlacher *et al.,* 2011). This is consistent with a previous finding that South African females are generally more likely to experience anxiety than males (Stein *et al.,* 2008). This, coupled with the fact that females seem more sensitive to experiencing sleep disturbances in general (Groeger *et al.*, 2004; Tsai & Li, 2004; Bambaeichi *et al.*, 2005; Landis & Lent, 2006; Sekine *et al.*, 2006; Zhang & Wing, 2006; Lund *et al.*, 2010; and Petrov *et al.*, 2014), may explain the higher reports of sleep fragmentation in females in this study (Table 12). Juliff *et al.* (2015) did not, however, find a difference between the sexes with regards to reports of anxiety, unlike the findings of Erlacher *et al.* (2011) and the questionnaire findings of the current study.

Further research should investigate whether females are indeed at a higher risk of experiencing pre-competitive anxiety and, by extension, have higher sleep disturbances before competition.

5.3.4 Competition-level differences – Questionnaire

The only area of sleep that was found to be rated differently between competition-level groups was feeling refreshed in the morning. The provincial cyclists were found to report a significantly higher incidence of waking up not feeling refreshed the morning of a race than recreational athletes. With no other differences being recorded between the two groups, it is unclear why this may be the case and more research is needed to engage with this finding.

All competition-level groups seemed to attribute sleeping issues largely to thoughts and anxiety about the competition. Recreational athletes were, however, found to report a higher incidence of foreign environments disrupting their sleep compared to international/national cyclists. The "first-night effect" is the phenomenon whereby sleep quality is compromised the first few nights sleeping in an unfamiliar environment (Browman & Cartwright, 1980). The difference noted in this study could possibly have to do with experience. It is possible that elite athletes would be more likely to have coping methods to adapt to new sleeping environments prior to competition. Theoretically, elite athletes should be competing more frequently and in several different locations compared to recreational athletes. More research is needed to identify whether elite athletes adapt to new sleeping environments more quickly than recreational athletes. Further investigations should also endeavour to identify whether this is explained by experience or coping methods developed by elite athletes.

5.4 ATHLETE PERCEPTIONS OF SLEEP LOSS AND PERFORMANCE

As is consistent with previous questionnaire investigations (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015), over half (55%) of the cyclists who reported experiencing pre-competitive sleep loss also reported perceiving sleep loss to have no impact on their performance. To the knowledge of the author, there is no consistent evidence to suggest that realistic bouts of sleep loss (partial sleep restriction that simulates real world experience as derived from objective sleep measures) are linked to reductions in athletic performance which would support this result. Total sleep deprivation has in the past been shown to decrease time-to-exercise failure (Martin, 1981; and Temesi *et al.,* 2013). Total sleep deprivation is, however, typically not the reality of what athletes, elite or amateur, experience prior to competition (Mougin *et al.*, 1991; Leeder *et al.*, 2011; Lastella *et al.*, 2014; Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; Lastella *et al.*, 2015b; Romyn *et al.*, 2016; Ehrlenspiel *et al.*, 2017; and Knufinke *et al.,* 2017). Partial sleep loss, either through sleep restriction or sleep fragmentation, has been shown to be more likely, both in an athletic context as well as in the general population (Mougin *et al.*, 1991; Leeder *et al.*, 2011; Lastella *et al.*, 2014; Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; Lastella *et al.*, 2015b; Romyn *et al.*, 2016; Ehrlenspiel *et al.*, 2017; and Knufinke *et al.,* 2017). The results of this study found that sleep duration decreased before competition but that sleep was not curtailed entirely. Indeed, not a single cyclist monitored the night before the races in the current study reported no sleep whatsoever. That being said, 45% of the cyclists indicated that their sleep, or lack thereof, negatively affected them on competition day and 16% reported previous deteriorations in performance. To the author's knowledge, no study has been able to demonstrate that a realistic bout of sleep restriction can alter the pacing and performance of endurance athletes. The need to answer the question of whether sleep loss does indeed alter pacing and performance still needs to be addressed by future research.

5.5 ATHLETE PRE-SLEEP BEHAVIOUR

5.5.1 Worse sleep group – Questionnaire

Over half the cyclists that reported worse sleep before competition indicated that they had no specific routine to help them fall asleep. Watching television or the use of media devices to aid falling asleep was the next most frequently reported activity (18%) by the sleep loss group (Table 10). The blue frequency light emitted by such devices may in fact have negative consequences on the small athlete population which reported using them. (Minors *et al.*, 1991; Kubota *et al.*, 2002; Khalsa *et al.*, 2003; Higuchi *et al.*, 2005; Gellis & Lichstein, 2009; and Eisenstein, 2013).

The proportion of athletes using multimedia devices before bed in this study is not, however, consistent with regards to all athlete groups that have been studied (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). Erlacher *et al.* (2011) found 34% of athletes claimed to watch television before bed to relax, while Juliff *et al.* (2015) report that only 19.3% did the same. Despite the inconsistent findings, media device use at night by athletes, even at the most conservative estimates, is enough to warrant concern.

The second and third most specific pre-sleep practice which was recorded were reading and relaxation techniques, respectively. While reading may have an arousing effect owing to light, this has been shown to be less excessive than the arousal from media screens (Chang *et al.*, 2015). Relaxation techniques seem to be the most appropriate pre-sleep practice owing to the prevalence of pre-competitive anxiety. Future research should aim to investigate whether relaxation methods do indeed correlate with better pre-competitive sleep and possibly what the best technique would be.

The prevalence (10%) of using sleep medication by the worse sleep group the night before the races was consistent with Juliff *et al.* (2015) (13.1%). Erlacher *et al.* (2011), however, found that sleeping pills were only used by 1.3% of German elite athletes. Tuomilehto *et al.* (2017) have also analysed the prevalence of sleep medication used by athletes. Elite male ice hockey players were found to use sleep medication differently depending on whether it was off season or competitive season (Tuomilehto *et al.*, 2017). While 4% of athletes reported using sleeping pills during off season, 17% used sleep medication three or more nights a week during competitive season (Tuomilehto *et al.*, 2017). This may explain the inconsistency of sleep medication used in the different studies. Despite one in six elite athletes reporting using sleep medications on a regular basis, many still reported poor or disturbed sleep (Tuomilehto *et al.*, 2017). The effects of popular sleep-aiding medications on next-day performance have not yet been fully explored and remain tentative (Chennaoui *et al.*, 2015; and Nédélec *et al.*, 2015). It is thus unclear whether this practice truly benefits sleep prior to competition.

It would seem that, with current and previous studies' findings combined, few athletes have appropriate methods for managing sleep prior to an important competition (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). As anxiety has been shown to be a major sleep disruptor prior to competition, strategies that reduce nervousness and stress could possibly improve pre-competitive sleep for athletes. Another possible intervention that future research may take into consideration is the role of sleep-hygiene education. Indeed, sleep feedback and sleep-hygiene education have been shown to be viable methods of intervening in athlete populations to correct these issues (Tuomilehto *et al.*, 2017; and Van Ryswyk *et al.*, 2017). These strategies have been shown to increase sleep duration and efficiency 6 weeks post intervention (Van Ryswyk *et al.*, 2017) and improve sleep quality a year post intervention (Tuomilehto *et al.*, 2017). These interventions focused on athlete sleep in general, however, and future research should identify whether similar strategies can lower the incidence rate of pre-competitive sleep loss. These interventions did not record how athlete pre-sleep behaviour changed after sleep-hygiene educational programs were conducted (Tuomilehto *et al.*, 2017; and Van Ryswyk *et al.*, 2017). Specific pre-sleep behaviours that may be particularly negative for athlete sleep were, therefore, not identified.

5.5.2 Worse sleep group vs normal sleep group – Questionnaire

Cyclists who reported not having slept worse before competition in the last year were significantly more likely to have no specific routine to help them fall asleep (Table 10). Furthermore, the normal sleep cyclists were significantly less likely to use relaxation techniques and reading to try to promote sleep onset (Table 10). It seems, however, that the worse sleep group were more likely to engage consciously in activities which they perceived would promote sleep. From this, it might be theorised that the worse sleep group are more conscious about their compromised sleep before competition and, therefore, attempted to compensate by using a sleep-promoting strategy which they perceived to be effective. For instance, athletes have been shown to value good sleep as an important factor in performance (Oliver *et al.*, 2009; Lastella *et al.*, 2014; Sargent *et al.*, 2014a; and Lastella *et al.*, 2015a). If the athletes struggle to sleep while knowing that sleep is important, then sleep latency may become a source of anxiety. The theory would then be that the conscious thoughts about needing good sleep may be causing anxiety that would prolong sleep onset which would in turn increase anxiety even further.

The correlation data may add credence to this notion. Significant, albeit weak, links between pre-competitive sleep quality and: general sleep quality; pre-race estimated sleep quality and whether or not the cyclists slept worse before competition in the past year were found (Table 24). Pre-race estimated sleep quality was also found to correlate significantly with pre-competition sleep duration. That is to say that the worse athletes anticipated their sleep would be prior to competition, the shorter their sleep duration tended to be. These findings all suggest that poor sleep prior to competitions is a recurring experience. That is to say, the subset of cyclists who experience deteriorated sleep before competition in the past year were likely to experience it again before the races. This may suggest that those cyclists experiencing poorer sleep quality before competition have experienced it before and are now actively trying to avoid experiencing it again.

One of the 'other' responses from the questionnaire serves as a good example to attempt to elucidate this theory: "Go to sleep early" was reported by two cyclists as their sleep strategy, with one of them adding "usually never works". Firstly, it should be noted that this is a conscious act in an effort to avoid poor sleep. Secondly, the reason why going to sleep earlier than usual is not a reliable method to increase or maintain normal sleep durations is because of the "Forbidden Zone of Sleep" (Lavie, 1986). This is a fluctuation within the circadian rhythm where it is difficult to fall asleep, typically in the early evening, a few hours prior to a major sleep phase (Pereira & Alves, 2011). The circadian rhythm is, thus, not in a sleep-promoting phase at the time that the individuals wish to sleep. The result is that the individuals cannot fall asleep. The individuals are, however, acutely aware that they should be asleep already or at least that they should fall asleep soon. This may result in psychological stress and anxiety which would cause a rise in cortisol (Taylor *et al.*, 2008). The possible cortisol spike would further delay sleep.

ıntervention study findings would seem to contradict this notion (Tuomilehto *et al.*, 2017; and Van Ryswyk *et al.*, 2017). Sleep feedback and sleep-hygiene education interventions have been shown to improve sleep, not worsen it (Tuomilehto *et al.*, 2017; and Van Ryswyk *et al.*, 2017). Perhaps the issue it is not that the athletes were simply consciously trying to avoid a bad night of sleep. Perhaps the methods they were implementing were having a contrary effect, as was shown to be the case with the use of multimedia devices prior to competition. This does not explain, however, why the "normal sleep" group were statistically just as likely to use multimedia devices before bedtime as the "worse sleep" group.

The findings of the current study cannot definitively point to activities which increase the likelihood of good or poor sleep. The relationship between pre-sleep behaviour and pre-competition sleep is complex and further research is needed. Furthermore, there is also a need to corroborate whether pre-competition sleep loss is a recurring event in a subset of athlete populations.

