Quality and Quantity of Sleep Study and its Relationship to the Performance of LPGA Tour Players

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Quality and Quantity of Sleep Study and its Relationship to the Performance of LPGA Tour Players

By

Maria Elena Lopez

A Graduate Thesis Submitted to the
Department of Human Factors and Systems
In Partial Fulfillment of the Requirement for the Degree of Master of Science in Human Factors and Systems

Embry-Riddle Aeronautical University
Daytona Beach, Florida
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LPGA and Sleep Performance

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Maria Elena Lopez

This thesis was prepared under the direction of the candidate’s thesis committee chair, Jon French, Ph.D., Department of Human Factors and Systems, and has been approved by the members of the thesis committee. It was submitted to the Department of Human Factors and Systems and has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Human Factors and Systems.

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II
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Abstract

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The relationship between sleep efficiency and elite level athletic performance that has a definitive and individual measure of performance (like golf, track, & swimming) has never been systematically studied. The extreme and rigorous travel schedules of professional golfers prevent consistent and necessary sleep schedules. The Ladies Professional Golf Association (LPGA) permitted Embry-Riddle Aeronautical University (ERAU) to ask for volunteers at two tournaments during October of 2010 to complete subjective sleep fatigue logs. Analysis of the sleep fatigue logs revealed a relationship between sleep quality and performance (golf score). Subsequent relationships were also found between subjective fatigue and sleep quality, and subjective fatigue and performance. These results could have important implications for athletes and others who require consistently skilled performance in the course of their duties; particularly for those individuals that are subjected to extreme travel schedules, extended work shifts or extreme work environments.
Introduction

The rigors of professional golf include extended days, frequent travel, poor nutrition and high stress, which can all lead to inadequate rest. Little is known about how inadequate sleep interferes with the professional athlete’s performance, although there are many anecdotal accounts to suggest that it does. The close association of the PI (Primary Investigator) with the LPGA created the opportunity to study sleep deprivation in this population of athletes. A method was devised to evaluate sleep quality and quantity in professional golfers during two official LPGA tournaments. This study examined the strength of the relationship between inadequate rest and golf score. It is assumed that these results will have implications for all athletes who tour to competitive events. First, a background on sleep will be described, the importance of sleep to normal human functioning and what is known about sleep mechanisms. Finally, the unique methods to evaluate sleep in an applied setting, like an LPGA tournament, will be described.

Importance of Sleep

It is well known that sleep is essential for all vertebrates and probably something like sleep for invertebrates as well (Rechtschaffen, Bergmann, Everson, Kushida & Gilliland., 1989). In fact, animals can survive longer without food and water than they can without sleep (Frederickson & Rechtschaffen, 1978). The typical life span of a rat is two to three years. The National Institute for Neurological Disorders and Stroke estimates that when deprived of all sleep, rats survive no more than three weeks (National Institute for Neurological Disorders and Stroke, 2007).
Sleep has a direct impact on health (Harenstram & Theorell, 1990). For example, in one sleep deprivation study, even though the food intake of rats was increased, they became hyperactive, lost weight, developed skin lesions and experienced erosion of their intestinal tract that lead to sepsis and eventually death (Frederickson & Rechtschaffen, 1978). Sleep deprivation caused deterioration in the immune system of the rat and consequently brought on immune collapse, opportunistic infection and death. These studies reflect sleep’s importance in normal physiological function, particularly to the immune system (Everson, 1993; Centers for Disease Control, 2008). Without sleep animals can essentially breakdown from the inside out.

Adequate sleep is also essential for human cognitive and psychomotor performance (Dement, 2005a; Kase, 2007). The impairment of cognitive abilities produced by fatigue, which is brought on by sleep deprivation, irregular schedules and night operations, has been known for some time (Babkoff, Mikulincer, Caspy, Kempinski, & Sing, 1988; Gillberg, Kecklund, & Akerstedt, 1994; Tilley & Wilkinson, 1984). Both sleep and wakefulness are actively maintained. The mechanisms of sleep are not well understood but seem to be an intricate interplay of hormone signals and brain function (Vgontzas, et al., 1997). Without the proper functioning of these neuronal signals, dramatic physiological, psychomotor and cognitive consequences occur (VanDongen, Maislin, Mullington & Dinges, 2003). Certain structures in the brain may trigger the onset of sleep, but it is uncertain of all the systems involved. The suprachiasmatic nucleus (SCN) is a structure in the hypothalamus that resets the 24-hour body clock of the sleep-wake cycle based on environmental light and indirectly impacts many physiological functions like hormones release. Notably, melatonin is one of these hormones influenced, which may in turn signal nocturnal variations in physiological processes such as urination and also blood pressure (Vgontzas, et al., 1998). Hypertension is a good example of a
condition that has a clear relationship with sleep disorder or malfunction (National Institute for Neurological Disorders and Stroke, 2007). Getting less or inefficient sleep leads to the stress of chronic daytime fatigue that can then impact cardiovascular indicators of stress (Mohler, 1966). Normally, humans sleep the best during the night. Sleep interruptions and restlessness are more characteristic of daytime sleep effects. This timing of sleep has to do with our circadian timing system that makes it easier to sleep during the night than during the day (Ralph, et al., 1990).

The amount of sleep needed is different for each person and differs from day to day, but most people seem to function best with seven to nine hours of rest (Dement, 1974). As we age the amount of sleep needed over a lifetime can vary (Zammit, et al., 1999). Infants need an average of 16-hours of sleep, teenagers 9-hours, and adults approximately seven to eight hours. The elderly can require much less in a single sleep period, but average about the same over a 24-hour period with naps making up the difference (Bliwise, Ansari, Straight, & Parker, 2005). There are cases of persons with reduced sleep times who are in good health and have longevity. This is certainly not normal. There is far more research that supports the contrary. Sleep deprivation can lead to impaired memory, decreased motor skills, and can bring on hallucinations and mood swings (Dinges, Pack, & Williams, 1997). Neurons become so depleted in energy that they begin to malfunction. This is likened to the misfiring of pistons or fuel injectors in a motor (Johnson, 1969). Muscle strength and ability can be decreased significantly with just a few days of sleep interruption or deprivation (Reilly & Piercey, 1994).

Any interruption to a person’s normal sleep-wake cycle (circadian rhythm) can create what is called sleep debt (Rogers, et al., 2002). Sleep debt is a cumulative effect of recurring inappropriate amounts of sleep (Dement, 2005a). When these reductions in sleep occur cognitive function, reaction time, and physiological function become compromised (Dement,
Even moderate sleep debt or sleep deprivation of 22-hours is about the equivalent of consuming four shots of liquor (Dawson & Reid, 1997). The dramatic data obtained through Dawson’s study shows the performance of an otherwise healthy adult can be reduced to that of someone who has a blood alcohol (BAC) level of 0.08 percent after just 20-hours of wakefulness (Lawson & Dawson, 1999). Thus, even a mild sleep deprivation can cause dramatic changes in behavior. The physiological changes associated with elevated BAC and sleep deprivation are quite different but apparently the behavior consequences are similar. This can cause reaction time to be 57 percent less than normal; hand-eye coordination, 31 percent less; and memory 10 percent less (Maas, Wherry, Axelrod, Hogan & Bomin, 1998). Alcohol and sleep deprivation have different physiological differences but similar cognitive effects. The slightest and greatest interruptions can create a debt that is difficult to pay off. There are conflicting beliefs that sleep can ever be recovered or made up (Dinges, Orne, Waterhouse & Orne, 1987). If it can be made up, there is a ceiling as to how much can be restored (Carskadon & Dement, 1981). Recent sleep extension studies at Stanford University have shown an increase in the average sleep time of 8-hours to 10-hours per night can lead to improved performance cognitively, physically, and mentally (Mah, Mah, Kezirian & Dement, 2010). The ability for one to sleep poorly or well is not linked to one factor (Monroe, 1967). Environment, illness, and genetics play a factor as well (Katz & McHorney, 1998; Kripke, Garfinkel, Wingard, Klauber & Marler, 2002; Van Dongen, Maislin, Mullington & Dinges, 2003).

**Sleep Deprivation and Insomnia**

The terms sleep deprivation and insomnia are often used interchangeably. They are separate conditions, but often have a synergetic effect (Harvey, 2002). Sleep deprivation or
inadequate sleep is endemic in our increasingly technical society and is often seen in athletic competition (Hill, Hill, Fields & Smith, 1993). The key difference between sleep deprivation and insomnia is that with sleep deprivation, unlike insomnia, the opportunity for adequate sleep does not exist or it is taken away. An example of sleep deprivation would be medical personnel voluntarily working for 36-hours straight to fulfill their residency (Roth, 2007). Sleep deprivation is the loss sleep, where as insomnia is the inability to fall asleep. Continued sleep deprivation from either sleep deprivation or insomnia can lead to diseases as the immune system is weakened by stress, but it also can foster further insomnia (Roth, Roehrs & Pies, 2007).

It is estimated that 30 percent of the general population is impacted by chronic insomnia or the inability to fall asleep (Balter & Uhlenhuth, 1992). Insomnia quickly impairs cognitive and physical functioning during daytime functions (Roth & Roehrs, 2003). People with persistent sleep interruptions may have higher rates of serious accidents in the home or work, chronic work absenteeism, diminished job performance, decreased quality of life, and increased health issues (Ancoli-Israel & Roth, 1999). Insomnia is the most prevalent of all sleep problems (Shepard, et al., 2005). As insomnia relates to this study the definition provided by Dr. Thomas Roth of the Henry Ford Sleep Center will be used.

"Insomnia is the (1) difficulty of falling asleep, staying asleep or non-restorative sleep; (2) this difficulty is present despite adequate opportunity and circumstance to sleep; (3) this impairment in sleep is associated with daytime impairment or distress; and (4) this sleep difficulty occurs at least 3 times per week and has been a problem for at least 1 month. (Roth, 2007)."

Those with insomnia have issues with mood control, gastrointestinal ailments, headache and pain (Kuppermann, et al., 1995). In addition, individuals with insomnia have greater self-
diagnosed impairment, days of limited activity, and higher total health costs (Simon & VonKorff, 1997). Quality of life is significantly lower for individuals with insomnia than for those without (Zammit, et al., 1999).

