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

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By

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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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Table of Contents

List of Tables

List of Figures

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 suprachaismatic 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, 2005b; Edwards & Waterhouse, 2009). 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 selfdiagnosed 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 & Vaughan1999). 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., 2005). 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 suprachaismatic 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.

Nation	Quantity	Average Age	Average Rank
USA	19	32.9	85.1
Taiwan	2	29.5	43.5
Australia	2	27.0	41.5
Korea/USA	3	24.0	47.3
Wales	1	36.0	81.0
Scotland	1	37.0	67.0

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. Polysomonogram 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.

Average Weight:	144 pounds
Average Age:	32
Perceived Sleep Quantity:	7.5 hours
Perceived Enough Sleep and Good Quality:	75%
Sleep Disrupted:	50%
Take Naps:	21%
Poor Sleep Quality Due to Early Tee Time:	54%

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.

Trying to Sleep Hours: (On Average)	Sleep Quantity Hours: (On Average)	Hours Golfing: (On Average)	Golf Score: (On Average)	Sleep Quality (Median)	Fatigue Sum (Median)
0.9 ± 0.69	8.3 ±1.50	4.8 ±3.38	71.2 ±3.09	2.0	18.0

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.

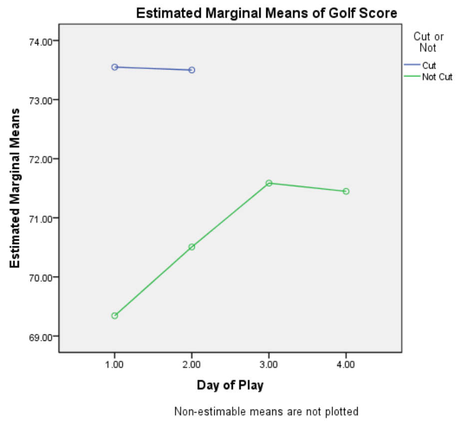

Figure 1. The golf scores for the two days of the players who did not make the cut compared to the four days of those who did make the cut.

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 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.

Trying to Sleep Hours: (On Average)	Sleep Quantity Hours: (On Average)	Hours Golfing: (On Average)	Golf Score: (On Average)	Sleep Quality (Median)	Fatigue Sum (Median)	FADE Score (On Average)
0.9 ± 0.67	8.1±1.40	5.0±3.2	70.7±2.87	2.0	18.0	461.5±34.28

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.

		Golf Score	Sleep Quantity	Trying to Sleep	Hours Golfing	FADE SUM	LPGA Rank
Golf Score	Pearson Correlation Sig (1-tailed) N	1 136	-.049 .285 136	.044 .305 136	.208** .007 136	-.020 .408 136	.131 .065 136
Sleep Quantity	Pearson Correlation Sig (1-tailed) N	-.049 .285 136	1 136	.359** .000 136	-.481** .000 136	.540** .000 136	.065 .226 136
Trying to Sleep	Pearson Correlation Sig (1-tailed) N	.044 .305 136	-.359** .000 136	1 136	.048 .289 136	-.193* .012 136	-.066 .222 136
Hours Golfing	Pearson Correlation Sig (1-tailed) N	.208** .007 136	-.481** .000 136	.048 .289 136	1 136	.097 .130 136	.018 .418 136
FADE SUM	Pearson Correlation Sig (1-tailed) N	-.020 .408 136	-.540** .000 136	-.193* .012 136	.097 .130 136	1 136	-.120 .082 136
LPGA Rank	Pearson Correlation Sig (1-tailed) N	.131 .065 136	.065 .226 136	-.066 .222 136	.018 .418 136	-.120 .082 136	1 136

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

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 (r_s =0.20, p<0.02, n=136). Figure 2 captures the relationship between fatigue sum and golf score. Sleep quality rating (r_s=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.

Spearman's rho		Golf Score	Sleep Quality	SUM Fatigue
Golf Score	Correlation Coefficient	1.000	.120	.195*
	Sig. (1-tailed)		.081	.011
	N	136	136	136
Sleep Quality	Correlation Coefficient	.120	1.000	.393**
	Sig. (1-tailed)	.081		.000
	N	136	136	136
SUM Fatigue	Correlation Coefficient	.195*	.393**	1.000
	Sig. (1-tailed)	.011	.000	
	N	136	136	136

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

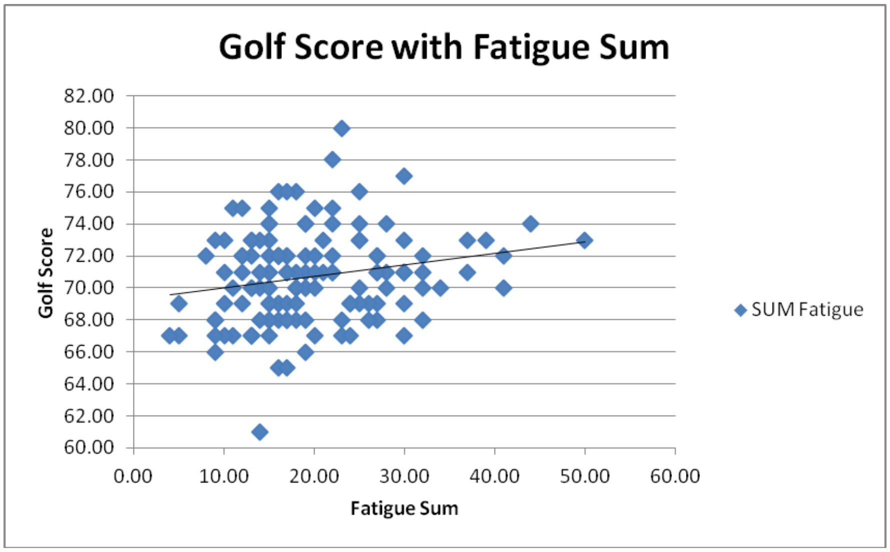

Figure 2. Scatter plot of golf score as it relates to subjective fatigue sum for participants that made the cut at both tournaments.

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.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.306	.094	.059	2.780	.094	2.691	5	130	.024

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.

ANOVA b Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	103.978	5	20.796	2.691	.024a
	Residual	1004.662	130	7.728		
	Total	1108.640	135			

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.

Model	Unstandardized Coefficients		Standardized Coefficients			Correlations		
	B	Std. Error	Beta	t	Sig.	Zero-Order	Partial	Part
(Constant)	57.343	7.815		7.338	.000			
Quantity, Sleep Hours	.343	.299	.168	1.145	.254	-.049	.100	.096
Trying to Sleep Hours	.466	.462	.109	1.010	.315	.044	.088	.084
Hours Golfing	.243	.092	.271	2.643	.009	.208	.226	.221
FADE Score Ea Day	.008	.010	.101	.818	.415	-.019	.072	.068
LPGA RANK	.871	.353	.210	2.466	.015	.203	.211	.206

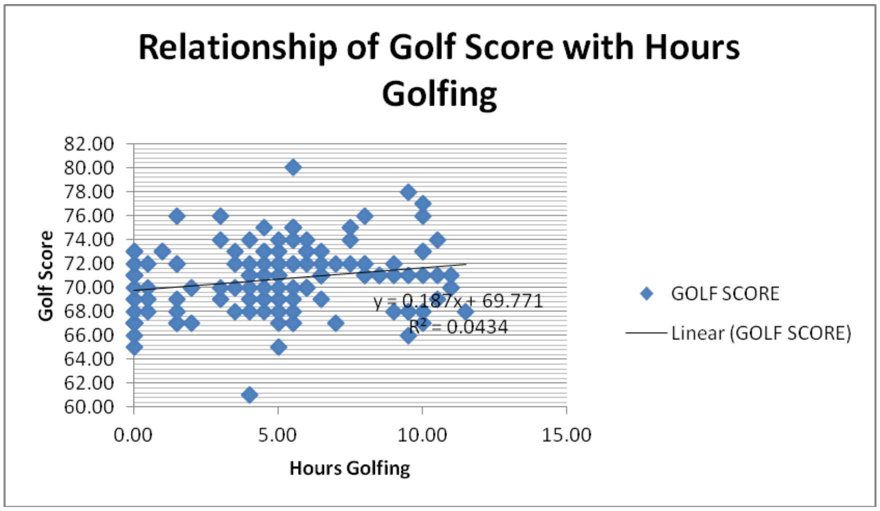

Figure 3. Scatter plot of golf score as it relates to hours golfing for participants that made the cut at both tournaments.