5.6 EXPLAINING LARGE VARIANCE

The sleep diary data consistently had high variance on the Friday night before the races (two nights before the race). This could be explained by a pattern well documented in the general public. Repeatedly partially restricting sleep during week nights and subsequently "catching up" lost sleep over weekend nights has been noted by several studies (Monk *et al*., 2000; Hansen *et al*., 2005; National Sleep Foundation, 2010; Tsui & Wing, 2009; and Wing *et al*., 2009). It could be argued that this pattern explains the large variation seen in sleep length and bed times two nights before the races. When considering the comments on the sleep diary and the 'other' responses on the questionnaire regarding sleep strategies, however, a different explanation can be considered. Several cyclists noted that they ingested alcohol and went out on the Friday night. In contrast, others indicated that in anticipation of poor sleep the night before the race (Saturday night), they attempted to over-compensate by accruing extra sleep on the Friday night. It is likely that both of these explanations play a role in understanding the variance in the current findings. Further research into this finding should, however, be conducted to further understand the sleeping patterns of cyclists and athletes in general. It should also be noted that the sex and competition-level comparison data suggest that this variance is mainly attributed to male- and recreational-cyclist variance. This may suggest that male, recreational cyclists are more likely to vary from normal sleep either on a Friday night or two nights before a race. Another possible explanation for the variance being largely limited to male and recreational cyclists is that of sampling error. The sample disproportionally consisted of male and recreational cyclists, allowing for the possibility of more variance in the data. This is another finding which should be addressed by future research.

5.7 LIMITATIONS

There were limitations to the current study, over and above those which have already been outlined, which should be acknowledged.

The participants in this study were only monitored via sleep diary for a maximum of three nights prior to the races. This adds the limitation of not knowing how participants slept prior to the races compared to their habitual sleeping habits. Future research should no doubt try to monitor a sample over rest, training and competition phases to truly gain insight into the fluctuations within athlete sleep. Future iterations of similar investigations should also try to better screen potential participants for sleep disorders so that this does not skew the data.

While the Telkom 94.7 Cycle Challenge only offered one distance to be raced (94.7km), the Tsogo Sun Amashova offered three (35km, 65km and 106km). All participants taking part in the Telkom 94.7 Cycle Challenge were entered for the full race. The participants taking part in the Tsogo Sun Amashova, however, could be entered in any of the three race variations. This was done to allow for the greatest scope of competition level of cyclists to be recruited. This decision may, however, also be seen as a limitation. The different distances would have meant different start times. The differing start times may have skewed the sleep data.

Although both male and female data were recorded, it must be noted that there were double the number of male participants than females in the study. This uneven distribution has not been a common feature in previous large-scale athlete sleep quantification studies (Erlacher *et al.*, 2011; and Juliff *et al.*, 2015). It is unclear whether the disparity in numbers in the current study is owing to a sampling error or whether it is representative of the breakdown of the sexes taking part in mass participation cycling races within South Africa. The races monitored in this study have not, to the knowledge of the author, released demographic details of the total field of cyclists participating. Ascertaining whether the sample in the study is truly representative is, therefore, not possible.

In hindsight, proactive participant recruitment over social media could have allowed for recruitment to have taken place prior to and including during the registration expos. Recruitment on social media sites and targeting cycling teams may not only have increased the overall sample size but it may have specifically increased the amount of elite athletes that could have been recruited.

The author did intend on determining the chronotype of each cyclist, but for pragmatic reasons, a decision was made against this. Potential participants were less willing to take part in the study when being told that they had to complete multiple questionnaires. A compromise was decided upon by removing the morningness eveningness questionnaire in order to increase the overall sample of the study. As a consequence, however, inferences could not be made regarding whether certain chronotypes are more susceptible to experiencing pre-competitive sleep loss. Replication studies should take this into account and find appropriate ways of navigating this issue.

A subjective sleepiness rating before each race could also have been used to investigate the sleepiness of cyclists at the start of the races as well as possibly during and after the races. The practicality of such a measure on such a large sample could potentiallybe a problem in and of itself, however. Without this measure, it is not possible to know what the influence of sleep and sleep loss was on how participants felt upon awaking before the races, as well as during and after the races.

Equipment such as actigraphs were not available for large samples such as that monitored in this study. As a consequence, more detailed insights into sleep and sleep efficiency could not be recorded. While this may be of interest to future research projects, the monitoring and tracking of hundreds of participants and actigraphs seems impractical.

This is the first known attempt at documenting and comparing the pre-competitive sleeping habits of both competitive and amateur athletes. That being said, many limitations restricted this study from comparing competition levels appropriately. Firstly, not enough international, national and provincial cyclists were recruited to allow for comparisons of appropriate statistical power to be made. As a result, international and national cyclists had to be grouped into an elite-athlete category for questionnaire comparisons, while international, national and provincial athletes had to be grouped into a competitive-cyclist category for the sleep diary data. This was done to allow for comparisons of appropriate statistical power. That being said, the highest statistical power observed for the sleep diary comparisons, for example, was OP=0.17. No significant differences were found between the competition-level groups for the sleep diary items. This result may seem contrary to what may be expected. Indeed, certain differences would be expected to exist considering the different start times of the races for different levels of cyclists. For example, in the races monitored in this study, an elite cyclist could have started the races up to 4 hours before a novice rider. With recreational cyclists having much later starting times, it would be expected that this would mean pre-competitive sleep loss would be less prevalent in this group. This is especially probable when considering that wake-time was the strongest predicting factor of pre-competitive sleep loss (Sargent *et al.*, 2014a; Sargent *et al.*, 2014b; Lastella *et al.,* 2014; Lastella *et al.*, 2015b; and Romyn *et al.*, 2016). The second major limitation of this study regarding competition-level differences was that start times were not recorded. This means that a correlation between start time and total sleep duration could not be made. Studies that have looked at the sleeping habits of athletes prior to training sessions have found that start times are a major predictor of sleep loss (Sargent *et al.*, 2014a; and Sargent *et al.*, 2014b). Replication studies are needed to show whether early morning start times have a causal link with pre-competitive sleep loss. If found to be the case, then it should also be identified whether elite athletes have earlier start times than recreational athletes in general which would place them at a higher risk of experiencing pre-competitive sleep loss.

Another major limitation that may explain the large variation within the data of the recreational group would be that the definition of the various competition-level groups, in the current version of the questionnaire, were not definitive enough. One method by which to group competition level of the cyclists that may have been more appropriate would have been to group them according to batch starting time. This would, however, present another issue. The 94.7 race alone had 60 different batches starting at different times. Getting large enough samples from enough batches to make meaningful comparisons between competition-level groups would have been highly unlikely for a single researcher recruiting at the race Expos. Future research should take this into account when comparing the pre-competition sleeping habits of athletes of varying competition levels.

Of the 336 participants who completed the Competitive Sports and Sleep Questionnaire, only 92 (27%) filled in and returned a Core Consensus Sleep Diary. This highlights a limitation with regards to questionnaire studies, namely, poor retention of participants.

It must be noted that the correlation data from this study only found significant correlations that were weak. This should be taken into consideration when inferring trends from the correlations that have been discussed. No definitive conclusions can be drawn from the strength of the correlations in the results. Rather, the correlations which have been identified as significant should be further explored in a more homogenous group of athletes to identify whether true links exist and whether the links are strong enough to warrant concern.

The approach to the current research was constrained by a reductionist approach. The focus on the link between the races and athlete sleep may have detracted from other variables of importance. No information regarding travel, family or work life was taken into consideration in the current study. Any of these aspects could on their own have altered sleep patterns regardless of the presence of a race. Future research should aim to study the athlete from a systems approach in which as many variables as possible are monitored in an effort to fully understand athlete pre-competitive sleep behaviour.

CHAPTER VI

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The current study aimed to investigate the pre-competitive sleep behaviour of South African male and female cyclists of varying skill levels. Ninety percent of the sample identified their nationality as South African. This is, to the knowledge of the author, the first mass sleep quantification study that has been conducted on a primarily South African athlete population.

The findings of the study showed that the majority of the cyclists experienced worse sleep the night before competition. A total of 225 out of 336 cyclists indicated sleeping worse at least once prior to competition within the past year. Furthermore, out of the 92 cyclists who completed a sleep diary for the nights before the race, 61 were found to sleep less than the lowest recommended sleep duration of 7hrs for healthy adults (Balkin *et al.*, 2008, Bixler, 2009; Carskadon & Dement, 2011 Hirshkowitz *et al.,* 2015; and Watson, *et al.*, 2015). The average sleep duration was only 6h19min and the average sleep quality of the cyclists was shown to be worse the night before the race. This investigation shows, therefore, that cyclists experience shorter sleep durations than is recommended and poorer sleep quality than normal the night before a race.

No differences were found between the sexes regarding any of the sleep diary variables the night before the races. Males and females had similar reported sleep durations and sleep quality. Similarly, no differences in sleep diary data were found with regards to the competition-level of the cyclists.

In general, the cyclists reported that falling asleep was the primary problem they faced with sleep prior to competition in the retrospective questionnaire. This perception was not, however, corroborated by sleep diary data; in this, no increase in sleep latency prior to competition was reported. The sleep diary data suggested instead that the time at which cyclists awoke the morning of the race was the major contributor to reduced sleep durations. Both of these factors should be seen as major barriers to pre-competitive sleep. The most reported reason for sleep disturbances was found to be thoughts and anxiety related to the race the night before competition. Interventions aimed at reducing anxiety should thus be the focus of future research.

Sex differences revealed that females were more likely to wake-up after sleep onset and experienced more unpleasant dreams than males. Females were also found to be more likely to report pre-race anxiety the night before competition than males.

The analysis of pre-sleep behaviours for the night before the race showed a clear lack of sleep-hygiene knowledge within the cyclist population. Many cyclists engaged in activities which are theorised to delay or disrupt sleep indicating that sleep education is a need within this population.

Overall, this study concludes that cyclists are an at risk group with regards to experiencing sleep loss the night before competition.

6.2 RECOMMENDATIONS

6.2.1 Future sleep quantification research

The findings of this study are limited to a group of road cyclists competing in mass participation cycling events within South Africa. While the results are comparable to previous athlete pre-competition sleep quantification studies, the current findings cannot be generalized to all cyclists or all athletes. Replication studies are needed to verify the current findings and possibly show similar or varying trends in other athlete populations. More research, specifically in the interest of identifying sex and competition-level differences in athlete sleep, is needed owing to the weak statistical inferences that could be made in the current study. Chronotype should ideally be included in future quantification studies to identify whether an individual’s chronotype influences pre-competitive sleep behaviour.

A universal, validated and reliable questionnaire must be identified or constructed to investigate athlete sleep/wake behaviour. The disparity between the questionnaire and sleep diary used in the current study is of concern. If used in isolation, the results of either tool may overlook additional problem areas of sleep. A more in-depth analysis of pre-competitive sleep loss was only possible in this study because of the use of both tools.

The relationship between pre-race anxiety/excitement and sleep/wake behaviour needs to be further investigated. The interaction the chemical response to stress has on increasing the likelihood of sleep loss needs to be understood in more detail.

Pre-competitive sleep loss has been shown in several independent studies on different athlete populations. What remains unclear is whether this sleep alteration objectively alters performance. The results of this study would suggest that any laboratory-based sleep restriction protocol looking into the effects of sleep loss on physical performance, specifically cycling should consider the following: Participants should be housed in a laboratory to simulate the issues raised in the questionnaire with regards to sleeping in a foreign environment. Bed time should be slightly delayed to simulate problems falling asleep. The participants should then be woken up and kept awake for short periods of time during the night owing to the increase, albeit non-significant, in the number of awakenings and duration of those awakenings the night before the races. Final awakening should be scheduled in a manner that ensures that this is the major contributor to shortened sleep periods before an exercise protocol. According to the results of this study, the protocol above would serve as the most realistic option of testing the effects of sleep loss on performance within a laboratory setting. This is owing to the results of this study showing patterns of sleep fragmentation to be the issue faced in real world situations. This is in contrast to the sleep restriction protocols that laboratory studies have used previously.