**Physiological Effects of Sleep Interruptions**

The rampant pace of technology and what socio-economic factors have demanded is not a pace to which our circadian rhythms can easily adapt (Shepard, et al., 2005). More information for humans to process and more information to manage can increase stress levels (Soderstrom, Ekstedt, Nilsson, Axelsson & Akerstedt, 2004). Increased stress such as that from chronic fatigue leads to more cortisol and aldosterone secreted into the body (Maslach & Jackson, 1981). The increase of these hormones in the human body can impair the sleep process (Dahlgren, Kecklund & Akerstedt, 2005). Too little sleep creates a physiological stress that increases the amount of stress hormones in the body that can further impede getting a good quality of sleep. Impairment of the sleep process can lead to a detrimental systematic domino effect within the human physiology (Chuah & Chee, 2008; Dement, 2005a).

Sleep deprivation, whether voluntary or involuntary, induces physiological stress as evidenced by higher levels of stress hormones known as glucocorticoids. This causes an increase of inflammation and this decreases immune function (Motivala & Irwin, 2007; Spiegel, Leproult & Van Cauter, 1999). A corticoid stress hormone found in high levels in poor sleepers is cortisol (Vgontzas, et al., 2001; Vgontzas, et al., 1998). Cortisol suppresses testosterone and some parts of the immune system making people more vulnerable to illness (Chrousos, 1998; Dahlgren, et al., 2005). Cortisol levels have also been linked with reduced total wake time.
Urinary catecholamines (another indicator of stress) have been correlated with Stage 1 sleep loss and frequency of awakenings after sleep onset (Roth, 2007; Vgontzas, et al., 1997).

A study in Sweden also showed that higher workloads and stress affect physiological stress markers such as cortisol and can cause increased sleepiness (Dahlgren, et al., 2005). Stress impairs the quality and rapidity of recovery (Freedman & Sattler, 1982). High job strain and stress can cause problems with relaxation and falling asleep, even though subjects have reported feeling sleepier. Increased stress can lead to quality and quantity of sleep problems, further perpetuating the stress cycle (Fiorica, Higgins, Iampietro, Lategola, & Davis, 1968; Steptoe, Cropley & Joekes, 1999). Thus, a situation with high workload and stress during wakefulness, such as what professional athletes experience, may lead to transient insomnia and possibly chronic insomnia in the long run (Freudenberger, 1983; Kecklund & Akerstedt, 2004).

Recent studies out of the University of Chicago have determined that sleep deprivation and obesity have a hormonal link (Spiegel, Leproult, & Van Cauter, 1999; Van Cauter, Spiegel, Tasali & Leproult, 2008). Dr. Eve Van Cauter has found that sleep deprivation activates a small part of the hypothalamus that is involved in appetite regulation (Van Cauter, et al., 2008). The stress of sleep loss can create more sleep loss, and induce obesity (Hemlich, 2004). Poor nutrition available to many touring athletes can also lead to obesity and may compound effects of sleep deprivation. Furthermore, obesity has been linked to restricted breathing during sleep called obstructive sleep apnea (OSA) (Carskadon & Rechtschaffen, 1994; Carskadon & Rechtschaffen, 2005).

OSA is one of many sleep disorders growing in its significance and epidemic in America (Ohayon, 1997). It is essentially the closing of one’s upper airway during sleep causing hypoxia a deprivation of oxygen in the blood (Dement, et al., 1996). The precise cause of the airway
closing is unknown, but a relationship has been found with being elderly or obese, but not exclusive to these groups (Young, et al., 1993). OSA is believed to have a direct relationship to hypertension, heart disease, heart failure and stroke (Nieto, et al., 2000; Peppard, Young, Palta & Skatrud, 2000). When the upper airway closes, oxygen can be deprived for a period of 30 to 60 seconds. At this time the brain stem is made aware of oxygen deprivation and it stimulates the heart, increasing its rate. This action is translated into what we know as snoring. Snoring is a strong indicator of the possible presence of OSA. People with severe apnea can have 30 or more of these episodes during a night’s sleep (Shahar, et al., 2001).

A method devised to maintain an open upper airway during sleep is a device known as continuous positive airway pressure (CPAP) (Sullivan, Issa, Berthon-Jones, & Eves, 1978). It has been found with the consistency of CPAP many conditions such as hypertension, obesity, aphasia, excessive drowsiness, insomnia, and fatigue are improved or eliminated (Remmers, de Groot, Sauerland & Anch, 1978).

Sleep Interruption’s Cognitive and Performance Effects

Inadequate sleep duration or sleep quality can have long-term effects for both body and cognitive ability (Ford & Kamerow, 1989). Approximately 40 percent of Americans get less than seven hours of sleep per week-night (Dement & Vaughn, 1999). The relationship between sleep and health is becoming more evident (Katz & McHorney, 2002). Sleep duration has decreased from a median of eight hours per night in the 1950s to seven hours per night (Maas & Robbins, 2010). With the decrease in sleep, an increase in health issues has occurred, particularly hypertension (Peppard, et al., 2000). Research at Stanford University and Cornell University has found that approximately 65 percent of Americans are sleep deprived (Maas, et al., 1998). Dr. James Maas (1998) of Cornell University believes the best predictor of longevity
is not exercise or nutrition, but quality and quantity of sleep. His recent studies on high school and college students support the idea that the circadian rhythm of the teenage brain is set to fall asleep at 3 a.m. and wake up at 11 a.m. Yet, most high school and college students get 2.5 hours less sleep per night than recommended. Subsequently, grades in high school and college are directly related to sleep length as evidenced primarily by the increase or decrease in a student’s G.P.A. (Maas, et al., 1998). Maas has deduced that sleeping longer than six hours per night helps in memory retention, but it takes eight hours to fully encode learned material (Jenkins & Dallenbach, 1924). Surveys by Maas and Robbins (2010) and by a research colleague at Stanford University, William C. Dement, found only 1 percent of students at their elite Universities are in an alert state throughout the entire day. Four out of five Cornell students experience drowsiness in the afternoon. Twenty-four percent say they take a nap each day (Maas & Robbins, 2010). It takes one hour of sleep to pay for every two hours of wakefulness. Thus, the ideal amount of sleep is eight hours per night.

In most industries eight hours of sleep is a difficult goal to attain. The smallest of sleep deficits can cause the largest of impacts upon performance. The military has researched and acknowledged these effects for years in order to enhance their protocols (Morgan, Cho, Hazlett, Coric & Morgan, 2002). It is not only with total sleep deprivation that we are able to see cognitive or physiological effects due to sleep loss or disturbance (Mohler, 1966; Della Rocco & Cruz, 1995). Moderate sleep debt can accumulate with successive nights of little sleep. Volunteers for a study who got four or six hours of sleep per night for two weeks showed ever-mounting deficits in attention to task and in speed of reaction compared to those sleeping eight hours per night (Van Dongen, et al., 2003). By the end of the study, the subjects getting less than eight hours of sleep per night had cognitive deficits equivalent to subjects who had been totally
sleep-deprived for three days (Price & Holly, 1990). Airline employees who had worked for five years on schedules that gave them little time to adapt to new time zones showed deficits in cognitive task of spatial memory. They also showed a reduced volume of the brain’s temporal lobe compared to employees on a schedule that permitted more time to recover from jet lag (Cho, 2001).

The National Commission on Sleep Disorders Research estimated that total sleep time for the U.S. population has decreased by 20 percent over the past century (National Commission on Sleep Disorders, 1993). Consequences of sleep deprivation can be catastrophic (Knipling & Wang, 1995). Sleep deprivation with operator error has been identified in numerous public disasters such as the grounding of the Exxon Valdez (oil spill) and the nuclear meltdown at Three Mile Island (Carskadon, 2005). There are as many as 100,000 traffic accidents, with approximately 40,000 injuries and 1,500 fatalities caused by drivers falling asleep annually in the United States (National Highway Traffic Safety Administration, n.d; Pack, 2006.). Sleep deprivation and sleep disorders may cost the American economy at least $150 billion dollars per year (Dement & Vaughan, 1999). The costs financially and physically due to fatigue or sleep issues have far reaching impacts (Walsh & Engelhardt, 1995). Research has shown that there is so much fatigue in American society that we are a nation distracted by our sleeplessness and carry a large sleep debt. Sleep debt is the difference between the hours of restorative rest people need for optimal physical and mental well being, compared to the number of hours they actually get.

**Sleep Interruption’s Athletic and Psychomotor Effects**

Athletes who compete in international or even national tournaments are frequently jet lagged by the travel. Jet lag is a feeling of grogginess due to the misalignment of the internal
circadian clock and local time/daylight cues (Jewett, Kronauer, & Czeisler, 1994). This can create a lethargic well-being and foggy headedness. A University of Witwatersrand, Johannesburg study conducted by Tamar Shira Goldin, induced jet lag in athletes. A six hour phase advance shift of the sleep-wake cycle disrupted objective sleep parameters, negatively altered mood states, and resulted in a poorer anaerobic athletic performance. The deterioration of physical measures of athletic performance after a six-hour phase advance shift indicates that there is a strong circadian influence, which may be relevant to success in athletic performance after transmeridian travel (Goldin, 2010).

A study by Stanford University of the National Football League (NFL) showed a significant advantage for West Coast teams competing against East Coast teams during Monday night football contests. The conclusion was drawn that the West Coast teams had the advantage travelling east due to competing during an ideal and peak circadian rhythm performance time. Conversely, East Coast teams competing on the West Coast were competing during a non-ideal circadian time of their actual bed time (Smith, Guilleminault & Efron, 1997). The tendency for West Coast teams to win was high not only for home games, but also for away games on the East Coast (Mah, et al., 2010). More than likely this is due to the differences in circadian rhythms between the two teams (Smith, et al., 1997).

Required athletic performance too late in the day, or too early is usually not in synch with one’s established peak performance time (Horne, 1981; Horne & Minard, 1985). This can create a jet lag effect, which can create a sleep disruption and therefore impair athletic performance (Hill, et al., 1993; Dean, Forger & Klerman, 2009). Shawn D. Youngstedt from the University of South Carolina erased time of day cues in 25 trained collegiate swimmers by keeping them perpetually in low lighting for two days at the schools fitness center (Kline, et al. 2007).
Throughout the study they were subjected to a short sleep-wake cycle. Participants swam every nine hours at times that varied from 0200 to 2300. Swimmers were successfully jet lagged through the disruption of their circadian rhythm, and it was shown that their peak performance would come later in the day, and be up to six seconds improved from earlier on in the day (Raloff, 2007).