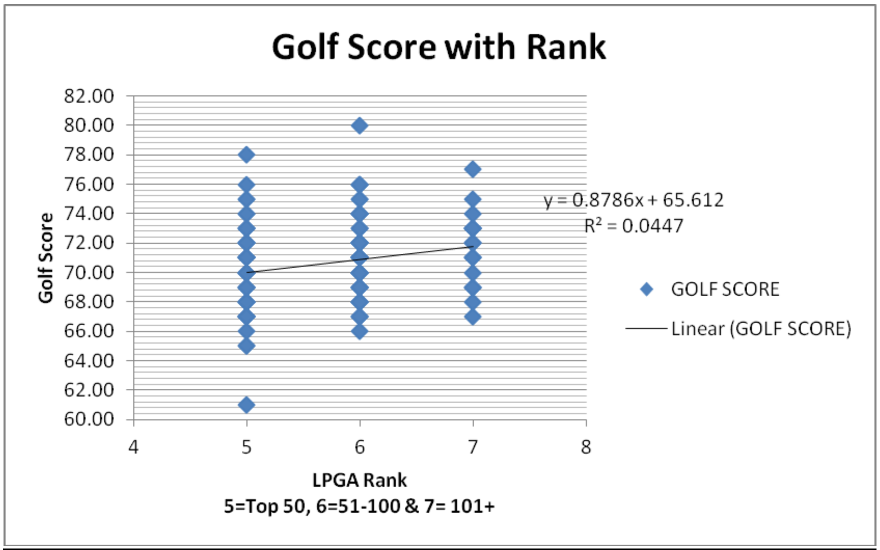

Figure 4. Scatter plot of golf score as it relates to LPGA rank for participants that made the cut at both tournaments.

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

Made the Cut Participants Model Fitting Information				
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	541.820			
Final	.000	541.820	66	.000

Table 11.

Ordinal Regression of participants that made cut over both tournaments

Made the Cut Participants Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	559.092	1014	1.000
Deviance	352.382	1014	1.000

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

Pseudo R-Square	
Cox and Snell	.981
Nagelkerke	.990
McFadden	.829

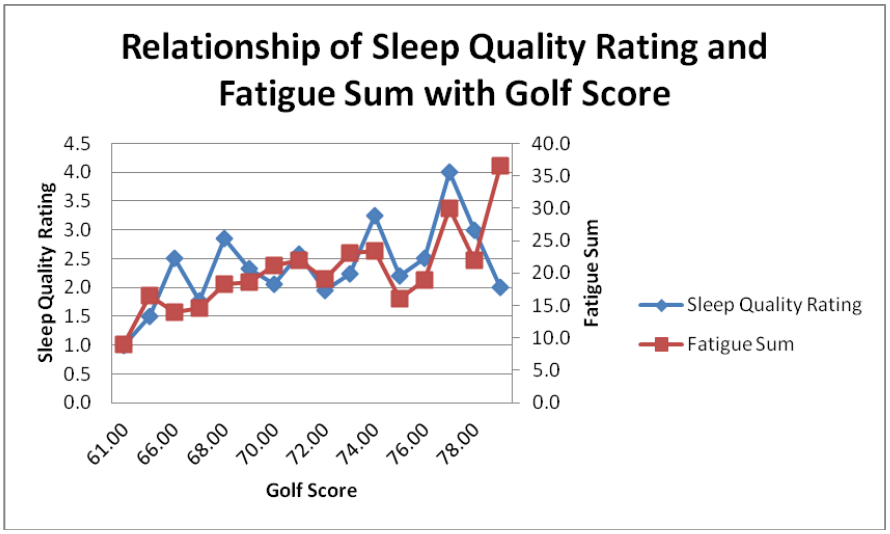

Figure 5. Relationship between subjective fatigue sum and sleep quality with golf score. Note the higher the sleep Quality score the lower the sleep quality.

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 (rs=-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.

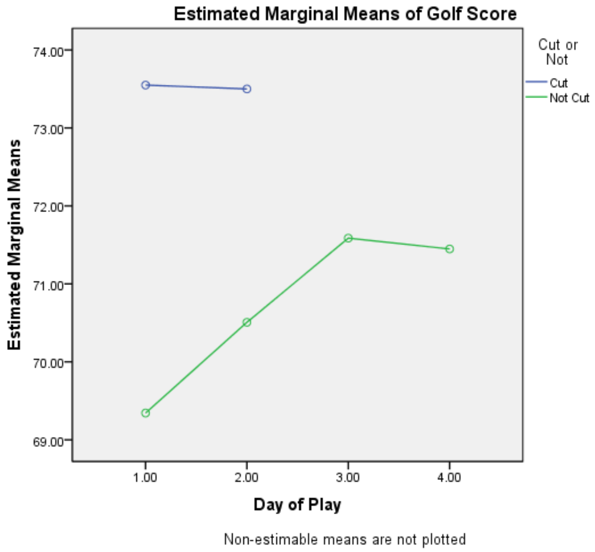

Figure 6. Relationship between golf score and making the cut across four days of competition between participants who were cut or not cut.

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.

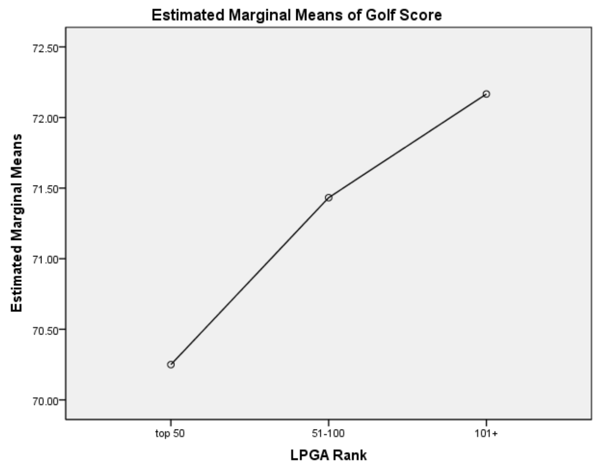

Figure 7. Relationship between golf score and the different LPGA rankings of participants.

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.

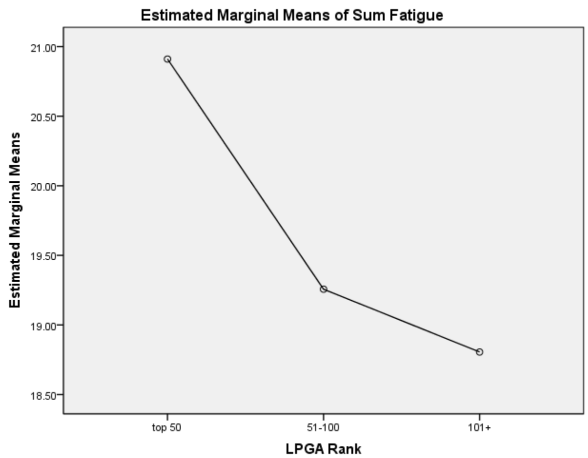

Figure 8. Relationship between fatigue sum and the different rankings of participants.

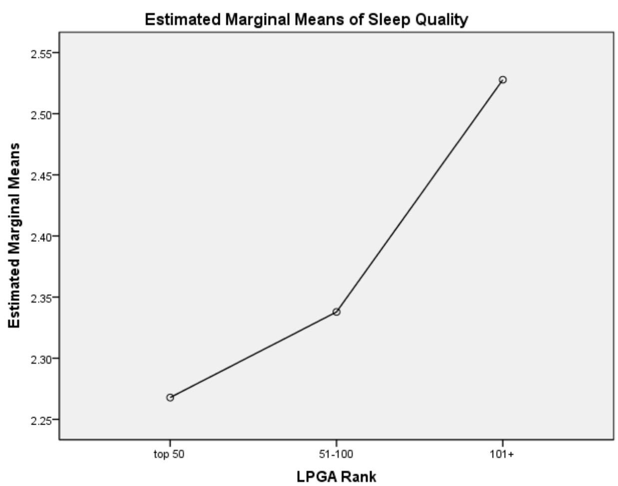

Figure 9. Relationship between sleep quality rating and the different rankings of participants.