6.2.2 Practical recommendations

Coaches and support staff of cyclists and athletes in general have to engage with not only the importance of sleep, but the strategies and practices that encourage good sleep. Sleep-hygiene education interventions have shown to improve the general sleep of athletes. Similar educational programs should be considered for all athletes, however, these interventions have yet to be shown to improve pre-competitive sleep. While elite athletes may have coaches to address such interventions, more accessible sleep education should be made available for recreational athletes. Future research may investigate which method of educational material dissemination would be most beneficial.

Athletes should be aware of the factors that have been identified in this study as being problematic for pre-competitive sleep. Anxiety seems to be a major cause of sleep loss the night before a race. As a consequence, appropriate stress relief techniques should be identified and practised before competition to try and negate increased sleep latency. Early morning competition times cannot be avoided. Going to sleep earlier than usual is not an appropriate method to counter early morning wake times as has been discussed. Instead, athletes should try to take early morning competition into consideration several days before. Napping the day before the race in order to increase overall sleep duration and decrease homeostatic sleep pressure may be one avenue which could be explored.

Traveling and sleeping in foreign environments before competition can also not always be avoided. Athletes should find strategies which aid them in getting comfortable more quickly in unknown sleeping conditions in order to minimise this variable's effect on sleep.

Closing statement

In summation, cyclists are at risk of experiencing poor sleep prior to competition regardless of sex and competition level. This risk is an artefact of athletic competition itself as is suggested in the current results. While the implications of sleep loss on performance are not entirely definitive, it is the recommendation of this study that strategies be developed by athletes to avoid poor pre-competitive sleep.

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8 APPENDICES

Appendix A

Table 25. Summary of all sleep quantification studies that could be found and were accessible to the author. Search was concluded in February 2017.

	Author:	Participants:	during:	Methods and materials	Major findings of sleep loss:	Major findings of sleep loss aetiology:
Training phase sleep	Leeder *et al*, (2012)	47 athletes - Males and females - Various sporting codes - Olympic athletes	Training phase sleep	Actigraphy measured sleep for 4 nights of an out of competition training phase	Athletes had significantly different values for all sleep variables except for total sleep duration when compared to a control, non athlete group	Athletes had poorer sleep characteristics than the control Male athletes had higher mean times for 'time awake' and lower sleep efficiency than females
	Sargent *et al*, (2014a)	7 swimmers - Males and females - Olympic athletes	Training phase sleep	Sleep diary and actigraphy measured sleep for 14 nights -12 training days -2 rest days	Athletes obtained 5h24 (±1h18) sleep before training days compared to 7h06 (±1h12) before rest days	Earlier bed times and earlier wake up times seemed to be the major changes causing the loss of sleep prior to training days. Early morning training sessions seem to be the cause of sleep restriction during training.
	Sargent *et al*, (2014b)	70 athletes - Males and females - Various sporting codes - Elite athletes	Training phase sleep	Sleep diary and actigraphy measured sleep for 14 nights	Athletes obtained 6h30 (±1h24) sleep on average. Athlete sleep was significantly reduced on nights prior to training compared to before rest days	Reduced sleep durations were correlated with increased levels of pre-training fatigue. Early morning training sessions seem to be the cause of sleep restriction during training and increased pre-training fatigue.
	Lastella *et al*, (2015a)	124 athletes - Males and females - Various sporting codes - Elite athletes	Training phase sleep	Sleep diary and actigraphy measured sleep for 7 nights of a typical training phase	Average sleep of 6h48 (±1h06)	Individual sport athletes had earlier bed times, earlier wake times and obtained less sleep (6h30 vs 7h) than team sport athletes.
	Knufinke *et al*, (2017)	98 athletes - Males and females - Various sporting codes - Elite youth athletes	Training phase sleep	Pittsburgh Sleep Quality Index Holland Sleep Disorder Questionnaire Expanded Consensus Sleep Diary Groningen Sleep Quality Scale The Global Vigor and Affect Scale The Karolinska Sleepiness Scale Sleep Hygiene Index	The athletes averaged sleep durations of 8h11 (±45min) 41% of the athletes, however, were classied as 'poor sleepers' and 12% were diagnosed with a sleeping disorder	Irregular sleep/wake patterns were noted along with psychological strain and arousing pre-sleep behaviours, specifically the exposure to blue-light and consumption of large meals.

Pre-competitive sleep	Erlacher *et al*, (2011)	632 German athletes: - Males and females - Various sporting codes - Elite athletes	Pre-competitive sleep behaviour	12 month retrospective questionnaire (Competitive Sports and Sleep Questionnaire)	62.3% had experienced worse sleep prior to competition within the perious 12 months	Problems falling asleep was the main reason reported for poor sleep (79.7%). Thoughts (76.6%) and nervousness (59.9%) about competition were the main cause of this.
	Lastella *et al*, (2014)	103 marathon runners - Males and females	Pre-competitive sleep behaviour	Survey/sleep diary BRUMS	Mean pre-competitive sleep duration of 5h51 (±1h25) 68% of participants experienced poorer than usual sleep	Anxiety (21%); Noise (15.3%) and toilet (14.3%) were the top three reasons given as the causes of sleep disturbances.
	Juliff *et al*, (2015)	283 Australian athletes: - Males and females - Various sporting codes - Elite athletes	Pre-competitive sleep behaviour	12 month retrospective questionnaire (Competitive Sports and Sleep Questionnaire) Pittsburgh Sleep Quality Index	64% had experienced worse sleep prior to competition within the perious 12 months	Problems falling asleep was the main reason reported for poor sleep (82.1%). Thoughts (83.5%) and nervousness (43.8%) about competition were the main cause of this.
	Ehrlenspiel *et al*, (2017)	79 athletes - Males - Various sporting codes - Elite athletes	Pre-competitive sleep behaviour	Recorded sleep quality and competitive anxiety for 4 days prior to competition	Sleep quality worsened from 4 days prior to competition to the day of competition	Pre-competitive sleep problems appear to correlate with cognitive anxiety
Multiphase sleep monitoring	Lastella *et al*, (2015b)	21 athletes Males - Endurance cyclists	Baseline, Pre-competition, during competition	Sleep recorded with actigraphy for 6 nights during training, 3 nights before competition and 2 nights during competition	Cyclists slept 7h24 during training and 6h48 before competition	Early morning competition times seemed to be the major cause of pre-competitive sleep loss
	Romyn *et al*, (2016)	8 athletes - Females - Netball - State level athletes	Sleep was monitored for a 7 day training phase and a 7 day competition phase	Sleep was monitored using actigraphy State anxiety was measured using the Profile of Mood States-Adolescents	Sleep efficiency was found to be greater during competition compared to training	Increased anxiety prior to bed seems to influence sleep quality negatively
	Dennis *et al*, (2016)	22 athletes - Males - Australian Football League - Elite athletes	Pre-match sleep, match-day, Post-match sleep	Actigraphy measured for 2013 competitive season	Athlete sleep was found to have no significant correlation with injury incidence	
	Staunton *et al*, (2017)	17 athletes - Females - Basketball - Elite athletes	Baseline, Pre-match, Match-day, Post-match sleep	Sleep was recorded for two consecutive competition seasons (30 weeks) using actigraphy	Athletes averaged 7h36 (±1h30) of sleep a night over the time monitored	Match scheduling was found to impact sleep/wake behaviours Large inter-individual variability was found for the correlation of sleep and match performance
Sleep interventions	Tuomilehto *et al*, (2017)	107 athletes - Males - Ice hockey - Elite athletes	1 year follow up post intervention	Athletes were given sleep counselling and if needed individuals were given treatment plans based on polysomnography data	83% of athletes reported having benefited from the intervention	The intervention increased sleep quality significantly in the athletes
	Van Ryswyk *et al*, (2017)	25 athletes - Males - Australian Football League - Elite athletes	6 week intervention	Athletes were given constant sleep feedback and had a mid intervention education and feedback session	The intervention increased athlete sleep duration and sleep efficiency significantly	The intervention alsop increased scores of vigor and dreased fatigue scores for the participants

Appendix B

12 month retrospective Competitive Sports and Sleep Questionnaire

Dear Participants,

The following questionnaire is collecting data about your activity in sports and your sleeping habits prior to important competitions or games. The aim of the survey is to examine any correlation between activity in sports and sleep. The questions are referring to several areas:

- Demographic data
- Questions about your sport
- Questions about sleep habits prior to important competitions or games

All data will be kept strictly confidential and will be used solely for scientific purposes. Please answer all questions. If you are not completely sure for one question then, please, check the answer which is closest to your answer.

Thank you very much for your participation!

	Section 1 - Demographic			
1.1	**First name:**			
1.2	**Surname:**			
1.3	**Age:**			
1.4	**Please state your sex:**	M / F		
1.5	**Nationality:**			
1.6	**Email Address:**			
	Section 2 - Questions about your sport			
2.2	**How long have you been cycling:**			
2.3	**Who do you cycle for:**			
			Club	
			School	
			University	
			Company	
			Unorganised	
	Other (Please fill in)			
2.4	**On which level are you practicing your sport right now:**			
	(please mark the highest level you belong to)		International level	
			National level	
			Provincial level	
			Local level	
2.5	**How much time do you spend practicing per week on average?**			
2.6	**How often do you practice per week?**			

	Section 3 - Questions about sleeping habits for the past 12 months before competition			
3.1	How long do you sleep on an average night?			
3.2	How long do you sleep regularly during the day? (e.g. naps)			
3.3	How do you estimate your sleep quality in general?			
			Very good	
			Good	
			Normal	
			Bad	
			Very bad	
3.4	How do you sleep in the night(s) prior to an important competition or game in comparison to your usual sleep habits?			
			Much better	
			Slightly better	
			Same	
			Slightly worse	
			Much worse	
3.5	Have you in the past 12 months, compared to your usual sleep habits, slept worse in the night(s) prior to an important competition or game?		Yes	No
	If no, skip to Qu 3.9			
3.6	What kind of problems did you experience with your sleep prior to an important competition or game?			
	(more than one answer is possible)	Problems falling asleep		
		Waking up at night		
		Waking up early in the morning		
		Not feeling refreshed in the morning		
		Unpleasant dreams		
	Others (please fill in):			
3.7	What reasons were responsible for your sleeping problems prior to an important competition or game?			
	(more than one answer is possible)	Not used to surroundings		
		Noises in the room or from outside		
		Nervousness about competition/ game		
		Thoughts about the competition/game		
	Others (please fill in):			
3.8	In what manner did the sleeping problems influence your performance during the competition or game?			
	(more than one answer is possible)	No influence		
		Worse performance in competition/game		
		Bad mood the following day		
		Increased daytime sleepiness		
	Others (please fill in):			
3.9	Which strategies do you use to sleep well in the night(s) prior to an important competition or game?			
	(more than one answer is possible)		No special strategy	
			Methods to relax	
			Reading	
			Watching TV	
			Sleeping pills	
	Others (please fill in):			

Appendix C

General Instructions

What is a Sleep Diary? A sleep diary is designed to gather information about your daily sleep pattern.

How often and when do I fill out the sleep diary? It is necessary for you to complete your sleep diary every day. If possible, the sleep diary should be completed within one hour of getting out of bed in the morning.

What should I do if I miss a day? If you forget to fill in the diary or are unable to finish it, leave the diary blank for that day.

What if something unusual affects my sleep or how I feel in the daytime? If your sleep or daytime functioning is affected by some unusual event (such as an illness, or an emergency) you may make brief notes on your diary.

What do the words "bed" and "day" mean on the diary? This diary can be used for people who are awake or asleep at unusual times. In the sleep diary, the word "day" is the time when you choose or are required to be awake. The term "bed" means the place where you usually sleep.

Will answering these questions about my sleep keep me awake? This is not usually a problem. You should not worry about giving exact times, and you should not watch the clock. Just give your best estimate.