There are numerous studies that document sleep restriction or deprivation and its impacts on athletic or psychomotor performance (Harmann & Langdon, 1965; Edwards & Waterhouse, 2009). Conclusively, these studies show that peak circadian time is critical, and many athletes are significantly sleep deprived as a whole (Hill, Bordon, Darnaby, Hendricks & Hill, 1992). Very few have gone the opposite direction and provided sleep extension, the opposite of deprivation, over an extended period of time (Kamdar, Kaplan, Kezirian & Dement, 2004). Cheri Mah of Stanford University performed such a study with the Stanford University Men’s Collegiate Basketball Team. While observing circadian disruptions, Mah discovered indirect evidence that sleep may affect athletic performance (Winget, DeRoshia & Holley, 1985). Extended sleep beyond one’s habitual nightly sleep average likely contributes to improved athletic performance, reaction time, daytime sleepiness, and mood (Bonnet & Arand, 1995). These improvements following sleep extension suggest that peak performance can only occur when an athlete’s overall sleep and sleep habits are optimal (Mah, et al., 2010).

**Mechanisms of Sleep**

Sleep researchers know very little about sleep compared to the number of research questions generated about sleep. For example, how is sleep turned on and off each night, why do we sleep, how is sleep maintained and why is it so dangerous not to sleep? There is an
understanding of some of the physiological structures that are involved in sleep, but far from the resolution scientists would like. Frederic Bremer was the first to suggest in 1938 that there were four mechanisms that control sleep (Bremer, 1938). These four areas; the hypothalamus, the Pons, the forebrain and the brain stem, that work in concert to make sleep happen.

There are several ways to organize the psychological and physiological features that characterize the period of unconsciousness known as sleep. Typically, the electrical patterns from the brain, the eye, and the voluntary muscles are used to organize sleep into stages. There are essentially two distinct stages of sleep; the Rapid Eye Movement (REM) sleep and the non-REM sleep (Rechtschaffen & Kales, 1968). The underlying brain events correlated with REM include the observation that certain neurons in the pons and in the brain stem are unusually active. This certainly contributes to the occurrence of REM (Hobson, 2009). The increased activity in the pons is also associated with a decrease in the release of monoamine neurotransmitters serotonin and norepinephrine, as well as histamine (Ashton-Jones, Gonzalez, & Doran, 2007). Serotonin and norepinephrine containing cells important to sleep regulation are located in the raphe nuclei and the locus coeruleus respectively; they may be responsible for switching between REM and Non-REM sleep (Sakurai, et all, 1998).

**Stages of Sleep**

The understanding of sleep couldn’t progress until the discovery of the organizing principles in the stages of sleep. This required the development of the electroencephalograph. In 1875, Caton discovered brain electrical activity in animals (Caton, 1875). Most had assumed that sleep was a very passive state, but electrical activity during sleep was quite an active process. It wasn’t until 1929 that Berger (1929) identified phenomenon like alpha waves in the EEG of man. Loomis first documented differing patterns of sleep in 1937 (Shepard, et al., 1937).
Aserinsky discovered eye movements during sleep in 1951, but it was not until 1953 that Rapid Eye Movements (REM) was established (Dement, 1974). It was Dement who categorized the stages of sleep in a long series of research studies on many individuals and included REM as a Stage 1 Sleep phenomenon (Dement & Vaughn, 1999).

The sleep stage process is comprised of five sequential stages that are repeated in cycle throughout sleep. Stages 1 to 4 known as Non-REM and REM sleep take approximately 90 to 110 minutes to complete (Aserinsky & Kleitman, 1953). Each stage is vital in the resting of the human body and processing of brain function. Stage 1 is light sleep where we can be awakened easily. This is where a falling or jerking asleep motion can be seen. Stage 2 is where brain waves and eye movements slow preparing for the body to enter the deep sleep of stages 3 and 4. Non-REM sleep has traditionally been organized into 4 separate stages, but more recently the American Association of Sleep Medicine has recommended that only 3 should be used (Schulz, 2008). Stages 3 and 4 were combined into one stage since the only difference was one degree of slow wave delta (0-4 cycles per second; Hz).

During deep sleep there is no muscle activity or eye movement. It is extremely difficult to wake someone during the stages of deep sleep. If they are awoken they can become very disoriented. Often when awoken at the beginning of stage 1 or during deep sleep, events are not remembered. If a stage is interrupted, it will begin in the stage where the interruption occurred when sleep resumes. During REM, breathing becomes more rapid, eye movements jerk in multiple directions and appendages are temporarily paralyzed (Ferman, et al., 1999). It is during this stage of sleep where it is believed rehearsal of the days events are played and memories encoded. We spend approximately 50 percent of sleep in the beginning stages of 1 and 2, and 20 percent in REM (National Institute of Neurological Disorders and Stroke, 2007). Disruptions of
the sleep cycle can have adverse effects on memory, coherence and motor function (Kuppermann, et al., 1995).

Each stage of sleep is essential to the process of recovery and reload of the human body (Morruzzi, 1972; VanDogen, et al., 2003). It is especially critical to brain function as well. REM sleep in particular is important for remembering things (Bliwise, et al., 2005). A study in 1924 showed that subjects retained and learned more efficiently followed by a cycle of sleep than those who learned earlier in the day (Jenkins & Dallenbach, 1924). This spurred further debate and research as to possible imprinting of memory and learning during sleep, especially after REM was discovered. One such study showed that after a psychomotor test was performed, the areas of the brain that were activated during the test were also lit during subsequent REM, as if to further assert REM’s role in memory and learning (Maquet, et al., 2000). A deprivation of REM sleep by three hours retards the rate of learning in some cases (Smith, 1995). There are instances in people with brain stem injuries that cannot enter REM, but they are still able to learn (Lavie, 1996). Thus REM is not the end all to learning; however, it has been clearly shown to have an important role.

There are other features that distinguish REM from non-REM. REM sleep is associated with active dreaming in which typically dream content is easily remembered, whereas non-REM is not. REM sleep is rare until the end of the sleep period. Non-REM is nearer the onset of sleep but the electrical patterns emanating from the brain are typically used to define sleep stages and to guide the research to find neurological changes associated with the gross EEG changes (Siegel, 2005). As evidenced by this brief discussion, there is much that is still unknown about sleep. It is clear that sleep is essential not just for normal functioning but also for our very survival.
**Hypothalamic and Circadian Systems**

Neurotransmitters from the Hypothalamic System in the brain manage wakefulness and sleepiness. The management of these hormones involved in sleep onset and sleep duration is controlled by the suprachiasmatic nucleus (SCN) (Welsh, Logothetis, Meister & Reppert, 1995). The SCN was discovered in 1971 (Moore & Eichler, 1972). The SCN is also instrumental in governing body temperature, hormone secretion, urine production and changes in blood pressure. These are critical to synchronizing the sleep-wake cycle or the body’s biological clock of circadian rhythm (Berson, Dunn, & Takao, 2002). The SCN is made up of two very tiny brain structures similar in size to the head of a pin. They contain approximately 20,000 neurons. These neurons are a part of the signaling process to begin and end the sleep process (Jewett, et al., 1994). They are located in the hypothalamus just above the optic nerve. A convenient location considering sleep is directly influenced by light (Moore & Eichler, 1972; Stephan & Zucker, 1972; Welsh, Logothetis, Meister & Reppert, 1995). Light has a direct impact because sleep is based on the body’s biological clock that follows the 24-hour cycle of the sun (Boivin, Duffy, Kronauer & Czeisler, 1996). Signals from the SCN neurons travel to the pineal gland to turn on and off the production of the hormone melatonin (Berson, Dunn & Takao, 2002; Freedman, et al., 1999). Melatonin builds naturally in the body inducing drowsiness and initiating sleep onset. Disruption of the circadian process can lead to feeling groggy and foggy headed, also known as jet lag (French, Bisson, Neville, Mitcha & Storm, 1994).

Sleep debt is prevalent in those who perform shift work, due to their work-rest schedules being in conflict with a normal sun-driven circadian rhythm. Shift work is estimated to affect 20 percent of the U.S. workforce, with sleep deprivation resulting as a strong consequence (Shepard, et al., 2005). Air Traffic Control (ATC) has been in the news recently because of their
concern with fatigue and out of rhythm operators (Levin, 2011). ATC is a 24-hour per day operation (Boquet, Cruz, Nesthus, Holcomb & Shappell, 2009). Most of these schedules limit midnight shifts to no more than one or two per workweek. Research has shown that even limited exposure to these shifts can result in significant problems related to sleep duration, sleepiness, alertness, vigilance, and complex task performance (Cruz, Boquet, Detwiler & Nesthus, 2002; Cruz & Della Rocco, 1995).

**Ladies Professional Golf Association Background**

The LPGA is comprised of two divisions, the Tournament Division and Teaching and Club Professional Division (T&CP). The Tournament Division is the assembly of the best touring golf professionals in the world that compete on a global tournament schedule all year. The T&CP is comprised of professional golfers that are engaged in the teaching, coaching, and management of all types of specialty fields within the golf industry. The PI, being a member of the T&CP, received approval from the Executive Director of the T&CP after the experiment outline was reviewed.

Following T&CP approval, the next step was approval from the Sr. Vice President of Professional Development and Member Services for the Tournament Division. She is responsible for the growth and welfare of opportunities for Tournament Division members. Any interaction or study of the Tournament Division must have her approval. Encouraged by the intent of the study, she provided her endorsement for the final approval from the legislative office of the LPGA. Once the facets of the study seemed to be appropriate and with no adverse impact on its members, the study was given clearance to proceed.
The LPGA Tour has evolved into a global tour. This means that players can compete in Alabama one week, the following week in California, and then proceed to South Korea, China and Singapore rounding out 5 weeks of non-stop competition. This travel can have an extreme impact on fatigue levels and performance (Caplan, Cobb & French, 1979; Baxter & Reilly, 1983). There are also instances of players driving great distances between tournament sites. Traveling by automobile or airline charter service are the preferred modes of transportation. However, due to the distance between events and fiscal reality, commercial airlines are the default medium, and this travel provides its physiological challenges on performance (Youngstedt & O’Connor, 1999; Samuels, 2008).