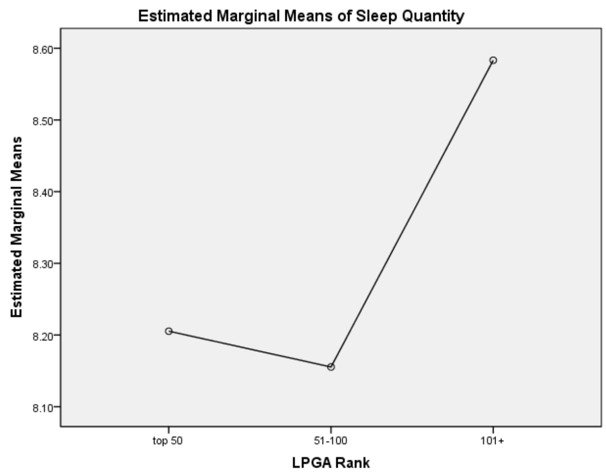

Figure 10. Relationship between sleep quantity and the different rankings of participants.

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 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 ($r = -.18$, $p < 0.04$, $n = 92$) 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 unvail 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

Akerstedt, T., Knutsson, A. Westerholm, P., Theorell, T., Alfredsson, L. & Kecklund, G. (2002). Sleep disturbances, work stress and work hours: a cross-sectional study. *Journal of Psychosomatic Research* 2002; 53:741-8.

Akerstedt, T., Knutsson, A., Westerholm, P., Theorell, T., Alferesson, L. & Kecklund, G. (2004). Mental fatigue, work and sleep. *Journal of Psychosomatic Research*, 57, 427-433.

American College of Sports Medicine *(2008). Annual Meeting*. Indianapolis, IN. http://www.drugs.com/news/walking-golf-course-affects-swing-performance-12488.html

Ancoli-Israel, S. & Roth, T. (1999). Characteristics of insomnia in the United States: results of the 1991 National Sleep Foundation Survey. *Sleep* 1999; 22(Suppl 2): S347-53.

Aserinsky, E. & Kleitman, N. (1953). Regularly occurring episodes of eye mobility and concomitant phenomena during sleep. *Science* 1953; 118:273-4.

Aston-Jones G., Gonzalez M., & Doran S. (2007). "Role of the locus coeruleus-norepinephrine system in arousal and circadian regulation of the sleep-wake cycle." Ch. 6 in *Brain Norepinephrine:*

Babkoff, H., Mikulincer, M., Caspy, T., Kempinski, D. & Sing, H. (1988). The topology of performance curves during 72 hours of sleep loss: A memory and search task. *The Quarterly Journal of Experimental Psychology*, 324, 1988, p. 737-356.

Balter, M. & Uhlenhuth, E. (1992). New epidemiologic findings about insomnia and its treatment. *Journal of Clinical Psychiatry.* 1992; 53(Suppl): 34-9.

Baxter, C. & Reilly, T. (1983). Influence of time of day on all-out swimming. *British Journal of Sports Medicine* 1983;17:122-7.

Berger, H. (1929). Uber das elektroenkephalogramm des menschen. *Arch Psychiatr Nervenkr* 1929;97:6-26.

Berson, D., Dunn, F. & Takao, M. (2002). Photo transduction by retinal ganglion cells that set the circadian clock. *Science* 2002;295(5557):1070-3.

Bliwise, D., Ansari, F., Straight, L. & Parker, K. (2005). Age changes in timing and 24-hour distribution of self-reported sleep. *American Journal of Geriatric Psychiatry 13*(12), 1077-1082.

Boivin, D., Duffy, J., Kronauer, R. & Czeisler, C. (1996). Dose-response relationships for resetting of human circadian clock by light. *Nature* 1996; 379(6565):540-2.

Bonnet, M. & Arand, D. (1995). We are chronically sleep deprived. *Sleep* 1995;18:908-11.

Boquet, A., Cruz, C., Nesthus, T., Holcomb, K. & Shappell, S. (2009). *Strategic Napping for Air Traffic Control Paper.*

Bremer, F. (1938). L'activite electrique de l ecorce cerebrale. *Actualites Scientifques et Industrielles*, 635, 3-46.

Caplan, R., Cobb, S. & French, J. (1979). White collar workload and cortisol: disruption of a circadian rhythm by job stress? *Journal of Psychosomatic Research* 1979;23:181-92.

Carskadon, M. (2005). Sleep deprivation: health consequences & societal impact. *Medical Clinics of North America* 88(2004)767-776.

Carskadon, M. & Dement, W. (1981). Cumulative effects of sleep restriction on daytime sleepiness. *Psychophysiology* 1981; 18:107-13.

Carskadon, M., Dement, W., Mitler, M., Roth, T., Westbrook, P. & Keenan, S. (1986). Guidelines for the multiple sleep latency test (MSLT): a standard measure of sleepiness. *Sleep* 1986;9:519-24.

Carskadon, M. & Rechtschaffen, A. Monitoring and staging human sleep. In: Kryger, M., Roth, T. & Dement, W., editors. *Principles and Practice of Sleep Medicine.* 2nd ed. Philadelphia (PA): WB Saunders Company; 1994. pp. 943-944.

Carskadon M. & Rechtschaffen A. Monitoring and staging human sleep. In: Kryger M., Roth T., Dement W., editors. *Principles and Practice of Sleep Medicine.* 4th ed. Philadelphia: Elsevier; 2005. pp. 1359–77.

Caton, R., (1875). The electric currents of the brain. *British Medical Journal* 1875;2:278.

Centers for Disease Control and Prevention (CDC) (2008). Perceived insufficient rest or sleep among adults-United States, 2008. *CDC-Morbidity and Mortality Weekly Report* 2009;58:1175-9.

Cho, K. (2001). Chronic "jet lag" produces temporal lobe atrophy and spatial cognitive deficits. *Nature Neuroscience*, 4, 567-568.

Chrousos, G. (1998). Stress as a medical and scientific idea and its implications. *Advances in Pharmacology* 1998;42:552-6.

Chuah, L. & Chee, M. (2008). Cholinergic augmentation modulates visual task performance in sleep-deprived young adults. *Journal of Neuroscience* 28(44):11369-77.

Cruz, C. & Della Rocco, P. (1995). Sleep patterns in air traffic controllers working rapidly rotating shifts: A field study (DOT/FAA/AM-95/12). Washington, DC: *Federal Aviation Administration, Office of Aviation Medicine.*

Cruz, C., Boquet, A., Detwiler, C. & Nesthus, T. (2002). *A laboratory comparison of clockwise and counter-clockwise rapidly rotating shift schedules.* (DOT/FAA/AM-02/8). Washington, DC: Federal Aviation Administration, Office of Aerospace Medicine.

Dahlgren, A., Kecklund, G. & Akerstedt, T. (2005). Different levels of work-related stress and the effects on sleep fatigue and cortisol. *Scandinavian Journal of Work Environment & Health* 2005;31(4):277-285.

Dawson, D. *&* Reid, K. (1997). Fatigue, alcohol and performance impairment. *Nature*, *1997*; *388*: *235*.

Dean, D. 2nd, Forger, Klerman, E. (2009). Taking the lag of out of jet lag through model-based schedule design. *Public Library of Science Computational Biology.* 2009; D5(6):e1000418.

Della Rocco, P. & Cruz, C. (1995) Shiftwork, age and performance: Investigation of the 2-2-1 shift schedule used in air traffic control facilities *I.* The sleep-wake cycle (DOT/FAA/AM-95/19). Washington, DC: *Federal Aviation Administration, Office of Aerospace Medicine.*

Dement, W. (1974). Some must watch while must sleep. SanFrancisco, Ca. Freeman.