Item Instructions

Use the guide below to clarify what is being asked for each item of the Sleep Diary.

Date: Write the date of the morning you are filling out the diary.

1. What time did you get into bed? Write the time that you got into bed. This may not be the time that you began "trying" to fall asleep.

2. What time did you try to go to sleep? Record the time that you began "trying" to fall asleep.

3. How long did it take you to fall asleep? Beginning at the time you wrote in question 2, how long did it take you to fall asleep.

4. How many times did you wake-up, not counting your final awakening? How many times did you wake-up between the time you first fell asleep and your final awakening?

5. In total, how long did these awakenings last? What was the total time you were awake between the time you first fell asleep and your final awakening. For example, if you woke 3 times for 20 minutes, 35 minutes, and 15 minutes, add them all up (20+35+15= 70 min or 1 hr and 10 min).

6. What time was your final awakening? Record the last time you woke up in the morning.

7. What time did you get out of bed for the day? What time did you get out of bed with no further attempt at sleeping? This may be different from your final awakening time (e.g. you may have woken up at 6:35 a.m. but did not get out of bed to start your day until 7:20 a.m.)

8. How would you rate the quality of your sleep? "Sleep Quality" is your sense of whether your sleep was good or poor.

9. *Comments* If you have anything that you would like to say that is relevant to your sleep feel free to write it here.

Thank you very much for your participation!!

Consensus Sleep Diary - Core				
Date	Example	17th November	18th November	19th November
1. What time did you get into bed?	10:15 p.m.			
2. What time did you try go to sleep?	11:30 p .m.			
3. How long did it take you to fall asleep?	55 min.			
4. How many times did you wake-up, not counting your final awakening?	3 times			
5. In total, how long did these awakenings last?	1 hour 10 min.			
6. What time was your final awakening?	6:35 a.m.			
7. What time did you get out of bed for the day?	7:20 a.m.			
8. How would you rate the quality of your sleep?	○ Very poor ○ Poor ● Fair ○ Good ○ Very good	o Very poor o Poor o Fair o Good o Very good	o Very poor o Poor o Fair o Good o Very good	o Very poor o Poor o Fair o Good o Very good
9. Comments (if applicable)	I have a cold			

Appendix D

How much sleep do you get?

Participate in a scientific study that aims to find out if cyclists get enough sleep before competition

The Department of Human Kinetics and Ergonomics at Rhodes University is interested in investigating the following:

- The incidence rate of precompetitive sleep loss in a cyclist population.
- If precompetitive sleep loss does occur, what are the major reasons for why it happens.
- Identifying whether or not cyclists implement good sleep hygiene practices prior to competitions.
- Quantifying just how much sleep cyclists are getting the night prior to competition.

Ethical approval for the study was granted by the Rhodes University Ethics Committee

What would you have to do?

1. Fill in a few quick questionnaires
2. Keep a sleep diary for the nights remaining until the Telkom 94.7 Cycle Challenge

In return you'll receive evidence based sleep hygiene tips as well as learn a little about how your participation in sport affects your sleep!

Researcher:
Travis Steenekamp
083 309 7305
g10s2379@campus.ru.ac.za

RHODES UNIVERSITY
Where leaders learn

Appendix E

INFORMATION LETTER

Dear Participant

Thank you for showing interest in being involved in this project entitled:

"QUANTIFICATION OF PRECOMPETITIVE SLEEP/WAKE BEHAVIOUR IN A SAMPLE OF SOUTH AFRICAN CYCLISTS"

The Department of Human Kinetics and Ergonomics at Rhodes University is interested in investigating the following:

- The incidence rate of precompetitive sleep loss in a South African cyclist population.
- Identifying the major reasons for why precompetitive sleep loss occurs, if indeed it does occur.
- Identifying whether or not South African cyclists implement good sleep-hygiene practices prior to competitions.
- Quantifying just how much sleep South African cyclists are getting the night prior to competition.

WHAT WILL BE REQUIRED

Your involvement in this study will require you to fill in three short questionnaires and a sleep diary for the nights remaining from the time of your registration until the Telkom 94.7 Cycle Challenge. The questionnaires are the Horne-Östberg Morningness-Eveningness questionnaire and a shortened version of The Competitive Sports and Sleep Questionnaire. You will be asked to fill these in at your own pace and once completed return it once more to the primary researcher. You will then be given a sleep diary to take home with you. You will be asked to record estimations of the time you go to bed, the time you fall asleep, the time you wake-up, the time you get out of bed and the number of times you wake-up during the nights leading up to the race. Along with this you will also have to record the length of any daytime naps or additional sleep you gained during the days before the race. On the morning of the race you will need to return your completed sleep diary to a primary researcher who will be located at the starting and venues of the race or you can simply complete this information in an online version.

Please note that will have the right to withdraw your participation from the study at any point for any reason whatsoever. Your personal data will also be kept strictly confidential and your anonymity will be ensured throughout the process. Each participant's data will be coded for the sake of anonymity and only primary researchers will keep and have access to the lists of participant names and the corresponding codes that identified them. All data will be stored in electronic or written form with all electronic data being stored on the personal computers of the researchers. Any data recorded on communal research laptops will be transferred and removed from said laptop.

All participants are offered to be kept informed of the final results of the study if they express an interest in wanting feedback on the project. Along with any results you will also be sent some sleep-hygiene do's and don'ts tips that may help you in the future.

Thank you for your interest shown and for agreeing to participate in this study. If you have any questions or concerns please feel free to ask me at any time.

Yours Sincerely

Travis Steenekamp Dr Jonathan Davy Prof Candice Christie

g10s2379@campus.ru.ac.za j.davy@ru.ac.za C.Christie@ru.ac.za

0833097305 0722260430 083 561 6936

Appendix F

PARTICIPANT CONSENT FORM

I,……………………………….having been fully informed of the research project entitled:

"QUANTIFICATION OF PRECOMPETITIVE SLEEP/WAKE BEHAVIOUR IN A SAMPLE OF SOUTH AFRICAN CYCLISTS"

do hereby give my consent to act as a participant in the above named research.

I am fully aware of the procedures involved as well as the potential risks and benefits associated with my participation as explained to me verbally and in writing. In agreeing to participate in this research I waive any legal recourse against researchers of Rhodes University, from any and all claims resulting from personal injuries sustained whilst partaking in the study. This waiver shall be binding upon my heirs and personal representatives. I realise that it is necessary for me to promptly report to my researchers any signs or symptoms indicating any abnormality or distress. I am aware that I may withdraw my consent and withdraw from participation in the research at any time. I am aware that my anonymity will be protected at all times, and agree that all information collected may be used and published for statistical or scientific purposes or for teaching purposes.

Any questions which may have occurred to me have been answered to my satisfaction.

PARTICIPANT

…………………	…………………..	…………………..
(Print name)	(Signed)	(Date)

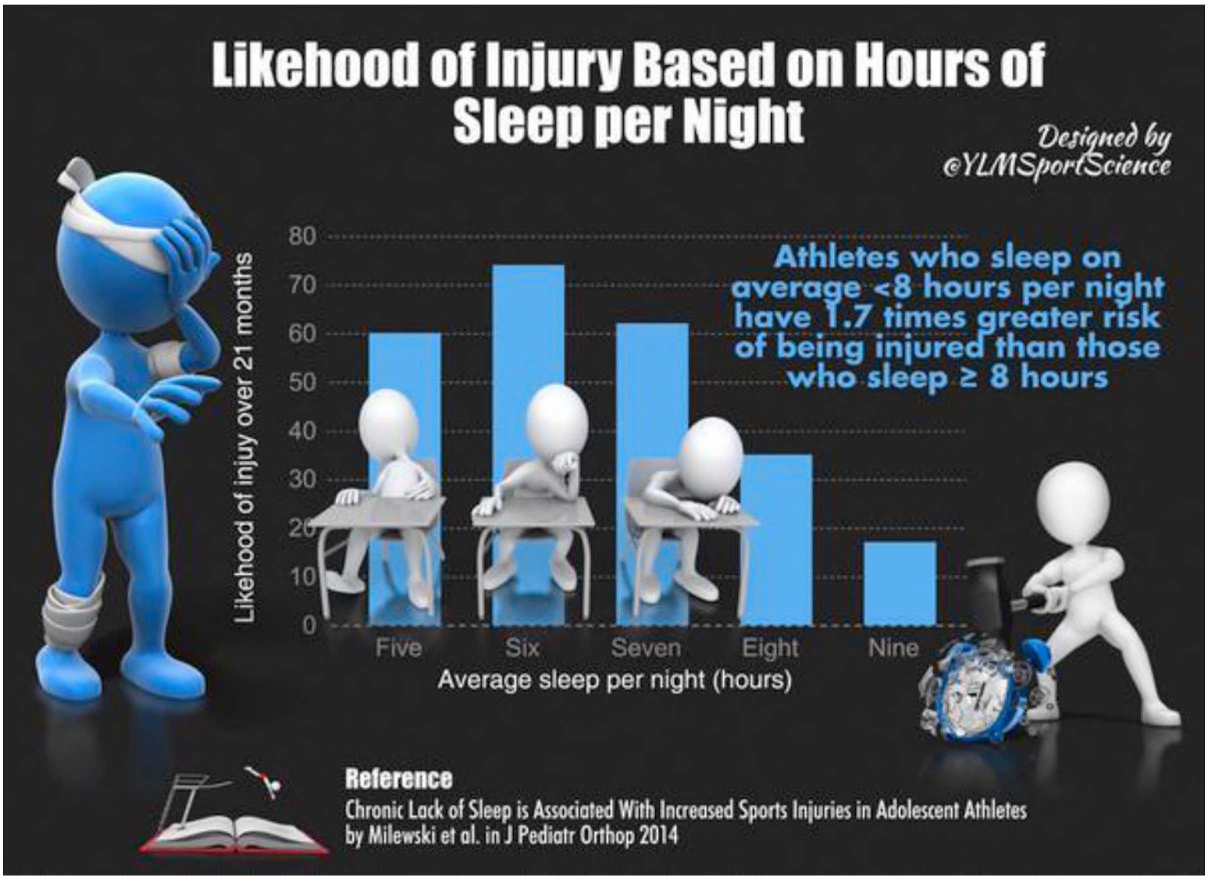
RESEARCHER

…………………	…………………..	…………………..
(Print name)	(Signed)	(Date)