As any former tour player can attest, the typical tournament week for a touring golf professional varies from week to week. Time zone changes and additional professional commitments can alter travel. On average, the arrival to the tournament site is on a Monday. The player will practice that day with subsequent practices on Tuesday and Wednesday. Typically Wednesday and Thursday may provide Pro-Am events where the players compete with amateurs to promote the event and raise money for charity. Thursday or Friday is normally when the official tournament competition begins. Not all tournaments on the LPGA schedule are 4-day competitions; some are 3-day events as well. This will alter the player’s preparation schedule along with their professional obligations to sponsors and fans. There are many meetings and events scheduled between practice and competition days. In some instances, players may play one-day events in different parts of the country on Monday and Tuesday prior to the beginning of the actual tournament days in a differing location or region.

Tournament days also vary from week to week. Each individual tournament committee determines the number of competition days. This has a dramatic impact on the start and end
times (tee times) of tournament competition. These times are not revealed until Tuesday of each tournament week, and are randomly arranged by a computer program. The computer program selects tee times for players based on their LPGA ranking. Players ranked in the approximate top 70 get A-time selection. Players outside of the top 70 are placed in B-time selection. A-times start some time between 0830 and 1300. B-times begin before 0830 or start after 1300. Three-day events have randomized times established for the first day of competition. The second and third days are determined by performance. The better a player’s score, the later they play each day. Four-day tournaments have the first two days of tee times randomly established by a computer program with one day being an afternoon start, and the additional time as more of an early morning start. As an example, a player can have a 1400 tee time for Thursday and a 0700 tee time for Friday.

Start times can be as early as 0700, and as late as 1600 depending on daylight availability. A player’s tournament day revolves around these tee times. If they begin competition at 0700, more than likely their warm up begins at 0600. This requires them to wake up at approximately 0430 to allow time to prepare, eat and travel to the course. After a competitive round, the player will likely do some light practice, tend to any injuries and fitness concerns, and catch up on day-to-day responsibilities. Essentially these tournament days can last a minimum of eight hours at the golf course, and can be much longer due to weather delays. The typical day of an LPGA Tour Player during a competition week is often unpredictable and very difficult to characterize. They must be broken down into four types of days. There are travel days, practice days, Pro-Am/Outing days and days of competition. Travel days could be done via automobile or airplane, ferrying from state to state, or another country. Usually there is very little time for practice or physical conditioning on travel days. Although most players travel luggage
containing their golf equipment weighs 75 pounds, and their clothing luggage an additional 50 pounds, this can feel like physical conditioning.

Practice days entail an 18-hole round of golf (practice round), individual skill practice and physical conditioning. On practice days, it is up to the player as to what time their day will begin and end. How much impact the previous travel day had can influence the start time. Players walk and have a caddy carry their forty-pound golf bag for them during their practice and tournament rounds. It can take an average of five hours to complete a round of golf. This time frame does not include a practice warm up or practice cool down. This can add an additional three hours to preparation. Many players also receive sports medicine therapy services before and after play or practice. There is a possibility of a physical conditioning workout session that normally spans an hour or so. The amount of time these activities take are based on the individual can range widely. An average practice day can be at least eight-hours, but usually longer.

Pro-Am and Outing days are similar to practice days, except that warm-up and cool down practice sessions may be shorter due to being on the course longer. These outings are rounds of golf that do not impact tournament standing or tour ranking. These events take place at a set time, normally not revealed till the day before. They are opportunities to entertain sponsors and raise money for charity. Amateurs pay an entry fee to compete with Professionals, and the entry fee is provided to the tournament’s named charity. Usually there are four amateurs and one professional. It is the professional’s duty to entertain, assist and play for her assigned team. Afterwards there is a lunch or dinner with her team to conclude who had the best score of the day and thank participants.
Touring professional caliber golf is a sport that demands top physical endurance minded conditioning. It also requires elite fine motor skills, adept cognitive capabilities and elite focus over extended periods of time. With on-course strategizing, focus and endurance being critical components to achieving good golf (United Sleep Medicine, 2011). Research has shown interruptions of sleep patterns by stress, travel or the act of the athletic performance itself can have detrimental effects (Mougin, et al., 1991).

**Variables That Impact Tournament Golf Performance**

Many variables that can impact a professional golfer’s performance are weather, golf course conditions, golf course difficulty, injury, fatigue, interpersonal issues and various types of stress (Marquie, Foret & Queinnec, 1999). Golf is played in an extreme of environments, topography, and time zones. Some of these environments can create a delay or extension of the competition. Tournaments are typically only delayed for the following extreme weather conditions: dangerous weather (such as lightning), golf course flooding, frost conditions and darkness. Otherwise tournaments proceed under rain, wind, cold and heat. However, when extreme weather conditions occur, play can be suspended for hours till the situation is dissipated. A typical eight-hour competition day can quickly evolve into a 12 to 14-hour day at the golf course impacting nutrition, rest and recovery (Parker, 2007; Parker, 2011).

**Summary**

One group of professional athletes who probably suffers from the most demanding of schedules is touring golf professionals. The schedules of tour players are similar to that of other industries that require worldwide travel, sharp cognitive and physical execution (Boquet, et al., 2009). Some of the most prevalent predictors of fatigue are interrupted sleep, high work
demands and being female (Akerstedt, et al., 2002). This argues that the LPGA tour players could be assaulted with profound game changing fatigue that affects performance (Reilly, et al., 2007; Srinivasan, et al., 2010). Professional golf takes amazing dexterity, high cognitive function, married with exceptional endurance and focus. Golf score performance directly indicates ability and success. Insomnia is also shown to be especially problematic for females (Roth & Roehrs, 2003; Johnson, Roth, Schultz & Breslau, 2006).

According to a study presented at the 2008 American College of Sports Medicine annual meeting, golf mechanics change and performance may decline the longer the golfer walks and swings (American College of Sports Medicine, 2008). In studying LPGA athletes during two tournaments to assess the effect of sleep quality and quantity on their scores, an innovative performance prediction tool (FADE) estimated the extent of impairment anticipated. It was then compared to data obtained from subjective fatigue log sheets (Carskadon, et al., 1986). Golf being a profession and sport that is individualized and quantifiably calculated, provides an interesting opportunity to discover a correlated relationship of sleep quality and quantity in regards to performance.

**Hypothesis: 1**

The quality of sleep will impact golf performance of LPGA tour players. Poor quality of sleep (high subjective values) will equal poor quality of golf tournament performance (high value golf scores). Subsequently, high quality of sleep (low subjective values) will impact high quality golf tournament performance (low golf scores). A spearman rank order correlation test was used to equate the quality of rest (sleep quality rating) and fatigue sum with tournament score to test this hypothesis. Additionally when correlations were found an ordinal regression on these non-parametric variables was performed. The scores for players who made the cut (played
4 days of each tournament) were primarily evaluated. Those who did not make the cut (played only 2 days of each tournament) were evaluated as their own separate group. They were evaluated separately from those who made the cut for the relationship between golf score and fatigue measures. Finally, the fatigue variables and scores of the participants ranked in the top 50 of the LPGA rankings were evaluated separately from those participants ranked 101 and higher during both tournaments.

**Hypothesis: 2**

The quantity of sleep will impact golf performance of LPGA tour players. Low quantity of sleep will equal low quality of golf tournament performance (high value golf scores). Subsequently, high quantity of sleep will impact high quality golf tournament performance (low value golf scores). A Pearson product moment correlation test was used to equate sleep quantity, hours trying to sleep, hours golfing, LPGA and FADE (for those who made the cut) with tournament score. Additionally, when correlations were found a multivariate linear regression on the parametric variables was preformed. The scores for players who made the cut (played 4 days of each tournament) were primarily evaluated. Those who did not make the cut (played only 2 days of each tournament) were evaluated as their own separate group. They were evaluated separately from those who made the cut for the relationship between golf score and fatigue measures. Finally, the fatigue variables and scores of the participants ranked in the top 50 of the LPGA rankings were evaluated separately from those participants ranked 101 and higher during both tournaments.
Methods

This study examined the relationship between sleep quality and quantity and golf scores for professional women golfers during a typical LPGA tournament. The Embry-Riddle Aeronautical University Institutional Review Board approved the methods and the study began with the October 7-10, 2010 Navistar LPGA Classic in Prattville, Alabama and ended with the October 14-17, 2010 CVS Pharmacy Challenge in Danville, CA.

Participants

The participants in this study were some of the top LPGA players in the world. Table 1 shows the number of players from each country of origin for the 30 elite golfers who participated in this study. The table also shows the average age of the participants from each country and that the overall average age was 31.4 years. There were 38 players who volunteered to participate but only 28 of the participants completed the study measures in the Alabama tournament (Table 1). There were 144 players competing in the Alabama event. Twenty-one of the 28 participants completed the study measures for the additional event in California. That tournament was limited to 104 competitors. There were 21 players then, who completed both of the events in the study and five who were only at the Alabama tournament. Sleep Fatigue Log data, as shown in Appendix A were collected from all participants but actigraph data were obtained from only 17 players participating in both tournaments. There were eight players among the participants in the top 50 of the LPGA money list ranking, 12 players in the top 51-100 and eight in the top 101-175. The better-ranked golfers typically get preferential start times for tournament rounds known as A-times. Tournament rounds are played throughout the entire day. The first tee time can start at 0700 and the final tee time in the afternoon can end at local darkness. 18 holes of tournament golf can average approximately five hours pending weather conditions and course
difficulty. This represents a fair sample of all the players in the LPGA tournament. Data from all of the participants in Table 1 were used in the analysis.

**Table 1.**
The number of LPGA participants used in the study showing their home nation and the average age of the participants from that nation.