Dement, W. (2005a). History of sleep medicine. *Neurologic Clinics*. 23 (4): 945-65, v

Dement,W.(2005b). Sleep extension: getting as much extra sleep as possible. *Clinical Sports Medicine*. 2005; 24 (2): 251-68, viii

Dement, W. & Kleitman, N. (1957). Cyclic variation in EEG during sleep and their relation to eye movements, body motility and dreaming. *Electroencephalogy Clinical Neurophysiology* 1957;9:673-90.

Dement, W., Richardson, G., Prinz, P., Carskadon, M., Kripke, O. & Czeisler, C. (1996). Changes of sleep and wakefulness with age. In: Finch C., Schneider, E., and editors. *Handbook of the Biology of Aging*. 2nd ed. New York: VanNostrand Reinhold; 1996.

Dement, W. & Vaughan, C. (1999). *The Promise of Sleep.* Dell Publishing of Random House. New York.

Dinges, D., Pack, F., & Williams, K., et al. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. *Sleep* 1997;20:267-77.

Edwards, B. & Waterhouse, J. (2009). Effects of one night of partial sleep deprivation upon diurnal rhythms of accuracy and consistency in throwing darts. *Chronobiology International* 2009;26:756-68.

Everson, C. (1993). Sustained sleep deprivation impairs host defense. *American Journal of Physiology* 1993;265(5Pt2):R1148-54.

Ferman, T., Boeve, B., Smith, G., Silber, M., Kokmen, E., Petersen, R. & Ivnik, R. (1999). REM sleep behavior disorder and dementia; cognitive differences when compared with AD. *Neurology* 1999: 52:951-7.

Fiorica, V., Higgins, E., Iampietro, P., Lategola, M. & Davis, Q.W. (1968). Physiological responses of man during sleep deprivation. *Journal of Applied Physiology*, 24(2), 1968, p. 169-175.

Ford, D. & Kamerow, D. (1989). Epidemiolgic study of sleep disturbances and psychiatric disorders. An opportunity for prevention? *Journal of the American Medical Association* 1989;262:1479-84.

Frederickson, C. & Rechtschaffen, A. (1978). Effects of sleep deprivation on awakening thresholds and sensory evoked potentials in the rat. *Sleep* 1978;1:69-82.

Freedman R. & Sattler, H., (1982). Physiological and psychological factors in sleep-onset insomnia. *Journal of Abnormal Psychology* 1982;91:380-9.

Freedman, M., Lucas, R., Soni, B., von Schantz, M., Munoz, M., David-Gray, Z. & Foster, R. (1999). Regulation of mammalian circadian behavior by non-rod, non-cone, ocular photoreceptors. *Science* 1999;284(5413):502-4.

French, J., Bisson, R., Neville, K., Mitcha, J. & Storm, W. (1994). Crew Fatigue during simulated long duration B1-B bomber missions. *Aviation Space and Environmental Medicine*, 1994 May;65(5 Suppl):A1-6.

Freudenberger, H. (1983). Burnout: contemporary issues, trends, and concerns. In: Farber BA, editor. Stress and burnout. New York (NY): Anchor Press/Doubleday;1983. P 23-8.

Gillberg, M., Kecklund, G. & Akerstedt, T. (1994). Relations between performance and subjective ratings of sleepiness during a night awake. *Sleep*, 17(3), 1994, p. 236-41.

Goldin, T. (2010). Effects of simulated jet lag on sleep, exercise and cognitive performance in male athletes. *Dissertation Faculty of Science, University of Witwatersrand, Johannesburg, South Africa.*

Hartmann, B. & Langdon, D. (1965). A second study on performance upon sudden awakening (Report No. TR-65-61). *Brooks AFB, TX: U.S. Air Force School of Aerospace Medicine.*

Harvey, A. (2002). A cognitive model of insomnia. *Behavior Research Therapy*. 2002;40:869-93.

Hemlich, N. (2004). Sleep loss may equal weight gain. *USA Today,* December 6, 2004. http://www.usatoday.com/news/health/2004-12-06-sleep-weight-gain_x.htm

Hill, D., Bordon, D., Darnaby, K., Hendricks, D. & Hill, C., (1992). Effects of time of day aerobic and anaerobic responses to high-intensity exercise. *CanJournalSport Sci* 1992;17:316-9.

Hill, D., Hill, C., Fields, K., & Smith, J. (1993). Effects of jet lag on factors related to sport performance. *Canadian Journal of Applied Physiology* 1993;18:91-103.

Hobson, J.A. (2009). REM sleep and dreaming: towards a theory of protoconsciousness. *Nature Reviews* **10** (11): 803–813

Hoddes, E., Zarcone, V., Smythe, E, Phillips, R. & Dement, W. (1973). Quantification of sleepiness: A new approach. *Psychophysiology*, 10(4), 431-6.

Horne, J. (1981). The effects of exercise upon sleep: a critical review. *Biological Psychology* 1981;12:241-90.

Horne, J. & Minard, A. (1985). Sleep and sleepiness following a bihourly “active” day. *Ergonomics* 1985;28(3):567-75.

Jenkins, J. & Dallenbach, K. (1924). Oblivescence during sleep and waking. *American Journal of Psychology*, 35,605-612.

Jewett, M., Kronauer, R. & Czeisler, C. (1994). Phase-amplitude resetting of the human circadian pacemaker via bright light: a further analysis. *Journal of Biological Rhythms* 1994;9:295-14.

Johnson, E., Roth, T. Schultz, L. & Breslau, N. (2006). Epidemiology of DSMIV insomnia in adolescence: lifetime of prevalence, chronicity, and an emergent gender difference. *Pediatrics.* 2006;117;e247-56.

Johnson, L. (1969). Psychological and physiological changes following total sleep deprivation. In A. Kales (Ed.), *Sleep*: Physiology and pathology. Philadelphia: Lippincott.

Johnson, M. (1991). A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991;14:540-5.

Kamdar B., Kaplan K., Kezirian E. & Dement W. (2004). The impact of extended sleep on daytime alertness, vigilance, and mood. *Sleep Medicine*. 2004; 5 (5): 441-8.

Kase, L., (2007). Magic power of sleep. *Reader's Digest*, October 2007, P.110-115

Katz, D. & McHorney, C. (1998). Clinical correlates of insomnia in patients with chronic illness. *Archives of Internal Medicine.* 1998;158:1099-107.

Katz, D. & McHorney, C. (2002). The relationship between insomnia and health-related quality of life in patients with chronic illness. *Journal of Family Practice.* 2002;51:229-35.

Kecklund, G. & Akerstedt, T. (2004). Apprehension of the subsequent working day is associated with a low amount of slow wave sleep. *Biological Psychology* 2004;66(2):169-76.

Kline, C., Durstine, J., Davis, J,, Moore, T., Devlin, T., Zielinski, M. & Youngstedt, S. (2007). Circadian variation in swim performance. *Journal of Applied Physiology* 2007;102:641-9.

Knipling, R. & Wang, J. (1995). Revised estimates of the U.S. drowsy driver crash problem size based on general estimates system case reviews. *Association for the Advancement of Automotive Medicine, 39th Annual Proceedings* 1995;Oct. 16-18.

Kripke, D., Garfinkel, L., Wingard, D., Klauber, M. & Marler, M. (2002). Mortality associated with sleep duration and insomnia. *Archives of General Psychiatry* 2002;59:131-6.

Kuppermann, M., Lubeck, D., Maxonson, P., Patrick, D., Stewart, A., Buesching, D. & Fifer, S. (1995). Sleep problems and their correlates in a working population. *Journal of General Internal Medicine* 1995;10:25-32.

Kushida, C., Chang, A., Gadkary, C., Guilleminault, C., Carrillo, O., & Dement, W. (2001). Comparison of actigraphic, polysomnographic, and subjective assessment of sleep parameters in sleep-disordered patients. *Sleep Medicine*. 2001; 2 (5): 389-96

Lavie, P. (1996). *The enchanted world of sleep* (A. Berris, Trans). New Haven, CT: Yale University Press.