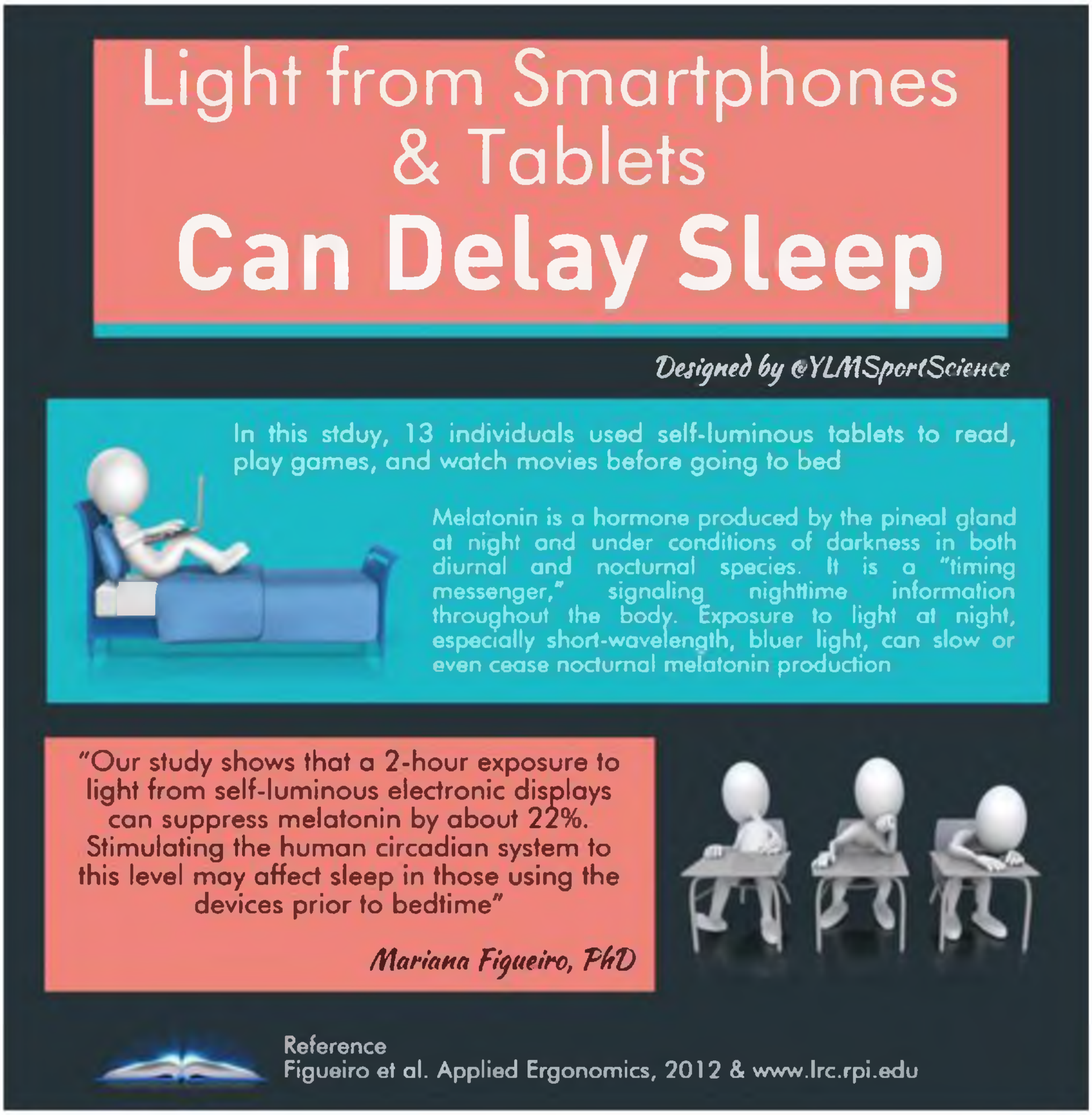
WITNESS

…………………	…………………..	…………………..
(Print name)	(Signed)	(Date)

Appendix G


Likehood of Injury Based on Hours of Sleep per Night
Designed by @YLMSportScience
Athletes who sleep on average <8 hours per night have 1.7 times greater risk of being injured than those who sleep ≥ 8 hours
Likehood of injury over 21 months
80
70
60
50
40
30
20
10
0
Five
Six
Seven
Eight
Nine
Average sleep per night (hours)
Reference
Chronic Lack of Sleep is Associated With Increased Sports Injuries in Adolescent Athletes by Milewski et al. in J Pediatr Orthop 2014


SLEEP DEPRIVATION & MENTAL FATIGUE
Sports Med
DOI 10.1007/s40279-014-0260-0
REVIEW ARTICLE
Sleep and Athletic Performance: The Effects of Sleep Loss on Exercise Performance, and Physiological and Cognitive Responses to Exercise
Hugh H. K. Fullagar · Sabrina Skorski · Rob Duffield · Daniel Hammes · Aaron J. Coutts · Tim Meyer
Sleep restriction can be generally associated with:
↘ Cognitive Performance
↘ Alertness
↗ Reaction Time
↘ Memory
↘ Decision Making
↗ Sleepiness
↘ Overall Mood States


Light from Smartphones & Tablets
Can Delay Sleep
Designed by @YLMSportScience
In this stduy, 13 individuals used self-luminous tablets to read, play games, and watch movies before going to bed
Melatonin is a hormone produced by the pineal gland at night and under conditions of darkness in both diurnal and nocturnal species. It is a "timing messenger," signaling nighttime information throughout the body. Exposure to light at night, especially short-wavelength, bluer light, can slow or even cease nocturnal melatonin production
"Our study shows that a 2-hour exposure to light from self-luminous electronic displays can suppress melatonin by about 22%. Stimulating the human circadian system to this level may affect sleep in those using the devices prior to bedtime"
Mariana Figueiro, PhD
Reference
Figueiro et al. Applied Ergonomics, 2012 & www.lrc.rpi.edu

2 MIN GUIDE

Designed by @YLMSportScience

WAYS TO GET BACK TO SLEEP

64% of athletes indicated worse sleep on at least one occasion in the nights prior to an important competition over the past 12 months

82% of athletes report problems falling asleep before a competition

59% of team sport athletes reported having no strategy to overcome poor sleep

1 STAY OUT OF YOUR HEAD

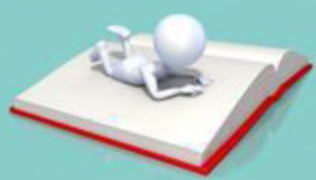
The key to getting back to sleep is continuing to cue your body for sleep, so remain in bed in a relaxed position. Hard as it may be, try not to stress over the fact that you're awake or your inability to fall asleep again, because that very stress and anxiety encourages your body to stay awake. A good way to stay out of your head is to focus on the feelings and sensations in your body.

2 MAKE RELAXATION YOUR GOAL, NOT SLEEP

If you are finding it hard to fall back asleep, try a relaxation technique such as visualization, deep breathing, or meditation, which can be done without even getting out of bed. Remind yourself that although they're not a replacement for sleep, rest and relaxation still help rejuvenate your body.

3 DO A QUIET, NON STIMULATING ACTIVITY

If you've been awake for more than 15 minutes, try getting out of bed and doing a quiet, non-stimulating activity, such as reading a book.



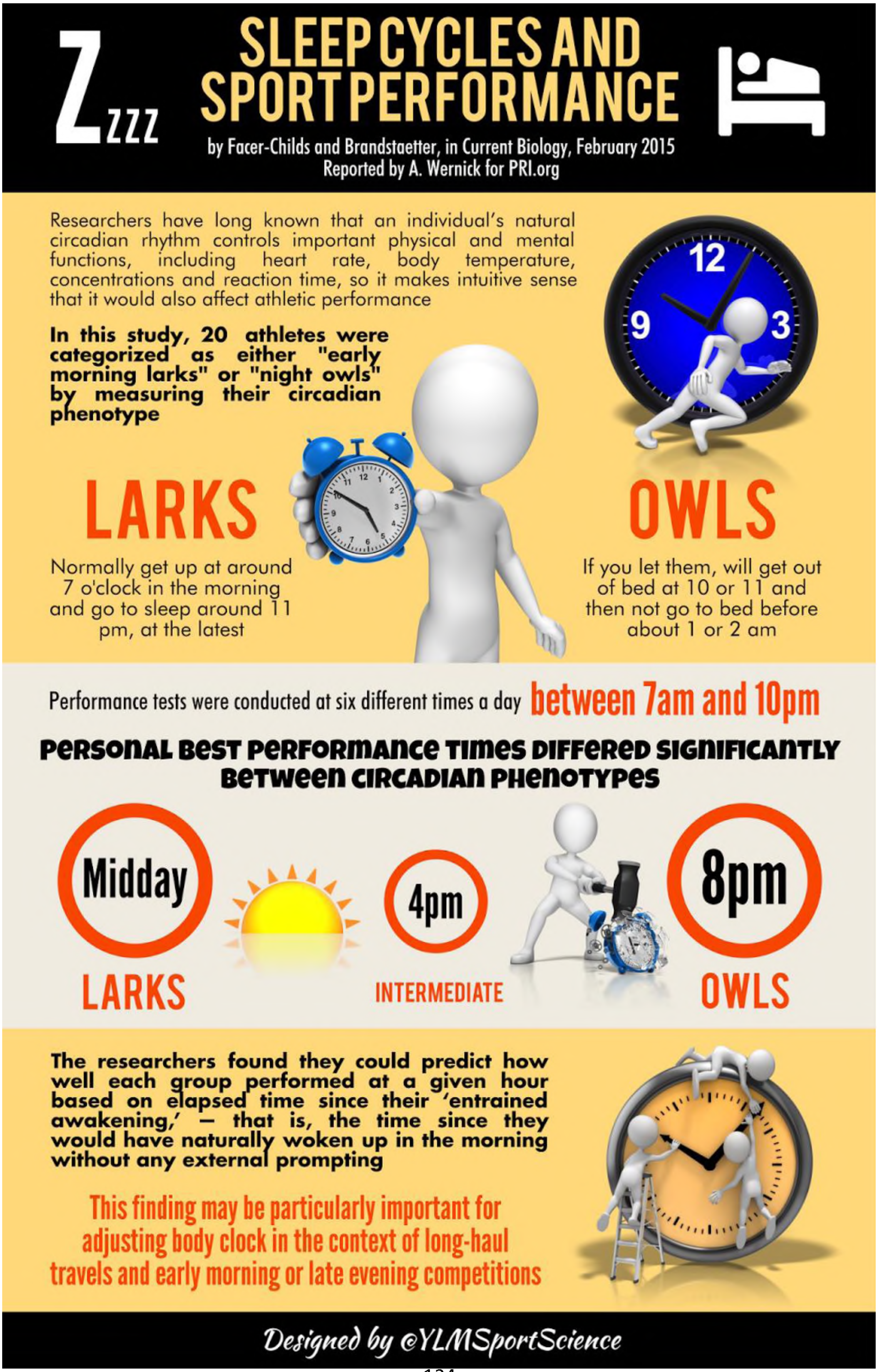
4 AVOID SOURCES OF BRIGHT LIGHT

Keep the lights dim so as not to cue your body clock that it's time to wake up. Also avoid screens of any kind—computers, TV, cell phones—as the type of light they emit is stimulating to the brain. A light snack or herbal tea might help relax you, but be careful not to eat so much that your body begins to expect a meal at that time of the day.