<table>
<thead>
<tr>
<th>Nation</th>
<th>Quantity</th>
<th>Average Age</th>
<th>Average Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>19</td>
<td>32.9</td>
<td>85.1</td>
</tr>
<tr>
<td>Taiwan</td>
<td>2</td>
<td>29.5</td>
<td>43.5</td>
</tr>
<tr>
<td>Australia</td>
<td>2</td>
<td>27.0</td>
<td>41.5</td>
</tr>
<tr>
<td>Korea/USA</td>
<td>3</td>
<td>24.0</td>
<td>47.3</td>
</tr>
<tr>
<td>Wales</td>
<td>1</td>
<td>36.0</td>
<td>81.0</td>
</tr>
<tr>
<td>Scotland</td>
<td>1</td>
<td>37.0</td>
<td>67.0</td>
</tr>
</tbody>
</table>

**Measures**

The measures employed allowed the strength of the relationship between sleep duration and sleep quality to be compared with golf performance. Key measures used were a subjective sleep fatigue log (Appendix A), FATigue DEgradation (FADE) equation, actigraphy and golf score. These were chosen for simplicity and ease of use during the applied setting of a professional golf tournament. Each of these will be discussed in turn.

There are many ways to measure sleep and sleep deprivation. Polysomnogram is the “gold standard” of measuring sleep. It is a clinical way to measure sleep by use of an electroencephalogram (EEG). The EEG captures brain wave activity and is paired with other modalities monitoring respiration, heart activity and limb movement (Dement & Kleitman, 1957).
These measures indicate the stages, duration and quality of sleep. Another way to measure sleep that has gained acceptance in the field is actigraphy (Sadeh, Hauri, Kripke & Lavie, 1995). Though not as detailed of a measure as EEG, it is less expensive and intrusive while still providing indications of sleep onset, activity and duration (Kushida, et al., 2001).

**Sleep Fatigue Log:**

The Sleep Fatigue Log contains detailed start and end times of not only sleep and wake activity, but also the fatigue level throughout the day (Gillberg, Kecklund & Akerstedt, 1994). The log records a rating of the subjective quality, quantity, times of sleep and a fatigue rating every few hours throughout the day along with a golf score on each day of competition (Hoddes, Zarcone, Smythe, Phillips & Dement, 1973). The Sleep Fatigue logs were based on similar sheets developed for the USAF at Brooks Air-force Base (Johnson, 1991; French, et al., 1994). They were developed to be quickly completed and unobtrusive. These data were inserted into FAtigue DEgredation (FADE) assessment tool to determine what the calculated impact of fatigue on performance should be compared to the actual fatigue levels reported. It was expected that the golf score would correlate well with the FADE fatigue equation; That is, the more tired the participants were or were estimated to be, the worse their golf score prediction would be.

Each participant completed a Sleep Fatigue Log. Each log sheet represented data over a seven-day period. The sleep log data that was completed by the participant indicated the subjective sleep times, duration and quality. It was the main source of player information used in the study. The participants completed two log sheets over the course of the two-week study. Fourteen days of activity were thus captured, with only eight of those being actual days of competition. These data represented most of the data collected and analyzed for the majority of the participants.
The data used in the analysis for each golfer and for each day were entered into a spreadsheet once returned to the PI. The golf score for the day was entered first for each participant, followed by the sleep duration and sleep quality scores from the preceding night. If the golfer napped before the golf event (on the day of the golf event), this was added to the sleep duration score and the sleep quality score (if indicated for both the night’s sleep and the nap) were averaged. Trying to sleep was an entry on the activity log and encompassed not only the onset of sleep, but also any interruptions of sleep throughout the night. If they awoke due to a sleep interruption like the snoring of a spouse, or needing to use the bathroom, an indication of the time and duration of the disruption was noted on the sleep fatigue log. The hours spent trying to sleep was expected to tell us how many awakenings or how difficult it was to fall asleep. The subjective fatigue score and the FADE score (see below) used in the data spreadsheet were the most proximal fatigue score within three hours of the golf event. Otherwise no sleep fatigue score was entered.

**FADE:**

FADE is a computer algorithm that estimates human performance dependent upon sleep duration and timing. It is based on a study where Air Force personnel were kept awake for over 50-hours (Shingeldecker & Holding, 1974; French, et al., 1994). Their resulting cognitive performance scores were mathematically modeled and fit to a prediction equation. The equation is embedded in a computer worksheet called the FADE assessment tool and was used to rate the performance expected of the participants based solely on sleep duration and timing. FADE was used to score the performance expected based upon prior sleep and wake times obtained from the Sleep Fatigue Log. The FADE algorithm produced a fatigue score that was linked to the golf score in the analysis.
**Actigraph:**

The actigraph is a wrist worn device that measures movement through accelerometers (Littner, et al., 2003). The data clearly shows when someone is asleep compared to awake and when they sleep restlessly, giving an idea of the quality of sleep. Many studies use actigraphs to monitor sleep in applied settings (Lieberman, Kramer, Montain & Niro, 2007). They were used as an objective measure of sleep duration and quality, but were primarily used to determine the compliance of those who wore them with their sleep logs. If these participants were compliant then there was some confidence that others were as well.

There were 17 actigraphs available to the study, however only 11 produced useable data. Seventeen of the 30 participants wore the actigraph device during sleep. Since only a few actigraphs were available for the study, they were used to compare with the wearer’s log sheet entries to determine the degree of compliance with the Sleep Fatigue Log. A decision was made depending on the deviation of compliance as to whether to keep the data or not. Players were selected to wear these based on their interest, and if they were competing in both tournaments.

**Golf Score:**

A player’s golf score during a tournament is the ultimate measure of their performance. The objective in each tournament is to achieve the lowest score possible in order to obtain the highest finish in the event. During competitive rounds another player in the group, along with an official tournament score person, keeps a player’s score. On competition days players also noted their golf score for the day on their Sleep Fatigue Log.

**Procedures**

The senior administration of the LPGA gave approval and participants were solicited from the Tournament Division membership via email and flyers as shown in Appendix B.
The PI enrolled all participants at the first tournament in Prattville, AL on October 5-6, 2010. All the participants completed an informed consent document and demographic questionnaire as shown in Appendix C and D, respectively. They were then provided two sleep fatigue log data sheets for the two-week duration of the study and actigraphs, if available. The PI briefed participants on how to use these measures and the restrictions of the study. They were also given a stamped, self-addressed envelope to return the measures to the PI, which they did at the end of their participation.

The players were asked to keep the sleep log sheets conveniently located throughout the day to record their subjective fatigue (sleepiness rating), and whether they were sleeping or competing in an event every three hours while awake (Akerstedt & Gillberg, 1990). This information was logged in the appropriate time slot on the log sheet. If they slept, they indicated sleep, the start/end of sleep, and rated the quality of their rest in the appropriate time slots. Entries on the log sheet took about 30 seconds to complete. There were no other requirements of the study that would have taken their attention away from the golf event. The actigraphs were not worn until they slept since the golfers did not want to wear them during the event. The PI or an associate was available via email and in person at the tournament site for any questions, but did not bother the participants otherwise. After completion of the two tournaments, the sleep log sheets and actigraphs were collected by LPGA staff and returned for post processing. Through the LPGA website, the PI was able to verify tee times and scores (Appendix E & F).

When all materials were returned to the PI, data analysis was able to begin. In order to perform SPSS regression analysis, raw data from the Sleep Fatigue Log was organized. The sleep quantity and quality of a participant for the day prior to competition was used as a predictor for the golf score of the following day. It was a staggered entry of the data into SPSS. This
staggered entry, along with utilizing data of non-cut participants was necessary to ensure an equal number of N’s for analysis. Pearson and Spearman correlations were performed, along with Linear and Ordinal regressions.

**Results**

The data collected during the two LPGA tournaments included parametrically distributed variables and ordinal, or distribution free, variables. The parametric variables were sleep quantity, hours trying to sleep, hours golfing, LPGA rank, golf scores and the FADE scores. The ordinal data were subjective and Likert-scaled and measured sleep quality rating and a daily fatigue sum. Linear and ordinal correlation and regression techniques were used to model the data to determine the impact of the independent variables on the dependent variable of golf score. The data were reviewed and the demographic survey results were organized. The variable data was then reduced to the eight days from which a tournament golf score was obtained. This was necessary since the data collection period consisted of two weeks of data. There were some days during the two weeks of evaluation that golf competition did not occur, and the study was only concerned with competition days. The main analysis focused on the scores for all players who made the cut (played all four days of each tournament). Then, those who didn’t make the cut (only played for two days of the tournament) were considered in a subsequent analysis. FADE scores were only calculated for those who made the cut. Finally, data from the participants in the top 50 of the LPGA rankings were compared with those participants ranked 101 and above.
**Demographics**

The study’s 28 participants were a sampling of the approximately 300 top qualifying female golfers in the world, approximately 10% of the golfing elite population. The rankings of the player’s in this study range from 16th to 200th on the LPGA Tour and in the world. All of the participants completed a demographic survey (Appendix D) upon entry into the study. Table 1 in the Methods Section above organized the participants by the nations they represent and showed their average LPGA rank and average age. Table 2 below provides a summary of the other demographic data collected on the survey. The survey addressed questions in regards to their perceived sleeping quantity and quality, individual challenges and details of any medical conditions or medications. For example, 75% of the participants indicated that they slept enough and well, yet 50% of them also reported that they have their sleep interrupted by such things as, stress, noisy roommates, uncomfortable hotels, spousal snoring or restless children. In addition, 54% of all participants indicated they had poor sleep quality on days where their tee times were early in the day. They indicated stress/fear of oversleeping and arising early as factors to sleep disruption on tournament days. Only 21 percent of participants scheduled or allowed naps in their routine. Two participants indicated medical conditions and required medications. Xyrem, Provigil, Effexor ER and one CPAP machine were listed on the demographic survey under medical treatments. The participant’s identities and self-reports of medical conditions were kept anonymous for confidentiality purposes by the design of the data collection.
Table 2.
Subjective information provided in participant’s demographic survey.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Weight</td>
<td>144 pounds</td>
</tr>
<tr>
<td>Average Age</td>
<td>32</td>
</tr>
<tr>
<td>Perceived Sleep Quantity</td>
<td>7.5 hours</td>
</tr>
<tr>
<td>Perceived Enough Sleep and Good Quality</td>
<td>75%</td>
</tr>
<tr>
<td>Sleep Disrupted</td>
<td>50%</td>
</tr>
<tr>
<td>Take Naps</td>
<td>21%</td>
</tr>
<tr>
<td>Poor Sleep Quality Due to Early Tee Time</td>
<td>54%</td>
</tr>
</tbody>
</table>

Golf Score Predictors

The relationships between sleep and fatigue variables upon golf scores during two LPGA tournaments was evaluated. As shown in Table 3, an initial review of the raw data provided some central tendencies of potential predictors of golf score.