Lawson, N. & Dawson, D. (1999). Quantifying the performance impairment associated with fatigue. *Journal of Sleep Research 1999, 8;4:255-262.*

Levin, A. (2011). Controller fatigue an ongoing concern. *USA Today March 24, 2011*: http://travel.usatoday.com/flights/story/2011/03/Reagan-air-traffic-incident-renews-fatigue-debate/45293452/1

Lieberman, H., Kramer, F., Montain, S. & Niro, P (2007). Field assessment and enhancement of cognitive performance: development of an ambulatory vigilance monitor. *Aviation Space and Environmental Medicine,* 2007 May;78(5 Suppl):B268-75.

Littner, M., Kushida, C., Anderson, W., Bailey, D., Berry, R., Davilla, D., Hirshkowitz, M., Kapen, S., Kramer, M., Loube, D., Wise, M. & Johnson, S. (2003). Practice parameters for the role of actigraphy in the study of sleep and circadian rhythms: an update for 2002. *Sleep* 2003;26:337-41.

Maas, J. & Robbins, R. 2010. *Sleep for Success.* Quill Publishing of Harpers. New York.

Maas, J., Wherry, M., Axelrod, D., Hogan, B. & Boomin, J. 1998. *Power Sleep.* Quill Publishing of Harpers. New York.

Mah, C., Mah, K., Kezirian, E. & Dement, W. *(2010). The Effects of Sleep Extension of the Athletic Performance of Collegiate Basketball Players Paper*.

Comment [ML1]: It's a paper she sent me and it's been used on the web. Got paper directly from her.

Comment [IT2]: What kind of publication is this? In a journal? A leaflet? A website?

Maquet, P., Laureys, S., Peigneux, P., Fuchs, S., Petiau, C., Phillips, C., Aerts, J., Del Fiore, G., Degueldre, C., Meulemans, T., Luxen, A., Franck, G., Van Der Linden, M., Smith, C. & Cleeremans, A. (2000). Experience-dependent changes in cerebral activation during human REM sleep. *Nature Neuroscience,* 3, 831-836.

Marquie, J., Foret, J. & Queinnec, Y. (1999). Effects of age, working hours, and job content on sleep; a pilot study. *Experimental Aging Research* 1999;25:421:-7.

Maslach, C. & Jackson, S. (1981). The measurement of experienced burn-out. *Journal of Occupational Behavior* 1981;2:99-113.

Mohler, S.R.(1966). Fatigue in aviation activities. *Aviation Medicine,* 37, 1966, p. 722-732.

Monroe, L. (1967). Psychological and physiological differences between good and poor sleepers. *Journal of Abnormal Psychology* 1967;72:255-64.

Moore, R. & Eichler, V. (1972). Loss of a circadian adrenal corticosterone rhythm following suprachaismatic lesions in the rat. *Brain Research* 1972;42:201-6.

Morgan, C., Cho, T. Hazlett, G., Coric, V. & Morgan, J. (2002). The impact of burnout on human physiology and on operational performance; a prospective study of soldiers enrolled in the combat driver qualification course. *Yale Biological Medicine* 2002;75:199-205.

Morruzi, G. (1972). The sleep-waking cycle. *Ergebnisse der Physiologie, Biolgoischen Chemie und Experimentellen Pharmakologie,* 64, 1-165.

Motivala, S. & Irwin, M. (2007). Sleep and immunity: cytokine pathways linking sleep and health outcomes. *Current Directions in Psychological Science.* 16:1:21-25.

Mougin, F., Simon-Rigaud, M., Davenne, D., Renaud, A., Garnier, A., Kantelip, J. & Magnin, P. (1991). Effects of sleep disturbances on subsequent physical performance. *European Journal of Applied Physiology and Occupational Physiology* 1991;63:77-82.

National Commission on Sleep Disorders Research (1993). *Wake up America: a national sleep debt.* 1993;1:15-74

National Highway Traffic Safety Administration (NHTSA).(*n.d.)* http://www.nhtsa.gov/

National Institute of Neurological Disorders and Stroke (NINDS). (2007). Office of Communications and Public Liaison, National Institutes of Health, Bethesda, MD 20892. NIH Publication No.06-3440-c. Updated May 21, 2007, p. 1-10. http://www.ninds.nih.gov/disorders/brain_basics/understanding_sleep.htm

Comment [IT3]: This is the organization but what is the publication? The publication is the thing that should be italicized, not the author.

Comment [ML4]: A government agency.It's their journal, their research, they also have it listed on their website. Just found it there and provided link as well.

Nieto, F., Young, T., Lind, B., Shahar, E., Samet, J., Redline, S., D'Agostino, R., Newman, A., Lebowitz, M. & Pickering, T. (2000). Association of sleep-disordered breathing, sleep apnea, and hypertension in a large community-based study. Sleep Heart Health Study. *Journal of the American Medical Association* 2000;283:1829-36.

Ohayon, M. (1997). Prevalence of DSM-IV diagnostic criteria of insomnia: distinguishing insomnia related to mental disorders from sleep disorders. *Journal of Psychiatric Research.* 1997;31:333-46.

Pack, A., Maislin, G., Staley, B., Pack, F., Rogers, W., George, C. & Dinges, D. (2006). Impaired performance in commercial drivers. *American Medical Journal of Respiratory Critical Care Medicine* 174;4:446-54.

Parker, K. (2007). Women and Sleep. *Emory Center for Women's Newsletter.*

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

Peppard, P., Young, T., Palta, M., & Skatrud, J. (2000). Prospective study of the association between sleep-disordered breathing and hypertension. *New England Journal of Medicine* 2000;342:1378-84.

Price, W. & Holly, D. (1990). Shiftwork and safety in aviation. *Occupational Medicine STAR,* 5(2):343-377.

Raloff, J. (2007). Body clock affects racing prowess. *Science News*, March 10, 2007: Vol. 171 #10, p.158.

Ralph, M., Foster, R., Davis, F. & Menaker, M. (1990). Transplanted suprachaismatic nucleus determines circadian period. *Science* 1990;247(4945):975-8.

Rechtschaffen A., Kales A., & editors. Los Angeles: Brain Information Service/Brain Research Institute, University of California; 1968. A manual of standardized terminology, techniques and scoring system of sleep stages in human subjects.

Rechtschaffen, A., Bermann, B., Everson, C., Kushida, C., & Gilliland, M. (1989). Sleep deprivation in the rat: X. Integration and discussion of the findings. *Sleep* 1989;12:68-87.

Reilly, T. Atkinso, G., Edwards, B. Waterhouse, J., Farrelly, K. & Fairhurst, E. (2007). Diurnal variation in temperature, mental and physical performance, and tasks specifically related to football (soccer). *Chronobiology International* 2007;24:507-19.

Reilly, T. & Piercey, M. (1994). The effect of partial sleep deprivation on weight-lifting performance. *Ergonomics* 1994;37:107-15.

Remmers, J., deGroot, W., Sauerland, E. & Anch, A. (1978). Pathogenesis of upper airway occlusion during sleep. *Journal of Applied Physiology* 1978;44:931-8.

Rogers, N., Van Dongen, H., Powell, I., Carlin, M., Szuba, M., Maislin, G. & Dinges, D.. (2002). Neurobehavioral functioning during chronic sleep restriction at an adverse circadian phase. *Sleep*, 25, Abstract Supplement, A126-7.

Roth, T. (2007). Insomnia: definition, prevalence, etiology and consequences. *Journal of Clinical Sleep Medicine.* 2007;August 15;3(Suppl); S7-S10.

Roth, T. & Roehrs, T. (2003). Insomnia: epidemiology, characteristics, and consequences. *Clinical Cornerstone.* 2003;5:5-15.

Roth, T., Roehrs, T. & Pies, R. (2007). Insomnia: pathophysiology and implications for treatment. *Sleep Medicine Review*..2007;11:71-9.

Sadeh, A, Hauri, P., Kripke, D. & Lavie, P. (1995). The role of actigraphy in the evaluation of sleep disorders. *Sleep* 1995;18(4):288-302.