References:

Juliff et al. J Sci Med Sport 2014

Le Meur et al. Sleep and athletic performance, in Recovery for Performance in Sport, HK 2014


Zzzz
SLEEP CYCLES AND SPORT PERFORMANCE
by Facer-Childs and Brandstaetter, in Current Biology, February 2015
Reported by A. Wernick for PRI.org
Researchers have long known that an individual's natural circadian rhythm controls important physical and mental functions, including heart rate, body temperature, concentrations and reaction time, so it makes intuitive sense that it would also affect athletic performance
In this study, 20 athletes were categorized as either "early morning larks" or "night owls" by measuring their circadian phenotype
LARKS
Normally get up at around 7 o'clock in the morning and go to sleep around 11 pm, at the latest
OWLS
If you let them, will get out of bed at 10 or 11 and then not go to bed before about 1 or 2 am
Performance tests were conducted at six different times a day between 7am and 10pm
Personal best performance times differed significantly between circadian phenotypes
Midday
LARKS
4pm
INTERMEDIATE
8pm
OWLS
The researchers found they could predict how well each group performed at a given hour based on elapsed time since their 'entrained awakening,' – that is, the time since they would have naturally woken up in the morning without any external prompting
This finding may be particularly important for adjusting body clock in the context of long-haul travels and early morning or late evening competitions
Designed by @YLMSportScience

4 TIPS FOR THE PERFECT
POWER NAP
Designed by @YLMSportScience
FIND A GOOD PLACE TO NAP
1 Turn off your mobile phone and any other potential distractions
2 If background noise is unavoidable, putt on headphones with relaxing music
3 Wear sunglasses or use an eye mask to simulate darkness
DOG HOUSE
HAVE CAFFEINE RIGHT BEFORE YOU NAP
Taking a "caffeine nap" will not only improve your performance, but it'll also lessen how sleepy you feel once you wake up
SET AN ALARM TO GO OFF IN 15-20 MINUTES
If you're one of those people who has a habit of pressing the "snooze" button and going right back to sleep, put your alarm across the room so that you have to get up to turn it off
WAKE UP ON TIME
1 Sleeping more than 30 minutes can lead to sleep inertia
2 Follow up with physical activity (with a few jumping jacks or push-ups)
3 Wash your face and expose yourself to bright light

Appendix H

Questionnaire data files

Sex Differences

Cyclists reporting sleep loss vs Cyclists not reporting sleep loss

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	40215,00	16401,00	10730,00	1,763855	0,077757	2,051303	0,040238	230	106

International/national vs Provincial

Cyclists reporting sleep loss vs Cyclists not reporting sleep loss

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Internation/national	Rank Sum Provincial	U	Z	p-value	Z adjusted	p-value	Valid N Internation/national	Valid N Provincial	2*1sided exact p
Var1	934,0000	896,0000	339,0000	-1,52906	0,126252	-1,76634	0,077340	34	26	0,126914

International/national vs Recreational

Cyclists reporting sleep loss vs Cyclists not reporting sleep loss

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Internation/national	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Internation/national	Valid N Recreational
Var1	5227,000	51389,00	4632,000	-0,933907	0,350353	-1,08029	0,280012	34	302

Provincial vs Recreational
Cyclists reporting sleep loss vs Cyclists not reporting sleep loss

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Provincial	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Provincial	Valid N Recreational
Var1	4808,000	49148,00	3395,000	1,143373	0,252885	1,320468	0,186680	26	302

All Participants

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists reporting sleep loss vs Cyclists not reporting sleep loss)

No special strategy

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Sleep loss	Rank Sum No sleep loss	U	Z	p-value	Z adjusted	p-value	Valid N Sleep loss	Valid N No sleep loss
Var1	34558,00	22058,00	11032,00	3,257489	0,001124	3,850859	0,000118	188	148

Methods to relax

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Sleep loss	Rank Sum No sleep loss	U	Z	p-value	Z adjusted	p-value	Valid N Sleep loss	Valid N No sleep loss
Var1	30378,00	26238,00	12612,00	-1,47008	0,141540	-2,67990	0,007365	188	148

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Sleep loss	Rank Sum No sleep loss	U	Z	p-value	Z adjusted	p-value	Valid N Sleep loss	Valid N No sleep loss
Var1	30640,00	25976,00	12874,00	-1,17369	0,240519	-2,11553	0,034385	188	148

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Sleep loss	Rank Sum No sleep loss	U	Z	p-value	Z adjusted	p-value	Valid N Sleep loss	Valid N No sleep loss
Var1	31022,00	25594,00	13256,00	-0,741547	0,458362	-1,18373	0,236519	188	148

Sleeping pills

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Sleep loss	Rank Sum No sleep loss	U	Z	p-value	Z adjusted	p-value	Valid N Sleep loss	Valid N No sleep loss
Var1	31098,00	25518,00	13332,00	-0,655570	0,512101	-1,41654	0,156619	188	148

Other

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum Sleep loss	Rank Sum No sleep loss	U	Z	p-value	Z adjusted	p-value	Valid N Sleep loss	Valid N No sleep loss
Var1	31072,00	25544,00	13306,00	-0,684983	0,493355	-1,91496	0,055499	188	148

Sex Differences

Problems falling asleep

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11390,00	6376,000	4030,000	0,138077	0,890180	0,176182	0,860151	120	68

Waking up at night

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	12104,00	5662,000	3316,000	2,129726	0,033195	2,576101	0,009993	120	68

Unpleasant dreams

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11702,00	6064,000	3718,000	1,008377	0,313274	2,029979	0,042360	120	68

Waking up early in the morning

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11044,00	6722,000	3784,000	-0,824275	0,409784	-1,00430	0,315236	120	68

Not feeling refreshed in the morning

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11452,00	6314,000	3968,000	0,311021	0,755785	0,401430	0,688104	120	68

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	**Rank Sum male**	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11272,00	6494,000	4012,000	-0,188286	0,850652	-1,05959	0,289332	120	68

Not used to surroundings

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	**Rank Sum male**	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11328,00	6438,000	4068,000	-0,032078	0,974410	-0,052019	0,958513	120	68

Noises in the room or from outside

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	**p-value**	Valid N male	Valid N female
Var1	11608,00	6158,000	3812,000	0,746171	0,455565	1,502128	0,133065	120	68

Nervousness about the competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	**Rank Sum male**	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	12432,00	5334,000	2988,000	3,044657	0,002330	3,824339	0,000131	120	68

Thoughts about the competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	**p-value**	Valid N male	Valid N female
Var1	10778,00	6988,000	3518,000	-1,56626	0,117288	-1,82105	0,068600	120	68

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	**p-value**	Valid N male	Valid N female
Var1	11060,00	6706,000	3800,000	-0,779644	0,435601	-1,91781	0,055137	120	68

No influence

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11658,00	6108,000	3762,000	0,885642	0,375811	1,028474	0,303728	120	68

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

Worse performance in competition

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11122,00	6644,000	3862,000	-0,606700	0,544051	-1,06895	0,285091	120	68

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

Bad mood the following day

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11380,00	6386,000	4040,000	0,110182	0,912265	0,169264	0,865589	120	68

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

Increased daytime sleepiness

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11314,00	6452,000	4054,000	-0,071130	0,943294	-0,096244	0,923327	120	68

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

Other

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11068,00	6698,000	3808,000	-0,757329	0,448853	-2,16618	0,030298	120	68

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists reporting sleep loss)

No special strategy

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11332,00	6434,000	4072,000	-0,020921	0,983309	-0,024169	0,980718	120	68

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

Methods to relax

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11764,00	6002,000	3656,000	1,181321	0,237476	1,888259	0,058992	120	68

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11704,00	6062,000	3716,000	1,013956	0,310605	1,644262	0,100123	120	68

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	10970,00	6796,000	3710,000	-1,03069	0,302686	-1,56422	0,117767	120	68

Sleeping pills

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11292,00	6474,000	4032,000	-0,132498	0,894591	-0,259979	0,794880	120	68

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female
Var1	11308,00	6458,000	4048,000	-0,087867	0,929983	-0,207524	0,835600	120	68

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists not reporting sleep loss)

No special strategy

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female	2*1sided exact p
Var1	7938,000	3088,000	1833,000	-1,12589	0,260212	-1,45246	0,146375	110	38	0,261409

Methods to relax

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female	2*1sided exact p
Var1	8172,000	2854,000	2067,000	-0,098762	0,921327	-0,238591	0,811423	110	38	0,921664

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female	2*1sided exact p
Var1	8282,000	2744,000	2003,000	0,379687	0,704178	0,835718	0,403314	110	38	0,705336

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female	2*1sided exact p
Var1	8130,000	2896,000	2025,000	-0,283119	0,777086	-0,488640	0,625097	110	38	0,777997

Sleeping pills

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female	2*1sided exact p
Var1	8413,000	2613,000	1872,000	0,954704	0,339728	2,437535	0,014788	110	38	0,341187

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum male	Rank Sum female	U	Z	p-value	Z adjusted	p-value	Valid N male	Valid N female	2*1sided exact p
Var1	8286,000	2740,000	1999,000	0,397245	0,691187	1,627438	0,103645	110	38	0,692385

Competition-level of athletes

Internation/national vs Provincial

Problems falling asleep

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	344,5000	151,5000	96,50000	0,338062	0,735317	0,407718	0,683481	21	10	0,723978

Waking up at night

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	374,0000	122,0000	67,00000	1,584664	0,113044	1,911177	0,055983	21	10	0,114132

Unpleasant dreams

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	343,0000	153,0000	98,00000	0,274675	0,783566	0,331271	0,740440	21	10	0,787181

Waking up early in the morning

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	337,5000	158,5000	103,5000	0,042258	0,966293	0,053722	0,957157	21	10	0,950342

Not feeling refreshed in the morning

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	357,5000	138,5000	83,50000	0,887412	0,374858	1,392286	0,163837	21	10	0,369831

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	331,0000	165,0000	100,0000	-0,190160	0,849184	-0,621059	0,534561	21	10	0,851768

Not used to surroundings

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	316,5000	179,5000	85,50000	-0,802897	0,422035	-1,10810	0,267818	21	10	0,416398

Noises in the room or from outside

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	321,0000	175,0000	90,00000	-0,612737	0,540051	-1,19594	0,231721	21	10	0,546334

Nervousness about the competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	324,0000	172,0000	93,00000	-0,485964	0,626993	-0,599887	0,548582	21	10	0,632596

Thoughts about the competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	338,5000	157,5000	102,5000	0,084515	0,932647	0,097590	0,922258	21	10	0,917330

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	362,5000	133,5000	78,50000	1,098701	0,271900	1,891222	0,058596	21	10	0,267824

No influence

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	334,0000	162,0000	103,0000	-0,063387	0,949459	-0,075094	0,940140	21	10	0,950342

Worse performance in competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	321,0000	175,0000	90,00000	-0,612737	0,540051	-1,19594	0,231721	21	10	0,546334

Bad mood the following day

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	**Rank Sum Elite**	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	316,0000	180,0000	85,00000	-0,824025	0,409926	-1,41842	0,156070	21	10	0,416398

Increased daytime sleepiness

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	**Rank Sum Elite**	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	368,0000	128,0000	73,00000	1,331118	0,183151	1,944222	0,051870	21	10	0,186438

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	**Rank Sum Elite**	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	336,5000	159,5000	104,5000	0,00	1,000000	0,00	1,000000	21	10	0,983439

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists reporting sleep loss)

No special strategy

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	**Rank Sum Elite**	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	323,0000	173,0000	92,00000	-0,528221	0,597346	-0,609938	0,541904	21	10	0,603223

Methods to relax

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	**Rank Sum Elite**	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	357,5000	138,5000	83,50000	0,887412	0,374858	1,392286	0,163837	21	10	0,369831

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	**Rank Sum Elite**	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	347,0000	149,0000	94,00000	0,443706	0,657255	0,763763	0,445009	21	10	0,662542

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	337,0000	159,0000	104,0000	0,021129	0,983143	0,030861	0,975381	21	10	0,983439

Sleeping pills

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	347,0000	149,0000	94,00000	0,443706	0,657255	0,763763	0,445009	21	10	0,662542

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Elite	Rank Sum Subelite	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Subelite	2*1sided exact p
Var1	347,0000	149,0000	94,00000	0,443706	0,657255	0,763763	0,445009	21	10	0,662542

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists not reporting sleep loss)

No special strategy

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Subelite	Rank Sum Elite	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Elite	2*1sided exact p
Var1	234,0000	201,0000	98,00000	-0,241191	0,809407	-0,311376	0,755515	16	13	0,812338

Methods to relax

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Subelite	Rank Sum Elite	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Elite	2*1sided exact p
Var1	257,5000	177,5000	86,50000	0,745499	0,455970	1,247459	0,212230	16	13	0,448768

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < ,05000

variable	Rank Sum Subelite	Rank Sum Elite	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Elite	2*1sided exact p
Var1	230,0000	205,0000	94,00000	-0,416603	0,676969	-0,593419	0,552901	16	13	0,681573

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Subelite	Rank Sum Elite	U	Z	p-value	Z adjusted	**p-value**	Valid N Subelite	Valid N Elite	2*1sided exact p
Var1	248,0000	187,0000	96,00000	0,328897	0,742234	1,040063	0,298311	16	13	0,746070