Table 3.
Typical values during two LPGA tournaments for hours trying to sleep, sleep quantity, hours golfing, golf score and the median score for sleep quality and fatigue sum score for all participants.

<table>
<thead>
<tr>
<th>Trying to Sleep Hours: (On Average)</th>
<th>Sleep Quantity: (On Average)</th>
<th>Hours Golfing: (On Average)</th>
<th>Golf Score: (On Average)</th>
<th>Sleep Quality: (Median)</th>
<th>Fatigue Sum: (Median)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9 ± 0.69</td>
<td>8.3 ±1.50</td>
<td>4.8 ±3.38</td>
<td>71.2 ±3.09</td>
<td>2.0</td>
<td>18.0</td>
</tr>
</tbody>
</table>
All of the data in Table 3 were drawn from each participant’s sleep/fatigue log (Appendix A) upon which the participants noted the beginning and end of sleep, the beginning and end of their competitive golf round, their golf score on days of competition, their subjective sleep quality rating and a subjective rating of their fatigue sum throughout the day. The PI calculated a daily sum of reported fatigue and a daily FADE score for the analysis from these data. The time asleep and the time awake data recorded on the sleep log were inserted into the FADE program to determine a daily fatigue estimate for each golf tournament day for each participant that made the cut.

**Making the Cut**

Participants who did not make the cut (n=11 in Alabama, n=5 in California) were not considered in the first analysis in order to focus on those golfers (n=17 in Alabama, n=16 in California) who played the most golf, all four days of each tournament. Figure 1 shows a graph of the two days of golf scores for those who were cut compared to the four days for those who made the cut. The lower the golf score, the better the performance, in turn the better the tournament finish and overall ranking. The difference is clear between the cut players and those not cut who made the cut.
Figure 1. The golf scores for the two days of the players who did not make the cut compared to the four days of those who did make the cut.

Table 4 below provides a summary of these participants. Scoring average tended to decrease from those shown in the overall profile above in Table 3 along with the quantity of sleep and trying to sleep. Conversely, average hours golfing tended to increase, while quality of sleep and fatigue sum score were maintained about the same. The average golf score of participants that made the cut over the two events was 70.7 (sd 2.87), with an average of sleep quantity being 8.06 hours (sd 1.40) and a sleep quality median of 2.0. Fatigue sum remained the same with a median of 18.0, hours golfing increased to an average of 5.0 hours (sd 3.2) and trying to sleep also decreased to 0.9 hours (sd 0.67).

The FADE score was used as a means to get an estimate of participant fatigue sum expected based on the amount of sleep the night before. This distinguishes it from the subjective fatigue sum score collected throughout the day. The FADE score was only calculated for participants that made the cut.
Table 4.
The typical values during two LPGA tournaments for hours trying to sleep, sleep quantity, hours golfing, golf score, FADE score and median of sleep quality, fatigue sum score for participants that made the cut.

<table>
<thead>
<tr>
<th>Trying to Sleep Hours (On Average)</th>
<th>Sleep Quantity Hours (On Average)</th>
<th>Golfing: (On Average)</th>
<th>Golf Score: (On Average)</th>
<th>Sleep Quality (Median)</th>
<th>Fatigue Sum (Median)</th>
<th>FADE Score (On Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9 ± 0.67</td>
<td>8.1±1.40</td>
<td>5.0±3.2</td>
<td>70.7±2.87</td>
<td>2.0</td>
<td>18.0</td>
<td>461.5±34.28</td>
</tr>
</tbody>
</table>

Pearson correlation coefficients as shown below in Table 5, were calculated comparing golf score with LPGA rank, sleep quantity, FADE score, hours trying to sleep and hours golfing for participants that made the cut at both tournaments. As reported in Table 5, significant correlations were found between golf score and hours golfing \( r = 0.21 \) \( p < 0.01, n=136 \). Sleep quantity was inversely related to hours trying to sleep \( r = -0.36, p < 0.00, n=136 \), hours golfing \( r = -0.48, p < 0.00, n=136 \), and FADE \( r = -0.54, p < 0.00, n=136 \). FADE also inversely correlated with hours trying to sleep \( r = -0.19, p < 0.01, n=136 \). Inverse relationships or correlations denote as one variable increases, another variable decreases.

Table 5.
A Pearson Correlation of golf score compared with parametrically distributed data of LPGA rank, sleep quantity, hours trying to sleep and hours golfing for participants that made the cut over both tournaments.
Spearman Rho coefficients were calculated for the ordinal data as shown below in Table 6. A significant correlation was found between golf score and fatigue sum ($rs = 0.20$, $p < 0.02$, $n = 136$). Figure 2 captures the relationship between fatigue sum and golf score. Sleep quality rating ($rs = 0.39$, $p < 0.00$, $n = 136$) was also found to have a significant relationship with fatigue sum. As fatigue increases, sleep quality is impacted negatively. In addition, when fatigue increases so does golf score.

**Table 6.**
A Spearman Correlation of golf score compared with non-parametric/distribution free data of sleep quality and fatigue sum participants that made the cut over both tournaments.
Table 6. Spearman’s rho

<table>
<thead>
<tr>
<th>Spearman’s rho</th>
<th>Golf Score</th>
<th>Sleep Quality</th>
<th>SUM Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golf Score</td>
<td>Correlation Coefficient</td>
<td>1.000</td>
<td>.120</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td></td>
<td>.081</td>
<td>.011</td>
</tr>
<tr>
<td>N</td>
<td>136</td>
<td>136</td>
<td>136</td>
</tr>
<tr>
<td>Sleep Quality</td>
<td>Correlation Coefficient</td>
<td>.120</td>
<td>1.000</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td></td>
<td>.081</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>136</td>
<td>136</td>
<td>136</td>
</tr>
<tr>
<td>SUM Fatigue</td>
<td>Correlation Coefficient</td>
<td>.195*</td>
<td>.393**</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td></td>
<td>.011</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>136</td>
<td>136</td>
<td>136</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (1-tailed).
**Correlation is significant at the 0.01 level (1-tailed).

Figure 2. Scatter plot of golf score as it relates to subjective fatigue sum for participants that made the cut at both tournaments.

Multiple linear regression was used to estimate the predictiveness of the variables upon golf score. These data are shown in Tables 7 and 8. The R square value indicates that a significant percent of the variability (9%) was explained by the overall grouping of the independent variables considered. The model of these predictors is significant. Table 9 shows the individual contribution of these variables to the model. Only hours golfing during
tournament days and LPGA rank, as shown in Table 9, Figure 3 and Figure 4, significantly predicts golf score.

**Table 7.**

Linear Regression Summary of participants who made the cut over both tournaments.

<table>
<thead>
<tr>
<th>Mode</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>R Square Change</th>
<th>df 1</th>
<th>df 2</th>
<th>Sig. F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.30</td>
<td>.094</td>
<td>.059</td>
<td>2.780</td>
<td>.094</td>
<td></td>
<td>2.691</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.024</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), LPGA RANK, Trying to Sleep Hours, Hours Golfing, FADE Score Ea Day, Quantity, and Sleep Hours.

**Table 8.**

Linear Regression ANOVA of participants who made the cut over both tournaments.

<table>
<thead>
<tr>
<th>ANOVA b Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>103.978</td>
<td>5</td>
<td>20.796</td>
<td>2.691</td>
<td>.024</td>
</tr>
<tr>
<td>Residual</td>
<td>1004.662</td>
<td>130</td>
<td>7.728</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1108.640</td>
<td>135</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), LPGA RANK, Trying to Sleep Hours, Hours Golfing, FADE Score Ea Day, Quantity, and Sleep Hours.
b. Dependent Variable: Golf Score.

**Table 9.**

Linear Regression Coefficients of participants that made the cut over both tournaments.
<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>(Constant)</td>
<td>57.343</td>
<td>7.815</td>
<td></td>
</tr>
<tr>
<td>Quantity, Sleep Hours</td>
<td>.343</td>
<td>.299</td>
<td>.168</td>
</tr>
<tr>
<td>Trying to Sleep Hours</td>
<td>.466</td>
<td>.462</td>
<td>.109</td>
</tr>
<tr>
<td>Hours Golfing</td>
<td>.243</td>
<td>.092</td>
<td>.271</td>
</tr>
<tr>
<td>FADE Score Ea Day</td>
<td>.008</td>
<td>.010</td>
<td>.101</td>
</tr>
<tr>
<td>LPGA RANK</td>
<td>.871</td>
<td>.353</td>
<td>.210</td>
</tr>
</tbody>
</table>

**Figure 3.** Scatter plot of golf score as it relates to hours golfing for participants that made the cut at both tournaments.
Figure 4. Scatter plot of golf score as it relates to LPGA rank for participants that made the cut at both tournaments.

An ordinal regression was used to determine the extent to which the subjective data could predict golf score, as shown in Table 10-12. The data in Table 10 show that the slopes are different for the predictor variables compared to a null effect. Table 11 shows that the fatigue variables with golf score form a perfect correlation of 1.0.

Table 10.

Ordinal Regression Model fitting of participants that made cut over both tournaments

<table>
<thead>
<tr>
<th>Model</th>
<th>-2 Log</th>
<th>Likelihood</th>
<th>Chi-Square</th>
<th>df</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>541.820</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final</td>
<td>.000</td>
<td>541.820</td>
<td>66</td>
<td>.000</td>
<td></td>
</tr>
</tbody>
</table>
Table 11.
Ordinal Regression of participants that made cut over both tournaments

<table>
<thead>
<tr>
<th>Made the Cut Participants</th>
<th>Goodness-of-Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chi-Square</td>
</tr>
<tr>
<td></td>
<td>Pearson</td>
</tr>
<tr>
<td></td>
<td>Deviance</td>
</tr>
</tbody>
</table>

The data in Table 12 show that the Nagelkerke Pseudo R squared statistic is 0.99 indicating a strong effect size (ES=99%). These effects can be seen more clearly in the chart in Figure 5, which compares the median values for sum fatigue scores and Quality of sleep scores in relationship to golf score.