Sakurai, T., Amenmiya, A., Ishil, M., Matsuzaki, I., Chemelli, R., Tanaka, H., Williams, S., Richardson, J., Kozolowski, G., Wilson, S., Arch, J., Buckingham, R., Haynes, A., Carr, S., Annan, R., McNulty, D., Liu, W., Terrett, J., Elshourbagy, N., Bergsma, D. & Yanagisawa, M. (1998). Orexins and orexin receptors: a family of hypothalamic neuropeptides and G protein-coupled receptors that regulate feeding behavior. *Cell* 1998;92:573-85.

Samuels, C. (2008). Sleep, recovery, and performance: the new frontier in high-performance athletics. *Neurologic Clinics* 2008;26:169-80.

Schulz, H. (2008), Rethinking sleep analysis. Comment on the AASM Manual for the Scoring of Sleep and Associated Events. *Journal of Clinical Sleep Medicine (American Academy of Sleep Medicine)* 4 (2): 99–103.

Schulz, P., Kirschbaum, C., Prussnes, J. & Hellhammer, D. (1998). Increased free cortisol secretion after awakening in chronically stressed individuals due to work overload. *Stress Medicine* 1998;14:91-7.

Shahar, E., Whitney, C., Redline, S., Lee, E., Newman, A., Nieto, F., O'Connor, G., Boland, L., Schwartz, J., & Samet, J., (2001). Sleep-disordered breathing, sleep apnea, and hypertension. *American Journal of Respiratory Critical Care Medicine 2001;163:19-25.*

Shepard, J., Buysse, D., Chesson Jr., A., Dement, W., Goldberg, R., Guilleminault, C., Harris, C., Iber, C., Mignot, E., Mitler, M., Moore, K., Phillips, B., Quan, S., Rosenberg, R., Roth, T., Schmidt, H., Silber, M., Walsh, J. & White, D. (2005). History of the development of sleep medicine in the United States. *Journal of Clinical Sleep Medicine* 2005;Vol1:No.1. p.61-82.

Shingeldecker, C.A. & Holding, D.H. (1974). Risk and effort measure of fatigue, *Journal of Motor Behavior*, 6, 1974, p. 17-25.

Siegel J.M. (2005). "REM Sleep." Ch. 10 in *Principles and Practice of Sleep Medicine*. 4th ed. M.H. Kryger, T. Roth, & W.C. Dement, eds. Elsevier. 120–135. Accessed 21 July 2010.

Simon, G. & VonKorff, M. (1997). Prevalence, burden, and treatment of insomnia in primary care. *American Journal of Psychiatry* 1997;154:1417-23.

Smith, C. (1995). Sleep states and memory processes. *Behavioral Brain Research*, 69, 137-145.

Smith, R., Guilleminault, C. & Efron, B. (1997). Circadian rhythms and enhanced athletic performance in the national football league. *Sleep* 1997;20:362-5.

Soderstrom, M., Ekstedt, M., Nilsson, M., Axelsson, J. & Akerstedt, T. (2004). Sleep and sleepiness in your individuals with high burn-out scores. *Sleep* 2044;27(7):1369-77.

Spiegel, K., Leproult, R. & Van Cauter, E. (1999). Impact of sleep debt on metabolic & endocrine function. *The Lancet* 354;9188:1435-39.

Srinivasan, V., Singh, J., Pandi-Perund, S., Brown, G., Spence, D. & Cardinali, D. (2010). Jet lag, circadian rhythm sleep disturbances and depression; the role of melatonin and its analogs. *Advances in Therapy* 2010 (11):796-813

Stephan, F. & Zucker, I. (1972). Circadian rhythms in drinking behavior and locomotor activity of rats are eliminated by hypothalamic lesions. *Proceedings of the National Academy of Sciences USA* 1972;69:1583-6.

Steptoe, A., Cropley, M. & Joekes, K. (1999). Job strain, blood pressure and response to uncontrollable stress. *Journal of Hypertension* 1999;17:193-200.

Sullivan, C., Issa, F., Berthon-Jones, M. & Eves, L. (1978). Reversal of obstructive sleep apnoea by continuous positive airway pressure applied through the nares. *Lancet* 1981;1(8225):862-5.

Tilley, A. & Wilkinson, R. (1984). The effects of a restricted sleep regime on the composition of sleep and on performance. *Psychophysiolog*y, 21, 1984, p. 406-412.

United Sleep Medicine (2011). Sleep better for a better golf game. Posted April 20, 2011. http://getmorezzz.wordpress.com/author/unitedsleepmedicine/

Van Cauter, Spiegel, K., Tasali, E. & Leproult, R. (2008). Metabolic consequences of sleep and sleep loss. *Sleep Medicine* 9(Supp1) S23-S28.

Van Dongen, H., Maislin, G., Mullington, J. & Dinges, D. (2003). The cumulative cost of additional wakefulness; dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep* 2003; 26:117-26.

Vgontzas, A., Bixler, E., Papanicoalaou, D., Kales, A., Stratakis, C., Vela-Bueno, A., Gold, P., & Chrousos, G.(1997). Rapid eye movement sleep correlates with the overall activities of the hypothalamic –pituitary-adrenal axis and sympathetic system in healthy humans. *Journal of Clinical Endocrinology and Metabolism.* 1997;82:3278-80.

Vgontzas, A., Tsigos, C., Bixler, E., Stratakis, C., Zachman, K., Kales, A., Vela-Bueno, A., & Chrousos, G. (1998). Chronic insomnia and activity of the stress system: a preliminary study. *Journal of Psychosomatic Research* 1998;45:21-31.

Vgontzas, A., Bixler, E., Lin, H., Prolo, P., Mastorakos, G., Vela-Bueno, A., Kales, A., & Chrousos, G. (2001). Chronic insomnia is associated with nyctohemeral activation of the hypothalamic-pituitary-adrenal axis: clinical implication. *Journal of Clinical Endocrinology and Metabolism* 2001;86:3787-94.

Walsh, J. & Engelhardt, C. (1995). The direct economic costs of insomnia in the United States for 1995. *Sleep* 1999;22 Suppl 2:S386-93.

Welsh, D., Logothetis, D., Meister, M. & Reppert, S., (1995). Individual neurons dissociated from rat suprachaismatic nucleus express independently phased circadian firing rhythms. *Neuron* 1995;14:697-706.

Winget, C., DeRoshia, C. & Holley, D. (1985). Circadian rhythms and athletic performance. Medicine and Science in Sports and Exercise 1985;17:498-516.

Young, T., Palta, M., Dempsey, J., Skatrud, J., Weber, S. & Badr, S.(1993). The occurrence of sleep-disordered breathing among middle-aged adults. *New England Journal of Medicine*1993;328:1230-5.

Youngstedt, S. & O'Connor, P. (1999). Influence of air travel on athletic performance. *Sports Medicine* 1999;28:3:197-207.

Zammit, G., Weiner, J., Damato, N., Sillup, G. & McMillan, C. (1999). Quality of life in people with insomnia. *Sleep* 1999;22 Suppl 2:S379-85.

(Appendix A)

Activity Log

Sleep Record LPGA Fall 2010

Start Date: (for this log sheet)______________ Participant no. ________________ Actigraph# (if applicable) ____

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

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

(Appendix A, Backside of Document)

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 EVERYTHREE 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:

4.

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

You don't need to tell us any other activity but these

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

LocalTime	1900	1930	2000	2030	2100	2130	2200	2230	2300	2330	0000	0030	0100	0130	0200	0230	0300	0330	0400	0430	0500	0530	0600	0630
ActualTime	1912		2058		2102		2255		2310					0145		0238		0353		0436				0645
Rating	4		5		7		5		5					3		1		2		2				2
Activity	C -	- -	C	C						T S	- -	- -	S- T	2							T T	S -	S 2	

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.

(*Appendix B)*

HUMAN FACTORS
AND SYSTEMS
at
EMBRY-RIDDLE
AERONAUTICAL UNIVERSITY
Daytona Beach, FL, USA

WHAT?

An evaluation of how much sleep matters for top performance in high level athletes.

WHEN?

October Tour Events: Alabama and California Tournaments, October 6-16, 2010.

HOW?