International/national vs Recreational

Problems falling asleep

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	**Rank Sum Elite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	2056,000	13875,00	1472,000	0,793629	0,427412	1,013405	0,310868	21	157	0,430093

Waking up at night

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	**Rank Sum Elite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	2064,500	13866,50	1463,500	0,831957	0,405434	1,016101	0,309582	21	157	0,406814

Unpleasant dreams

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	**Rank Sum Elite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1886,500	14044,50	1641,500	0,029310	0,976617	0,035798	0,971444	21	157	0,975002

Waking up early in the morning

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	**Rank Sum Elite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1860,000	14071,00	1629,000	-0,085676	0,931724	-0,110743	0,911820	21	157	0,932219

Not feeling refreshed in the morning

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	**p-value**	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1848,500	14082,50	1817,500	-0,137532	0,890610	-0,294965	0,768021	21	157	0,889628

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < 05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1497,500	14433,50	1266,500	-1,72028	0,085382	-5,50316	0,000000	21	157	0,085001

Not used to surroundings

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < 05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1618,500	14312,50	1387,500	-1,17466	0,240131	-1,92024	0,054828	21	157	0,241102

Noises in the room or from outside

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1791,000	14140,00	1560,000	-0,396814	0,691505	-0,779475	0,435700	21	157	0,693529

Nervousness about the competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1857,000	14074,00	1626,000	-0,099204	0,920977	-0,125253	0,900324	21	157	0,921549

Thoughts about the competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < 05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	2039,500	13891,50	1488,500	0,719226	0,472002	0,836894	0,402653	21	157	0,473303

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1906,000	14025,00	1622,000	0,117241	0,906669	0,281110	0,778626	21	157	0,907343

No influence

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < 05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1908,500	14022,50	1619,500	0,128514	0,897743	0,148854	0,881669	21	157	0,896708

Worse performance in competition

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1854,000	14077,00	1623,000	-0,112731	0,910244	-0,194029	0,846153	21	157	0,910892

Bad mood the following day

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1859,500	14071,50	1628,500	-0,087930	0,929932	-0,132203	0,894824	21	157	0,928661

Increased daytime sleepiness

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	2132,000	13799,00	1396,000	1,136332	0,255819	1,558136	0,119202	21	157	0,257821

Other

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1785,500	14145,50	1554,500	-0,421615	0,673306	-1,17490	0,240037	21	157	0,673783

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists reporting sleep loss)

No special strategy

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1877,000	14054,00	1646,000	-0,009019	0,992804	-0,010424	0,991683	21	157	0,992857

Methods to relax

variable	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000 Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1974,500	13956,50	1553,500	0,426124	0,670017	0,696595	0,486057	21	157	0,670513

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1849,000	14082,00	1618,000	-0,135278	0,892392	-0,205939	0,836839	21	157	0,893167

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1869,500	14061,50	1638,500	-0,042838	0,965831	-0,086470	0,931093	21	157	0,964295

Sleeping pills

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	1916,500	14014,50	1611,500	0,164588	0,869269	0,378970	0,704710	21	157	0,868442

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists not reporting sleep loss)

No special strategy

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	888,0000	7890,000	750,0000	0,175650	0,860569	0,225780	0,821373	13	119	0,862173

Methods to relax

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	718,5000	8059,500	627,5000	-1,11118	0,266494	-2,68861	0,007175	13	119	0,268216

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	936,0000	7842,000	702,0000	0,542223	0,587665	1,132635	0,257369	13	119	0,591642

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	830,0000	7948,000	739,0000	-0,259656	0,795129	-0,472347	0,636680	13	119	0,797430

Sleeping pills

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	850,5000	7927,500	759,5000	-0,103099	0,917885	-0,249459	0,803006	13	119	0,915846

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Elite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Elite	Valid N Recreational	2*1sided exact p
Var1	884,0000	7894,000	754,0000	0,145102	0,884630	0,562108	0,574044	13	119	0,885966

Provincial vs Recreational
Problems falling asleep

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	860,5000	13167,50	764,5000	0,134901	0,892690	0,174338	0,861600	10	157	0,891672

Waking up at night

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	644,0000	13384,00	589,0000	-1,31866	0,187284	-1,58111	0,113853	10	157	0,190219

Unpleasant dreams

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	791,0000	13237,00	736,0000	-0,327136	0,743565	-0,398329	0,690388	10	157	0,747195

Waking up early in the morning

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	819,5000	13208,50	764,5000	-0,134901	0,892690	-0,174338	0,861600	10	157	0,891672

Not feeling refreshed in the morning

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	664,5000	13363,50	609,5000	-1,18039	0,237847	-2,38344	0,017152	10	157	0,240433

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	845,0000	13183,00	780,0000	0,030353	0,975786	0,227140	0,820315	10	157	0,976153

Not used to surroundings

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	861,5000	13166,50	763,5000	0,141646	0,887359	0,246642	0,805185	10	157	0,886421

Noises in the room or from outside

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	910,0000	13118,00	715,0000	0,468782	0,639226	0,976583	0,328776	10	157	0,643964

Nervousness about the competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	919,0000	13109,00	706,0000	0,529488	0,596468	0,663727	0,506865	10	157	0,601555

Thoughts about the competition

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	897,5000	13130,50	727,5000	0,384469	0,700631	0,448209	0,654002	10	157	0,702286

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p < .05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	654,5000	13373,50	599,5000	-1,24784	0,212092	-2,68890	0,007169	10	157	0,214299

No influence

	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000									
variable	**Rank Sum Subelite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	794,0000	13234,00	739,0000	-0,306900	0,758919	-0,355810	0,721983	10	157	0,762360

Worse performance in competition

	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000									
variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	**p-value**	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	940,0000	13088,00	685,0000	0,671134	0,502136	1,193393	0,232718	10	157	0,507712

Bad mood the following day

	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000									
variable	**Rank Sum Subelite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	980,0000	13048,00	645,0000	0,940937	0,346738	1,454193	0,145894	10	157	0,352012

Increased daytime sleepiness

	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000									
variable	**Rank Sum Subelite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	721,0000	13307,00	666,0000	-0,799290	0,424123	-1,05538	0,291254	10	157	0,429747

Other

	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000									
variable	**Rank Sum Subelite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	791,5000	13236,50	736,5000	-0,323763	0,746118	-0,932753	0,350948	10	157	0,747195

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists reporting sleep loss)

No special strategy

	Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1) By variable Var2 Marked tests are significant at p <.05000									
variable	**Rank Sum Subelite**	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	936,0000	13092,00	689,0000	0,644154	0,519476	0,744125	0,456801	10	157	0,524995

Methods to relax

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	724,5000	13303,50	669,5000	-0,775683	0,437937	-1,21643	0,223823	10	157	0,441588

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	803,0000	13225,00	748,0000	-0,246195	0,805532	-0,392040	0,695029	10	157	0,808368

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	818,0000	13210,00	763,0000	-0,145019	0,884696	-0,221021	0,825076	10	157	0,886421

Sleeping pills

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	753,0000	13275,00	698,0000	-0,583448	0,559592	-1,14446	0,252432	10	157	0,564920

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	895,0000	13133,00	730,0000	0,367606	0,713167	0,855603	0,392218	10	157	0,717152

Which strategies do you use to sleep well in the night(s) prior to an important competition? (Cyclists not reporting sleep loss)

No special strategy

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <.05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	1062,000	8118,000	926,0000	-0,173591	0,862187	-0,224686	0,822224	16	119	0,863481

Methods to relax

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	1068,500	8111,500	932,5000	-0,129343	0,897087	-0,362353	0,717088	16	119	0,895394

Reading

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	1176,000	8004,000	864,0000	0,595656	0,551405	1,257042	0,208739	16	119	0,554785

Watching TV/ using media devices

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	954,0000	8226,000	818,0000	-0,908801	0,363456	-1,58148	0,113768	16	119	0,366829

Sleeping pills

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	1136,000	8044,000	904,0000	0,323356	0,746426	0,905883	0,364999	16	119	0,748692

Other

Mann-Whitney U Test (w/ continuity correction) (Spreadsheet1)
By variable Var2
Marked tests are significant at p <,05000

variable	Rank Sum Subelite	Rank Sum Recreational	U	Z	p-value	Z adjusted	p-value	Valid N Subelite	Valid N Recreational	2*1sided exact p
Var1	1112,000	8068,000	928,0000	0,159976	0,872900	0,626569	0,530942	16	119	0,874097

Appendix I

Sleep diary data files

Final Sleep Length

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	5281,839	1	5281,839	934,5395	0,000000	0,932172	934,5395	1,000000
Sex	6,492	1	6,492	1,1487	0,287611	0,016612	1,1487	0,184466
Level	0,237	1	0,237	0,0419	0,838428	0,000616	0,0419	0,054679
Error	384,323	68	5,652					
DAYS	52,002	2	26,001	6,9155	0,001379	0,092311	13,8311	0,919127
DAYS*Sex	2,710	2	1,355	0,3604	0,698077	0,005272	0,7208	0,106907
DAYS*Level	1,915	2	0,958	0,2547	0,775508	0,003732	0,5094	0,089449
Error	511,328	136	3,760					

Tukey HSD test; variable DV_1 (Summary spreadsheet)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = 3,7598, df = 136,00

Cell No.	DAYS	{1} 7,3171	{2} 7,7438	{3} 6,2238
1	Sleep length 3 nights		0,388870	0,002261
2	Sleep length 2 nights	0,388870		0,000030
3	Sleep length nights before	0,002261	0,000030	

Sleep quality

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	569,7448	1	569,7448	371,5557	0,000000	0,841470	371,5557	1,000000
Sex	5,4253	1	5,4253	3,5381	0,064135	0,048112	3,5381	0,458329
Level	3,8344	1	3,8344	2,5006	0,118315	0,034490	2,5006	0,344672
Error	107,3383	70	1,5334					
DAYS	6,7024	2	3,3512	4,2254	0,016527	0,056926	8,4507	0,732842
DAYS*Sex	1,5279	2	0,7640	0,9632	0,384170	0,013574	1,9265	0,214662
DAYS*Level	0,7590	2	0,3795	0,4785	0,620739	0,006789	0,9569	0,127094
Error	111,0355	140	0,7931					

Tukey HSD test; variable DV_1 (Summary spreadsheet)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = ,79311, df = 140,00

Cell No.	DAYS	{1} 2,1370	{2} 2,1781	{3} 2,5342
1	Sleep quality 3 nights		0,958062	0,019297
2	Sleep quality 2 nights	0,958062		0,041514
3	Sleep quality night before	0,019297	0,041514	

Bed time

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	51844,35	1	51844,35	11386,28	0,000000	0,994063	11386,28	1,000000
Sex	2,17	1	2,17	0,48	0,492261	0,006962	0,48	0,104546
Level	5,46	1	5,46	1,20	0,277264	0,017335	1,20	0,190580
Error	309,62	68	4,55					
DAYS	10,88	2	5,44	1,62	0,202427	0,023217	3,23	0,337004
DAYS*Sex	2,44	2	1,22	0,36	0,696646	0,005302	0,72	0,107254
DAYS*Level	3,49	2	1,74	0,52	0,596732	0,007564	1,04	0,133956
Error	457,63	136	3,36					

Sleep time

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	52922,79	1	52922,79	14799,52	0,000000	0,995426	14799,52	1,000000
Sex	1,20	1	1,20	0,34	0,564448	0,004907	0,34	0,088101
Level	2,02	1	2,02	0,57	0,454391	0,008257	0,57	0,115038
Error	243,17	68	3,58					
DAYS	8,78	2	4,39	1,52	0,221789	0,021904	3,05	0,319545
DAYS*Sex	0,32	2	0,16	0,05	0,946662	0,000806	0,11	0,058141
DAYS*Level	0,97	2	0,49	0,17	0,844748	0,002478	0,34	0,075716
Error	392,14	136	2,88					