Table 12.
Ordinal Regression Pseudo R-Square of participants that made cut over both tournaments

<table>
<thead>
<tr>
<th>Pseudo R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cox and Snell</td>
</tr>
<tr>
<td>Nagelkerke</td>
</tr>
<tr>
<td>McFadden</td>
</tr>
</tbody>
</table>
Figure 5. Relationship between subjective fatigue sum and sleep quality with golf score. Note the higher the sleep Quality score the lower the sleep quality.

**Cut predictors**
Some of the players did not qualify for the remaining two days of the tournament and were excluded. In order to evaluate this population to determine if inadequate sleep or excessive fatigue might have influenced golf scores analyses performed on made the cut participants and performed on missed the cut. A Pearson product moment correlation was run on the parametric data, and a Spearman Rho was completed on the non-parametric data. Multivariate linear regression and ordinal regression was utilized accordingly for the parametric and non-parametric variables. Sleep quantity is shown to be inversely correlated with hours golfing ($r=-0.72, p<0.00, n=30$). Trying to sleep is inversely correlated with LPGA rank ($r=-0.30, p<0.05, n=30$) and sleep quality rating is inversely correlated with fatigue sum ($r_s=-0.58, p<0.00, n=30$). None of the parametric variables besides golf score were found to significantly predict their impact upon golf score and making the cut. Fatigue sum and sleep quality rating were found to have a
relationship with golf score and perhaps missing the cut, but nothing of statistical significance. Golf score was the only variable between making the cut and missing the cut that was highly significant. Given the difference in score is what ultimately determines making the cut as shown in Figure 6.

Figure 6. Relationship between golf score and making the cut across four days of competition between participants who were cut or not cut.

Rank Predictors of Golf Score

The most common finding in relationship to golf score was LPGA rank as shown in Figure 7. The better the rank, the better the golf score. An analysis was run to determine if the variables those participants ranked in the Top 50 and ranked 101 and above had similar relationships to golf score. A general linear model was utilized to determine relationships and differences between ranks and the fatigue variables as they relate to golf score. The ranking
groups have distinctly different experiences with the fatigue variables as shown in Figures 8 through 10.

**Figure 7.** Relationship between golf score and the different LPGA rankings of participants.

As top 50 ranked players play more golf, their fatigue levels climb as shown in Figure 8. Participants ranked 101 and higher have lower fatigue ratings due to playing less golf than higher ranked participants. Though the top 50 has higher fatigue, their sleep quality rating and sleep quantity is lower than other ranks as shown in Figures 9 and 10.
Figure 8. Relationship between fatigue sum and the different rankings of participants.

Figure 9. Relationship between sleep quality rating and the different rankings of participants.
Discussion

The LPGA Tour consists of the best female golfers in the world. These players complete a complex qualification process every winter to maintain the privilege (status/rank) of competing on the circuit. These results were based on a sampling of a substantial numbers of these elite golfers. Every week on the LPGA tour provides a new town, a different schedule of events, a new sleep environment and often a new time zone. Players have the choice of staying in a hotel or are invited to stay with a family in a private home (private housing). Often there is not enough private housing for all competitors, and hotels become the housing for the tournament week. Hotel quality will vary with a player’s budget. Many players do not have large corporate sponsorship providing travel expense provisions. It is often necessary to have a roommate in order to be cost efficient. These changes coupled with stress can be significant factors in circadian rhythm disruption, in turn impacting sleep quality and quantity. Our results have shown that subjective fatigue can be predictive of golf score. The lower the fatigue sum, the better the golf score (lower number). The results indicated that the less time spent golfing in the

Figure 10. Relationship between sleep quantity and the different rankings of participants.
tournament the better (lower) the golf score. Effects were found that supported the validity of the measures used. For example, sleep quality was correlated with fatigue sum; that is, the better the sleep quality (the lower number) the lower was the fatigue sum. The less sleep obtained, the greater the FADE estimate of fatigue.

It was hypothesized that sleep quality would be much higher than recorded. The average sleep score across all participants was 2.36, fairly acceptable considering participants have a different sleep environment and time zone each week. Conversely, due to these challenges it was hypothesized that the quantity of sleep obtained to be much lower than an average of 8.29 hours. With the extreme of daily start and stop of the participant’s schedules and their self-predicted sleep quantity being an average of 7.53 hours of sleep, it was anticipated that sleep quantity would be shorter. In addition, hours’ trying to sleep was significantly higher than anticipated, 0.91 hours. Initial speculation from the PI personal experience as a former touring professional, was that participants would be so exhausted that there would be no difficulty in falling asleep, and maintain a continuous sleep. In review of the raw data, difficulty of falling asleep and interruptions were prevalent amongst all participants. Thus, it would be expected that the sum of fatigue sum throughout the day would be much higher than an average of 19.69 with such interruptions.

Could there be differences between the tournaments in Alabama and California? Upon further review of the data, very little variance could be accounted for to determine a distinct relationship amongst the variables. Each tournament requires further detailed independent analysis of their variables to determine the possibility of significance. Initial analysis was used to determine that there were differences more apparent in Alabama or California. The descriptive statistics reflect that scoring and sleep results were different between the two events.
A Pearson product moment and Spearman correlation of the Alabama tournament indicated results that were identical to the analysis of both tournaments as shown in Table 7 and Table 8. Golf score correlated with hours golfing ($r = 0.17, p < 0.05, n = 92$) and LPGA rank ($r = 0.27, p < 0.00, n = 92$). Alabama sleep quantity inversely correlated with trying to sleep ($r = -0.18, p < 0.04, n = 92$) and hours golfing ($r = -0.56, p < 0.00, n = 92$).

The Alabama tournament provided a wide range of tee times beginning at 06:50 and ending at 13:30, while also coupled with players travelling in from all over the world prior to the event. California with a smaller field of participants was able to begin at 8:00am and have its last tee time at 10:30am, providing an opportunity for fatigue sum recovery and a more circadian friendly competition time.

Fatigue sum was significantly higher for Alabama than California. Sleep hours were shorter in Alabama than California, along with sleep quality being stronger in California though golf rounds were longer there. Sleep quality and quantity were improved in California. This could be due to travelling from the Eastern Time zone to the Pacific Time zone, allowing the opportunity for sleep debt to be consumed. Further study in travel differences in going east to west needs to be evaluated. Over half of the participants in the study came from the west to Alabama, with some coming from Korea or Taiwan. It is not empirically proven if this could have added to the fatigue. Further study to provide empirical evidence if preferential allocation of A and B times aid or harm the performance of players needs to be pursued. The California event maintained similar tee times each day, and fatigue was reduced as compared to Alabama. Future study could unveil if having travelled to California towards the time zone they had previously been, allowed for sleep to be improved. Evidence could indicate eliminating A and B
time differences not only provide equal footing of all competitors, but improved fatigue management.

Regardless, the overall scoring average was lower in Alabama. However, this could be related to the fact that the California golf course is perceived as being more difficult by the players and has a higher golf course difficulty rating. It is so challenging that the tournament field is minimized from the standard of 144 players, to 110 in order to insure completion of tournament rounds. The difficulty of the course caused the hours golfing to be significantly higher than what occurred in Alabama. The length of competition could have played a factor towards fatigue in California.

The participants in both events are the very best female golfers in the world. Differences and significance are a challenge to detect statistically. It is in these slight differences that can be critical to success. Just one stroke can indicate a win, making the cut or maintaining status on the tour. Therefore, further analysis is required to calculate effectively how significant the fatigue variables could be to performance. More participants and more competition days would be helpful to increase effective sizes. Along with more detailed fatigue and sleep measurements and subjective analysis of stress levels, as well as exact previous travel, need to be considered in more detail.

The hypotheses have not been substantiated nor rejected, but partially supported. Further study is required. The regression models indicate the fatigue variables to have a significant relationship to golf score. Fatigue significantly correlates to golf performance, but it has yet to be determined what correlates to fatigue and in turn impacts golf score. These are questions that require further pursuit.
References


Parker, N. *University of Rochester School of Nursing. October 2011 Interview on her 2007 LPGA sleep and performance study.*


### Activity Log

**Sleep Record**

**LPGA Fall 2010**

**Participant no.**

<table>
<thead>
<tr>
<th>Activity Log</th>
<th>Actigraph (if applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Date: (for this log sheet)</td>
<td></td>
</tr>
<tr>
<td>Local Time</td>
<td>1200</td>
</tr>
<tr>
<td>Actual Time</td>
<td></td>
</tr>
<tr>
<td>Rating</td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td></td>
</tr>
</tbody>
</table>

**SCORE**

| Local Time | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | 2200 | 2300 | 0000 | 0100 | 0200 | 0300 | 0400 | 0500 | 0600 | 0700 | 0800 | 0900 | 1000 | 1100 |
| Actual Time | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rating | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Activity | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**SCORE**

| Local Time | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | 2200 | 2300 | 0000 | 0100 | 0200 | 0300 | 0400 | 0500 | 0600 | 0700 | 0800 | 0900 | 1000 | 1100 |
| Actual Time | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rating | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Activity | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**SCORE**

| Local Time | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | 2200 | 2300 | 0000 | 0100 | 0200 | 0300 | 0400 | 0500 | 0600 | 0700 | 0800 | 0900 | 1000 | 1100 |
| Actual Time | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rating | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Activity | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**SCORE**

| Local Time | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | 2200 | 2300 | 0000 | 0100 | 0200 | 0300 | 0400 | 0500 | 0600 | 0700 | 0800 | 0900 | 1000 | 1100 |
| Actual Time | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rating | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Activity | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**SCORE**

| Local Time | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | 2200 | 2300 | 0000 | 0100 | 0200 | 0300 | 0400 | 0500 | 0600 | 0700 | 0800 | 0900 | 1000 | 1100 |
| Actual Time | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rating | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Activity | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**SCORE**

**NOTES (Enter here any added notes about sleep, about food or drink or other information that will help us interpret your data):**

---

**INSTRUCTIONS AND EXAMPLE ON OTHER SIDE**
INSTRUCTIONS:

1. Enter the start DATE and your PARTICIPANT # (not your name) and the ACTIGRAPH # at the top of the front page (if you were given one). Fold the sheet up and keep it handy throughout the day. Takes only seconds to update.