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-Principle Investigator
ERAU Head Women's Golf Coach
2007 LPGA T&CP National Coach of the Year
(386) 547-4000 cell
LopezSleepStudy@gmail.com

(Appendix C)

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 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 6 October until 17 October 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 D)

LPGA Fatigue Study *Dr J. French /M. Lopez*

Participant # __________ **Date:** _____________

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.
J. French/ M. Lopez

Optional contact information
(if you would like feedback on your study results)

Cell____________________ Email ____________

(Appendix E)

NAVISTAR LPGA CLASSIC 2010; Pairings Sheet For Round 1, Thursday, 10/7/10

Tee #1		6:50AM	Diana D'Alessio	FLANDERS NJ
Group #1			Julieta Granada	PARAGUAY
			Cathryn Bristow	AUCKLAND NEW ZEALAND
Tee #1		7:01AM	Adrienne White	RED DEER ALB CANADA
Group #3			Mikaela Parmlid	GOTHENBURG SWEDEN
			Sarah Lee	SOUTH KOREA
Tee #1		7:12AM	Stephanie Louden	LAS VEGAS NV
Group #5			Beth Bader	ELDRIDGE IA
			Reilley Rankin	HILTON HEAD ISLAND SC
Tee #1		7:23AM	Yoo Kyeong Kim	INCHEON SOUTH KOREA
Group #7			Jill McGill	SAN DIEGO CA
			Marianne Skarpnord	NORWAY
Tee #1		7:34AM	Giulia Sergas	ITALY
Group #9			Lisa Meldrum	MONTREAL CANADA
			Mariajo Uribe	BUCARAMANGA COLOMBIA
Tee #1		7:45AM	Dorothy Delasin	SAN FRANCISCO CA
Group #11			Sarah Kemp	TUNCURRY AUSTRALIA
			Ilmi Chung	PUSAN SOUTH KOREA
Tee #1		7:56AM	Nicole Jeray	BERWYN IL
Group #13			Leah Wigger	LOUISVILLE KENTUCKY
			Allison Fouch	GRAND RAPIDS MI
Tee #1		8:07AM	Brandie Burton	HIGHLAND CA
Group #15			Wendy Ward	SAN ANTONIO TX
			Maria Hjorth	SWEDEN
Tee #1		8:18AM	Lorie Kane	P.E.I. CANADA
Group #17			Candie Kung	TAIWAN
			Stacy Prammanasudh	ENID OK
Tee #1		8:29AM	Sun Young Yoo	SEOUL SOUTH KOREA
Group #19			Sherri Steinhauer	MADISON WI
			Shi Hyun Ahn	SOUTH KOREA
Tee #1		8:40AM	Meena Lee	SOUTH KOREA
Group #21			Jeong Jang	SOUTH KOREA
			Katie Futcher	THE WOODLANDS TX
Tee #1		8:51AM	M.J. Hur	SOUTH KOREA
Group #23			Louise Friberg	HELSINGBORG SWEDEN
			Amy Yang	SOUTH KOREA
Tee #1		11:45AM	Eun-Hee Ji	SOUTH KOREA
Group #25			Azahara Munoz	MALAGA SPAIN
			Seon Hwa Lee	SOUTH KOREA
Tee #1		11:56AM	Amanda Blumenherst	SCOTTSDALE AZ
Group #27			Natalie Gulbis	LAKE LAS VEGAS NV
			Laura Davies	LYNE ENGLAND
Tee #1		12:07PM	Brittany Lincicome	SEMINOLE FL
Group #29			Cristie Kerr	MIAMI FL
			Sophie Gustafson	SWEDEN
Tee #1		12:18PM	Hee-Won Han	SEOUL SOUTH KOREA
Group #31			Christina Kim	SAN JOSE CA
			Paula Creamer	PLEASANTON CA
Tee #1		12:29PM	Laura Diaz	SCOTIA NY
Group #33			Brittany Lang	MCKINNEY TX
			Lindsey Wright	ALBURY AUSTRALIA
Tee #1		12:40PM	Alexis Thompson	CORAL SPRINGS FL
Group #35			Sandra Gal	COLOGNE GERMANY
			Beatriz Recari	PAMPLONA SPAIN
Tee #1		12:51PM	Katie Kempter	ALBUQUERQUE NM
Group #37			Mallory Blackwelder	VERSAILLES KY
			Whitney Wade	GLASGOW KY
Tee #1		1:02PM	Jane Park	RANCHO CUCAMONGA CA
Group #39			Song Yi Choi	SOUTH KOREA
			Heather Bowie Young	DOVER DE
Tee #1		1:13PM	Soo-Yun Kang	SOUTH KOREA
Group #41			Janice Moodie	GLASGOW SCOTLAND
			Marisa Baena	PEREIRA COLOMBIA
Tee #1		1:24PM	Christine Song	FULLERTON CA

Group	#43		Taylor Leon	DALLAS TX
			Becky Morgan	MONMOUTH WALES
Tee	#1	1:35PM	Minea Blomqvist	FINLAND
Group	#45		Jean Reynolds	NEWNAN GA
			Tania Elosegui	SPAIN
Tee	#1	1:46PM	Allison Hanna	PORTLAND OR
Group	#47		Nicole Hage	CORAL SPRINGS FL
			Silvia Cavalleri	MILANO ITALY
Tee	#10	6:50AM	Paige Mackenzie	YAKIMA WA
Group	#2		Russy Gulyanamitta	RAYONG THAILAND
			Pernilla Lindberg	BOLLNAS SWEDEN
Tee	#10	7:01AM	Tanya Dergal	DURANGO MEXICO
Group	#4		Louise Stahle	SWEDEN
			Sarah Jane Smith	CALOUNDRA QUEENSLAND
Tee	#10	7:12AM	Jimin Jeong	SOUTH KOREA
Group	#6		Jennifer Rosales	PHILIPPINES
			Kris Tamulis	NAPLES FL
Tee	#10	7:23AM	Ilhee Lee	SEOUL SOUTH KOREA
Group	#8		Aree Song	SEOUL SOUTH KOREA
			Jennifer Johnson	LAQUINTA CA
Tee	#10	7:34AM	Cindy Lacrosse	TAMPA FL
Group	#10		Moira Dunn	UTICA NY
			Jessica Shepley	OAKVILLE ONTARIO
Tee	#10	7:45AM	Kelli Kuehne	DALLAS TX
Group	#12		Anna Rawson	ADELAIDE AUSTRALIA
			Liz Janangelo	WEST HARTFORD CT
Tee	#10	7:56AM	Samantha Richdale	KELOWNA BC CANADA
Group	#14		Christi Cano	SAN ANTONIO TX
			Ashli Bunch	MORRISTOWN TN
Tee	#10	8:07AM	Mi Hyun Kim	SOUTH KOREA
Group	#16		Leta Lindley	PALM BCH GARDENS FL
			Jee Young Lee	SOUTH KOREA
Tee	#10	8:18AM	Angela Stanford	SAGINAW TX
Group	#18		Kristy McPherson	CONWAY SC
			Anna Nordqvist	ESKILSTUNA SWEDEN
Tee	#10	8:29AM	Ai Miyazato	OKINAWA JAPAN
Group	#20		Na Yeon Choi	SOUTH KOREA
			Karrie Webb	AYR QLD AUSTRALIA
Tee	#10	8:40AM	Mika Miyazato	OKINAWA JAPAN
Group	#22		Katherine Hull	SUNRISE BCH AUSTRALIA
			Morgan Pressel	BOCA RATON FL
Tee	#10	8:51AM	Hee Young Park	SOUTH KOREA
Group	#24		Shanshan Feng	GUANGZHOU CHINA
			Se Ri Pak	SOUTH KOREA
Tee	#10	11:45AM	In-Kyung Kim	SOUTH KOREA
Group	#26		Haeji Kang	SOUTH KOREA
			Stacy Lewis	THE WOODLANDS TX
Tee	#10	11:56AM	Gwladys Nocera	MOULINS FRANCE
Group	#28		Jimin Kang	SCOTTSDALE AZ
			Michele Redman	MINNEAPOLIS MN
Tee	#10	12:07PM	Pat Hurst	ARIZONA
Group	#30		Na On Min	SOUTH KOREA
			Alena Sharp	HAMILTON CANADA
Tee	#10	12:18PM	Ji Young Oh	SOUTH KOREA
Group	#32		Meaghan Francella	PORT CHESTER NY
			Vicky Hurst	MELBOURNE FL
Tee	#10	12:29PM	Karine Icher	FRANCE
Group	#34		Amy Hung	TAIWAN
			Karen Stupples	ENGLAND
Tee	#10	12:40PM	Jeehae Lee	ORLANDO FL
Group	#36		Mina Harigae	MONTEREY CA
			Irene Cho	LA HABRA CA
Tee	#10	12:51PM	Libby Smith	ESSEX JUNCTION VT
Group	#38		Meredith Duncan	LOUISIANA
			Angela Park	BRAZIL
Tee	#10	1:02PM	Karin Sjodin	GOTHENBURG SWEDEN
Group	#40		Mhairi McKay	GLASGOW SCOTLAND
			Misun Cho	SOUTH KOREA