Sleep latency

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	6,53048	1	6,530482	40,77560	0,000000	0,381881	40,77560	0,999993
Sex	0,30575	1	0,305750	1,90907	0,171726	0,028112	1,90907	0,275252
Level	0,04832	1	0,048319	0,30170	0,584675	0,004550	0,30170	0,084188
Error	10,57034	66	0,160157					
DAYS	0,38868	2	0,194340	2,57489	0,079984	0,037549	5,14978	0,506543
DAYS*Sex	0,40897	2	0,204487	2,70932	0,070285	0,039432	5,41865	0,528417
DAYS*Level	0,05197	2	0,025986	0,34429	0,709356	0,005189	0,68859	0,104176
Error	9,96274	132	0,075475					

Number of awakenings

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	333,281	1	333,2815	7,075754	0,009708	0,093009	7,075754	0,746299
Sex	61,711	1	61,7113	1,310166	0,256320	0,018634	1,310166	0,203927
Level	17,627	1	17,6268	0,374227	0,542720	0,005394	0,374227	0,092624
Error	3250,031	69	47,1019					
DAYS	72,116	2	36,0578	0,746195	0,476071	0,010699	1,492390	0,174656
DAYS*Sex	206,276	2	103,1381	2,134385	0,122207	0,030005	4,268769	0,431540
DAYS*Level	12,825	2	6,4127	0,132707	0,875834	0,001920	0,265413	0,070054
Error	6668,458	138	48,3222					

Awakening durations

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	3,21567	1	3,215673	15,97316	0,000162	0,192510	15,97316	0,976079
Sex	0,02038	1	0,020385	0,10126	0,751315	0,001509	0,10126	0,061346
Level	0,25259	1	0,252592	1,25470	0,266657	0,018383	1,25470	0,197134
Error	13,48826	67	0,201317					
DAYS	0,27031	2	0,135153	1,63176	0,199447	0,023776	3,26352	0,339787
DAYS*Sex	0,03217	2	0,016084	0,19418	0,823738	0,002890	0,38837	0,079705
DAYS*Level	0,02935	2	0,014675	0,17718	0,837829	0,002637	0,35435	0,077009
Error	11,09876	134	0,082827					

Wake time

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	3353,001	1	3353,001	1514,379	0,000000	0,957027	1514,379	1,000000
Sex	0,579	1	0,579	0,261	0,610889	0,003828	0,261	0,079570
Level	0,064	1	0,064	0,029	0,865572	0,000424	0,029	0,053222
Error	150,559	68	2,214					
DAYS	84,027	2	42,014	41,515	0,000000	0,379083	83,031	1,000000
DAYS*Sex	1,754	2	0,877	0,867	0,422609	0,012586	1,734	0,196690
DAYS*Level	0,497	2	0,248	0,245	0,782809	0,003595	0,491	0,087923
Error	137,632	136	1,012					

Tukey HSD test; variable DV_1 (Summary spreadsheet)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = 1,0120, df = 136,00

Cell No.	DAYS	{1} 5,8879	{2} 6,3786	{3} 4,4743
1	Wake time 3 nights		0,010231	0,000022
2	Wake time 2 nights	0,010231		0,000022
3	Wake time night before	0,000022	0,000022	

Out of bed time

Repeated Measures Analysis of Variance with Effect Sizes and Powers (Summary spreadsheet)
Sigma-restricted parameterization
Effective hypothesis decomposition

Effect	SS	Degr. of Freedom	MS	F	p	Partial eta-squared	Non-centrality	Observed power (alpha=0,05)
Intercept	3900,769	1	3900,769	394,1895	0,000000	0,851033	394,1895	1,000000
Sex	9,900	1	9,900	1,0004	0,320711	0,014291	1,0004	0,166724
Level	8,829	1	8,829	0,8922	0,348185	0,012765	0,8922	0,153771
Error	682,801	69	9,896					
DAYS	99,045	2	49,523	6,2091	0,002618	0,082557	12,4181	0,887235
DAYS*Sex	29,961	2	14,981	1,8782	0,156747	0,026499	3,7565	0,385458
DAYS*Level	13,331	2	6,665	0,8357	0,435753	0,011967	1,6714	0,191018
Error	1100,669	138	7,976					

Cell No.	Tukey HSD test; variable DV_1 (Summary spreadsheet) Approximate Probabilities for Post Hoc Tests Error: Within MSE = 7,9759, df = 138,00 DAYS	{1} 6,2935	{2} 6,7661	{3} 5,3329
1	Out of bed 3 nights		0,574241	0,102618
2	Out of bed 2 nights	0,574241		0,006589
3	Out of bed night before	0,102618	0,006589	

Appendix J

Sleep diary comments

Comments on participants sleep as were recorded on the sleep diaries for the three nights before the race.

3 Nights before the races	2 Nights before the races	Night before race
		Very nervous aboutvthe race
		I do not notice a change in my sleeping patterns before an event. I am an easy and deep sleeper though.
		I always have a poor sleep before any race
I got up early to drive to durban from bethlehem at 7am	got up early for northbeach park run	did amashova
	N/a	N/a
		Night before race
		none
		Too much excitement for Amashova
		NA
I have a baby that often dictates my sleep patterns		I was sick
		RWC 2015...
		Slightly nervous for the race but I don't feel it affected my sleep
		none
Not worried about the race at this stage	Was not worried about the race at this stage	Worrying about where I had left the car keys made me restless
Spent 8 hours on the road cycling	Spent 9 hours on the road cycling	None
I got home late, which is why I went to sleep late	N/A	It took me longer to fall asleep than usual
		I do normally get up during the night. It sucks like hell, as I can feel that I am not getting quality sleep! EVER!
n/a	n/a	nervous about race
No class on Fridays	I had a breakfast to be at before 9:30.	It took a while for me to feel tired enough to go to sleep. No real nerves just too much energy.

		None
Unavoidable late night	Unavoidable late night	None
		Up early for Amashova
	Not my normal bed, away at friends	nervous about the ride and not waking in time
		No comments
		N/A
	None	no comment
Partner was coughing all night and snoring the rest	Drove down to DBN and got in late, was exhausted	Race morning
	strange bed and environment	probably woke up more often as I had 3 beers while watching the rugby, also strange bed and environment
		No comments
		I always dream several dreams a night. And wake up for a few seconds and go back to bed
I went out to a club	Went to a drum circle	Woke early for the race
Due to my training programes is very easy for me to sleep because my body is tired		My 8hr sleep felt to short
		none
		None
		None
	Emotional conversation with girlfriend before going to sleep.	Very busy before bed prepping for the race, so was extremely tired when I went to bed.
		planned to go to bed earlier but due to unforeseen circumstances could not
Fitbit says I was 11 times restless	Fitbit says I was 11times restless	Fitbit says I was 15 times restless
		Mind gets too involved and produces thought I chase leading to wake ups

		None
		No
	My young baby was wrestless	i normally awake at mid night to go to the toilet
		N/a
I toss and turn a lot according to my fit bit		Super tired
		Sleep is very important to my training pattern, if I don't sleep well I can't perform on the bike
		I felt that I slept worse AFTER race day than before
		none
		-
	The data above is for the 19th November - Saturday	None
		n/a
Hung over	Not feeling well	n/a
		While the sleep periods were short it wasnt due to nerves but rather work and other factors.
		Slept really well the day before the race. Even though I went to be march later than I hOped.
		Race day, early start time and had to drive to Jhb
I woke up in the night to check my phone, my boyfriend was driving from Potch to PTA at 1 am, so wanted to make sure he was safe before falling asleep.	Have battled to sleep the entire week, so wanted to stay in bed for as long as possible on Saturday AM	Stayed in bed until 5:30 as only had to be up then for the ride/947CC
	Builders next door woke me up	None
		I do not really have issues sleeping
		n/a

		Woke up due to nerves of the race
	Had a few beers that night	Was exhausted…
	Drank too much the night before	Sleep quality affected by uneasy stomach before race
		anxiety re the race
NA	I went to bed late because I was waiting for family to arrive	NA
		Had some stress - not cycling related
	On my feet all day as an exhibitor at the expo	None
took organic sleeping pill: Tranquil Sleep	took organic sleeping pill: Tranquil Sleep	this was for the 19th. took organic sleeping pill: Tranquil Sleep
		Took a sleeping pill because of the race
I was very tired the night before	I was tired but could not fall asleep	This was on 19th Nov. Pre-race night sleep. Battled to fall asleep and was a bit tired
Had a very restful sleep	Was very restles My polar loop registerd only 3:55 of restful sleep	Restful but short
		None
None	None	None
		Took long to fall asleep becuse felt pressure that sleeping so late would impact on my performance on race day. Once I fell asleep il did not wake up during the nigh until 0345
		Nothing
		None
	woke up with major headache in the middle of the night	took a "Rescue" tablet before going to bed
	had a few beers Friday afternoon	none
		NA
i had bike issues the night before so was a very stressfull time before bed		no comments

Mosquitoes woke me up		
		None
		I generally sleep well but tend to fall asleep in front of the tv in the coach and the make my way to the bed.
		I never sleep as well as normal the night before a big event
		None
		all good
		Inconsistent pattern of going to bed and waking up times
		anxious about the race
		Had red wine late afternoon
	Was on leave day before and day of	Travel from KZN to JHB and overnight at family due to cycle race, unfamiliar bed and husband snoring!

Appendix K

Correlation data files

Correlations (Correlations for sleep diary)
Marked correlations are significant at p < ,05000
N=90 (Casewise deletion of missing data)

Variable	FINAL SLEEP LENGTH night before race
Age:	0,002188
Sex	-0,165401
How long have you been practicing this sport?	-0,040102
On which level are you practicing your sport right now?	-0,037879
How much time do you spend practicing per week on average?	-0,156271
How often do you practice per week?	-0,064414
How long do you sleep on an average night?	-0,023890
How do you estimate your sleep quality in general?	-0,153866
How do you sleep in the night(s) prior to an important competition or game in comparison to your usual sleep habits?	-0,272975
Have you ever, compared to your usual sleep habits, slept worse in the night(s) prior to an important competition or game?	0,106024
1. What time did you get into bed?	-0,411303
2. What time did you try go to bed?	-0,521534
3. How long did it take you to fall asleep?	-0,469975
4. How many times did you wake up, not counting your final awakening?	-0,070600
5. In total, how long did these awakenings last?	-0,289695
6. What time was your final awakening?	0,597019
7. What time did you get out of bed for the day?	0,183097
8. How would you rate the quality of your sleep?	-0,435278

Correlations (Correlations for sleep diary)
Marked correlations are significant at p < ,05000
N=90 (Casewise deletion of missing data)

Variable	8. How would you rate the quality of your sleep?
Age:	-0,073182
Sex	0,186173
How long have you been practicing this sport?	-0,233955
On which level are you practicing your sport right now?	-0,103987
How much time do you spend practicing per week on average?	0,040417
How often do you practice per week?	-0,000365
How long do you sleep on an average night?	0,034713
How do you estimate your sleep quality in general?	0,325875
How do you sleep in the night(s) prior to an important competition or game in comparison to your usual sleep habits?	0,319269
Have you ever, compared to your usual sleep habits, slept worse in the night(s) prior to an important competition or game?	-0,281782
1. What time did you get into bed?	0,024970
2. What time did you try go to bed?	0,130290
3. How long did it take you to fall asleep?	0,387986
4. How many times did you wake up, not counting your final awakening?	0,511469
5. In total, how long did these awakenings last?	0,506199
6. What time was your final awakening?	-0,133795
7. What time did you get out of bed for the day?	-0,157805
FINAL SLEEP LENGTH night before race	-0,435278