2. When you AWAKEN and for EVERY THREE HOURS that you are AWAKE, write the ACTUAL LOCAL TIME on the Actual Time row (for example, 19:12) would go below the corresponding Local Time row (in the example below, 1900) and then write in the following:

   **SLEEPINESS RATING**
   Write your sleepiness rating (1 to 7) in the Rating row:
   1 = Feeling active and vital; alert; wide awake.
   2 = Functioning at a high level, but not at peak; able to concentrate.
   3 = Relaxed; awake; not at full alertness; responsive.
   4 = A little foggy; not at peak; let down.
   5 = Fogginess; beginning to lose interest in remaining awake; slowed down.
   6 = Sleepiness; prefer to be lying down; fighting sleep; woozy.
   7 = Almost in reverie; sleep onset soon; losing struggle to remain awake.  

   TRY SETTING THE COUNT DOWN TIMER ON YOUR WATCH TO GO OFF EVERY 3 HOURS TO REMIND YOU TO UPDATE LOG

3. Show when you SLEEP (including naps) or COMPETING for every HALF HOUR on the Zulu Clock row using the following activity codes. Write the appropriate code (C, S or T) in the Activity row:

   - C = Competing in event
   - S = Sleeping or napping
   - T = Trying to sleep

   Rather than fill up all the boxes with a letter like S for Sleeping, indicate S at start and stop of sleeping and use dashes for the rest of the boxes. See examples below.

   Do not Wake up to fill out log sheet!!

4. For each SLEEP OR NAP, write the quality rating for your rest (1 to 4) in the Activity row at the end of the sleep or nap period, using these codes: SEE EXAMPLE BELOW

   1= Extremely good
   2= Moderately good
   3= Moderately poor
   4= Extremely poor

   **SCORE:** PLEASE INDICATE YOUR TOURNAMENT SCORE where indicated on the log sheet near the actual time column.

   **SEE EXAMPLE BELOW**

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<th>0530</th>
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</tbody>
</table>

**SCORE** 64 YEAH!

This process may sound complicated at first, but it will soon become routine and quick. Please make every effort to be accurate. Enter your data as it happens or soon after, don’t try to recall times and events hours later. Your data will be extremely useful in our effort to improve the performance and quality of life for LPGA competitors. We thank you. Please return once completed to study administrator or directly to the address below. You should have a stamped self addressed envelope to mail all of these forms. If not please mail to us on your own.

Please let the study administrator (Maria Lopez 386 547 4000) know if you have any questions or difficulties complying with this study. Thanks.
An evaluation of how much sleep matters for top performance in high level athletes.


We will be asking for volunteers to record their sleep quantity and quality (both voluntary and involuntary sleep-naps too!) during the 10 days of the Tournament. It’s that simple. We will provide you with a paper log that is easy to fill out and takes just seconds a day. Some of the players will have a ‘sleep watch’ to record their activity during the day but we don’t have enough for everyone. We need you to record your sleep and your score each day and we’ll compare how well the two match up. All data will be completely anonymous; no one else will see your records. It is the only way to determine how much of an impact effective sleep has on athletic performance. As an incentive, we will send you your results if you like along with an evaluation of your data and some sleep ‘on the road’ hints by noted sleep management consultant and Embry-Riddle professor, Dr Jon French. Please plan to help us. You’ll be learning a lot about what an advantage sleep can be for you and the best ways to make your sleep count!

Maria “Loopy” Lopez
Co-Principal Investigator
ERAU Head Women’s Golf Coach
2007 LPGA T&CP National Coach of the Year
(386) 547-4000 cell
LopezSleepStudy@gmail.com
INFORMED CONSENT DOCUMENT
The effects of sleep quality and quantity on elite golfer performance
Embry Riddle Aeronautical University
Human Factors Research Laboratory
600 S. Clyde Morris Blvd.
Daytona Beach, FL 32114-3900

Purpose of Research
The purpose of this study is to determine if the quality and quantity of sleep has an impact on elite athletic performance.

Specific Procedures to Be Used
First, you will be asked to provide your contact information, and normal sleep information. You will be asked to complete an activity log each day of your participation in the tournament. These sheets will be provided to you and will be kept anonymously. You will be asked to return the log sheets to us either in person or in a stamped self-addressed envelope also provided. The log sheets will provide us with your sleep duration, sleep quality and fatigue throughout the day for each day of the tournament, as well as your score. Please be careful in filling them out. Some participants will have an actigraph (a sleep quality watch) but we only have a few.

Duration of Participation
Entering data in your activity log should take approximately 10 seconds per entry. You only need to make about 6 entries (mostly fatigue scores and sleep scores) throughout the day. You will be asked to collect data from October 6 until October 17 or as many of those days as possible.

Benefits to the Individual
You will be provided with the results of your participation if requested. Your results will assist you in understanding your sleep/wake patterns and how they may impact athletic performance. This data can be extremely useful especially when attempting to combat fatigue induced by multiple time zone travel.

Risks to the Individual: None

Confidentiality
All efforts will be made to maintain the confidentiality of your information. You will be assigned a number, and only that number will be used while recording and reporting data. All data is confidential and will be kept in a locked office. You are also entitled a copy of your consent form and the results of your testing.

Voluntary Nature of Participation:
You do not have to participate in this research project. Also, you may terminate your participation at any time.

Dr. Jonathan French of the Human Factors Research Laboratory is the primary investigator and can be contacted for additional information at: Phone: (386) 226-6384 or email: frenc70f@erau.edu.
Coach Maria Lopez, LPGA T&CP Class A Member/Master Professional Candidate is the study administrator and secondary investigator. She can be contacted at: Phone: (386) 547-4000 or email: lopezsleepstudy@gmail.com
I have read and agree to the above information. All my questions have been answered.

PRINT NAME ___________________________ SIGN NAME __________________

Researcher __________________________

(Appendix C)
Demographic Questionnaire

Thank you for your participation in this research project. Please complete this demographic questionnaire so we can collect some background information on our participants. Your identity will remain completely anonymous.

Age __________________ Weight __________________

Known Medical Conditions that might affect your sleep/ Medications you are currently taking that might affect your sleep
_____________________________________________________________________________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________________________________________________________________________

How many hours of sleep do you get on an average night? Do you take naps normally?
_____________________________________________________________________________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________________________________________________________________________

Do you think you are getting enough sleep? Please Explain.
_____________________________________________________________________________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________________________________________________________________________

Please describe anything that impacts your sleep normally on tour. Are you a light sleeper for example, do you room with someone who snores, do you get insomnia on tour? Use the back if necessary.
_____________________________________________________________________________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________________________________________________________________________

Thank you for your help. Good luck.

Optional contact information
J. French/ M. Lopez
(if you would like feedback on your study results)

Cell____________________ Email____________
### Pairings Sheet for Round 1, Thursday, 10/7/10

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### NAVISTAR LPGA CLASSIC 2010

#### Tournament Summary
Sunday, October 10, 2010  
Purse: $1,300,000
RTJ GOLF TRAIL - THE SENATOR COURSE  
PAR: 36 36  YARDS: 6607

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Louise Stahle 75-68 143 CUT CUT
Leta Lindley 74-69 143 CUT CUT
Beth Bader 73-70 143 CUT CUT
Lorie Kane 73-70 143 CUT CUT
Yoo Kyeong Kim 71-72 143 CUT CUT
Jimin Kang 71-72 143 CUT CUT
Stacy Lewis 70-73 143 CUT CUT
Karin Sjodin 70-73 143 CUT CUT
Sarah Kemp 69-74 143 CUT CUT
Maria Hernandez 77-67 144 CUT CUT
Laura Davies 75-69 144 CUT CUT
Hee-Won Han 75-69 144 CUT CUT
Kristy McPherson 74-70 144 CUT CUT
Whitney Wade 74-70 144 CUT CUT

Jennifer Rosales 73-71 144 CUT CUT
Pat Hurst 73-71 144 CUT CUT
Misun Cho 73-71 144 CUT CUT
Dina Ammacapane 72-72 144 CUT CUT
Lisa Meldrum 71-73 144 CUT CUT
Ji Young Oh 70-74 144 CUT CUT
Amanda Blumenherst 74-71 145 CUT CUT
Pernilla Lindberg 73-72 145 CUT CUT
Reilley Rankin 72-73 145 CUT CUT
Sarah Lee 71-74 145 CUT CUT
Meredith Duncan 71-74 145 CUT CUT
Tania Elosegui 70-75 145 CUT CUT
Mariajo Uribe 68-77 145 CUT CUT
Nicole Jeray 78-68 146 CUT CUT
Mi Hyun Kim 74-72 146 CUT CUT
Stacy Pramanasudh 73-73 146 CUT CUT
Janice Moodie 73-73 146 CUT CUT
Maria Hjorth 70-76 146 CUT CUT
Mindy Kim 70-76 146 CUT CUT
Taylor Leon 75-72 147 CUT CUT
Chella Choi 75-72 147 CUT CUT
Sophie Gustafson 74-73 147 CUT CUT
Mallory Blackwelder 74-73 147 CUT CUT
Jennifer Johnson 73-74 147 CUT CUT
Song Yi Choi 73-74 147 CUT CUT
Michelle Ellis 73-74 147 CUT CUT
Jill McGill 72-75 147 CUT CUT
Ilmi Chung 72-75 147 CUT CUT
Jamie Hullett 71-76 147 CUT CUT
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Paige Mackenzie 75-73 148 CUT CUT
Allison Hanna 75-73 148 CUT CUT
Julieta Granada 73-75 148 CUT CUT
Libby Smith 73-75 148 CUT CUT
Aree Song 72-76 148 CUT CUT
Christine Song 72-76 148 CUT CUT
Ashli Bunch 76-73 149 CUT CUT
Lisa Strom 76-73 149 CUT CUT
Mikaela Parmlid 75-74 149 CUT CUT
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Cathryn Bristow 74-77 151 CUT CUT
Russy Gulyanamitta 72-79 151 CUT CUT
Jeehae Lee 72-79 151 CUT CUT
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Brandie Burton 80-75 155 CUT CUT
Anna Rawson 79-77 156 CUT CUT
Adrienne White 80-78 158 CUT CUT
Kelli Kuehne 83-79 162 CUT CUT
Angela Park 83-87 170 CUT CUT