Tee	#10	1:13PM	Jamie Hullett	MESQUITE TX
Group	#42		Mindy Kim	DIAMOND BAR CA
			Lisa Strom	HUNTERSVILLE NC
Tee	#10	1:24PM	Michelle Ellis	NSW AUSTRALIA
Group	#44		Dina Ammaccapane	PHOENIX AZ
			Paola Moreno	CALI COLOMBIA
Tee	#10	1:35PM	Gloria Park	SOUTH KOREA
Group	#46		Chella Choi	SOUTH KOREA
			Alison Walshe	WESTFORD MA
Tee	#10	1:46PM	Maria Hernandez	PAMPLONA SPAIN
Group	#48		Jin Young Pak	SOUTH KOREA
			Young-A Yang	DAEGU SOUTH KOREA

(Appendix F)

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

POS	NAME	SCORES		Rank	OFFICIAL MONEY
1	Katherine Hull	68-67-67-67	269	-19	$195,000
2	BrittanyLincicome	67-66-72-65	270	-18	$119,198
T3	Na Yeon Choi	68-64-70-69	271	-17	$76,680
T3	Cristie Kerr	65-67-67-72	271	-17	$76,680
T5	Lindsey Wright	72-70-67-63	272	-16	$44,920
T5	Amy Yang	68-66-72-66	272	-16	$44,920
T5	Se Ri Pak	69-67-67-69	272	-16	$44,920
T8	Anna Nordqvist	66-70-68-69	273	-15	$29,258
T8	Hee Young Park	69-67-67-70	273	-15	$29,258
T8	Mika Miyazato	69-63-71-70	273	-15	$29,258
11	Haeji Kang	68-68-67-71	274	-14	$24,471
T12	Laura Diaz	69-68-70-68	275	-13	$21,448
T12	Vicky Hurst	67-68-71-69	275	-13	$21,448
T12	Wendy Ward	70-67-67-71	275	-13	$21,448
15	Giulia Sergas	67-68-70-71	276	-12	$18,924
T16	Alison Walshe	68-70-73-66	277	-11	$16,641
T16	Paula Creamer	71-69-66-71	277	-11	$16,641
T16	Sun Young Yoo	71-69-65-72	277	-11	$16,641
T16	Alexis Thompson	69-68-68-72	277	-11	$16,641
T20	Azahara Munoz	72-69-69-68	278	-10	$13,471
T20	Amy Hung	71-71-67-69	278	-10	$13,471
T20	Alena Sharp	69-68-72-69	278	-10	$13,471
T20	Morgan Pressel	66-73-69-70	278	-10	$13,471
T20	Jee Young Lee	68-70-70-70	278	-10	$13,471
T20	Shi Hyun Ahn	69-70-68-71	278	-10	$13,471
T20	Nicole Hage	70-68-69-71	278	-10	$13,471
T27	Meena Lee	70-68-70-71	279	-9	$11,322
T27	Ai Miyazato	70-69-68-72	279	-9	$11,322
T29	Katie Futcher	70-72-70-68	280	-8	$9,472
T29	Beatriz Recari	72-69-70-69	280	-8	$9,472
T29	Louise Friberg	68-70-72-70	280	-8	$9,472
T29	Cindy Lacrosse	69-70-70-71	280	-8	$9,472
T29	Eun-Hee Ji	68-67-73-72	280	-8	$9,472
T29	Brittany Lang	75-66-66-73	280	-8	$9,472
T29	Paola Moreno	70-67-70-73	280	-8	$9,472
T36	Jane Park	71-71-69-70	281	-7	$7,104
T36	M.J. Hur	70-69-71-71	281	-7	$7,104
T36	Mhairi McKay	69-69-72-71	281	-7	$7,104
T36	Sandra Gal	70-70-69-72	281	-7	$7,104
T36	Sherri Steinhauer	69-68-72-72	281	-7	$7,104
T36	Karrie Webb	70-69-69-73	281	-7	$7,104

T36	Heather B-Young	70-69-68-74	281	-7	$7,104
T43	Na On Min	71-69-69-73	282	-6	$5,764
T43	Jin Young Pak	68-69-71-74	282	-6	$5,764
T43	Irene Cho	68-68-72-74	282	-6	$5,764
T46	Shanshan Feng	70-71-74-68	283	-5	$4,568
T46	Sarah Jane Smith	72-70-71-70	283	-5	$4,568
T46	Karen Stupples	70-72-71-70	283	-5	$4,568
T46	Christina Kim	67-73-73-70	283	-5	$4,568
T46	Stephanie Louden	72-68-72-71	283	-5	$4,568
T46	Seon Hwa Lee	70-71-70-72	283	-5	$4,568
T46	Leah Wigger	73-67-71-72	283	-5	$4,568
T46	Becky Morgan	69-70-72-72	283	-5	$4,568
T46	Katie Kempter	71-69-70-73	283	-5	$4,568
T46	Allison Fouch	69-68-71-75	283	-5	$4,568
T56	Marisa Baena	71-71-70-72	284	-4	$3,719
T56	Karine Icher	72-65-71-76	284	-4	$3,719
T58	Jessica Shepley	73-69-72-71	285	-3	$3,302
T58	Kris Tamulis	72-69-72-72	285	-3	$3,302
T58	In-Kyung Kim	72-70-70-73	285	-3	$3,302
T58	Natalie Gulbis	69-72-71-73	285	-3	$3,302
T58	Angela Stanford	71-69-70-75	285	-3	$3,302
T63	Michele Redman	71-71-71-73	286	-2	$3,002
T63	Samantha Richdale	72-69-70-75	286	-2	$3,002
T63	Dorothy Delasin	66-73-71-76	286	-2	$3,002
T66	Moira Dunn	69-71-76-71	287	-1	$2,773
T66	Gwladys Nocera	72-70-73-72	287	-1	$2,773
T66	Young-A Yang	72-70-73-72	287	-1	$2,773
T66	Ilhee Lee	71-71-70-75	287	-1	$2,773
T70	Mina Harigae	71-71-75-71	288	E	$2,561
T70	Jean Reynolds	70-69-76-73	288	E	$2,561
T70	Jeong Jang	74-67-72-75	288	E	$2,561
T70	Meaghan Francella	70-71-72-75	288	E	$2,561
74	Soo-Yun Kang	70-71-75-74	290	+2	$2,479
75	Silvia Cavalleri	67-73-76-76	292	+4	$2,449
76	Christi Cano	69-73-77-74	293	+5	$2,419
	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 Ammaccapane	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 Prammanasudh	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
MalloryBlackwelder	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
Gloria Park	70-77	147	CUT	CUT
Jimin Jeong	78-70	148	CUT	CUT
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
Tanya Dergal	78-72	150	CUT	CUT
Liz Janangelo	76-74	150	CUT	CUT
Candie Kung	77-74	151	CUT	CUT
Cathryn Bristow	74-77	151	CUT	CUT
Russy Gulyanamitta	72-79	151	CUT	CUT
Jeehae Lee	72-79	151	CUT	CUT
Diana D'Alessio	81-72	153	CUT	CUT
Minea Blomqvist	79-74	153	CUT	CUT
Marianne Skarpnord	75-78	153	CUT	CUT
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