2014

Effectiveness of sleep extension on athletic performance and nutrition of female track athletes

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EFFECTIVENESS OF SLEEP EXTENSION ON ATHLETIC PERFORMANCE AND NUTRITION OF FEMALE TRACK ATHLETES

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Thesis submitted
to the Davis College of Agriculture, Natural Resources & Design
at West Virginia University
in partial fulfillment of the requirements for the degree of
Master of Science in
Nutrition & Food Science

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2014

Keywords: Sleep Extension; Sleep Deprivation, Physical Performance, Nutrition, Athletes

ABSTRACT

Effects of extended sleep on female athlete's performance and nutrition

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Adequate sleep is an essential component to rest and recovery for athletes. Detrimental effects of inadequate sleep (sleep deprivation), on athletes' performance have been well documented. In contrast, increasing sleep (sleep extension), has not been thoroughly investigated in this population. Furthermore, the effect of sleep on an athlete's nutrition behaviors and choices has yet to be determined.

PURPOSE: The purpose of this study was to investigate the effects of one additional hour of sleep on performance and nutrition behaviors on collegiate, female, track and field athletes.

METHODS: Twenty-one females (age 20.2 ± 1.8 yrs) maintained normal sleep habits for one week. Baseline data were collected and followed by a one week sleep extension period. Physical performance was measured using a standard anaerobic test (Wingate Anaerobic Test). The Automated Self Administered (ASA) 24-hour food-recall questionnaire was used to test nutrient intake. Reaction time and mood, used in association with sleep efficiency, were measured using the Psychomotor Vigilance Test (PVT) and Profile of Mood States (POMS), respectively. Significance was set at $p \leq 0.05$.

RESULTS: Subjects (n=21) significantly increased total sleep from baseline (429.3 ± 38 minutes, 451.4 ± 44.8 minutes respectively; $p = 0.03$). Subjects showed a trend towards improvements in peak power (692.9 ± 213.2 watts versus 713.5 ± 214.6 watts) and slight decrements in fatigue index from baseline (37.3 ± 10.6% versus 38.8 ± 8.42%), however these were not significant ($p = 0.07$, $p = 0.28$ respectively). Mean PVT scores remained unchanged ($p = 0.98$) and POMS scores significantly decreased ($p = 0.01$) following more sleep. Although not significant, the athletes showed increased caloric intake ($p = 0.87$) with increased percentage of total fat ($p = 0.24$) after sleep extension.

CONCLUSION: No significant differences were seen in physical performance, however significant improvements in psychological performance (total mood disturbance score) was seen after sleep extension in college female track athletes. Increased caloric intake with an increase in dietary fat consumption was seen with more sleep, however not significant.

LIMITATIONS: Short sleep extension dosage may have limited the ability to detect a significant change in nutritional behaviors and physical performance in athletes.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Dr. Melissa Olfert for providing me with the opportunity to work as a graduate student in her research lab for the creation of the SleEP iN Study (sleeping longer to enhance performance). I would also like to thank her for her time, encouragement and expertise throughout the past two years.

Next, I would like to thank my additional committee members Dr. Hawley Montgomery-Downs and Dr. Randall Bryner for their continued support and flexibility. I would also like to extend my appreciation to Dr. Christa Lilly for his statistical advice and expertise.

I would also like to thank my fellow interns, research team, family members and friends who have supported me throughout my year at West Virginia University. Your support and willingness to help has led me to my success throughout my journey through my Master's Program.

Lastly, my sincerest gratitude goes out to the West Virginia University female track athletes who volunteered in the participation of this study. The work completed here could not have been done without each of your efforts and contribution.

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LIST OF ABBREVIATIONS

ASA-24-Automated Self Administered 24-Hour-Recall
BMI – Body Mass Index
CDC – Centers for Disease Control
CITI- Collaborative Institutional Training Initiative
GH- Growth Hormone
HPL-Human Performance Lab
IL-6-Interleukin 6
IRB- Institutional Review Board
MSLT- Multiple Sleep Latency Test
NCAA-National Collegiate Athletic Association
NHANES – National Health & Nutrition Examination Survey
NREM- Non Rapid Eye Movement
OC – Oral Contraceptive
OR- Odds Ratio
POMS – Profile of Mood States
PSS-Perceived Stress Score
PVT – Psychomotor Vigilance Test
QOL-Quality of Life
REM- Rapid Eye Movement
SleEP iN – Sleeping Longer to Enhance Exercise Performance and Improve Nutrition
VO_2max- Maximal Oxygen Uptake
VO_2-Resting Oxygen Uptake
WAnT-Wingate Anaerobic Test
WV – West Virginia
WVU – West Virginia University

CHAPTER I

INTRODUCTION

Sleep is an essential component to rest and recovery, both physically and mentally [1]. Athletes may need more sleep than their non-sporting counterparts in order to recover from the amount of stress delivered from training and competing, but also to organize the information received from training [1]. Depriving oneself of sleep, it can lead to anxiety, depression, stress and other psychological problems [2, 3], which can impact an athlete's sport or expectation of sport. Also, sleep is needed in order to limit the loss of cognitive or motor abilities needed to excel in exercise performance [4]. Although it is argued whether athletes need more sleep than others, they potentially are getting less [5]. Therefore sleep and its potential performance enhancing effects continues to be investigated by researchers.

Nutrition is also said to enhance performance [6, 7]. There is increasing research connecting sleep and nutrition; depriving oneself of sleep can lead to appetite stimulation and increased levels of hunger due to hormone imbalance [8]. These behaviors could be detrimental to an athlete if they are exercising more and sleeping less, with a result in feeling hungry because of the combination. Therefore, examining amount of sleep with energy intake and nutrient composition of an athlete's diet is paramount to assess if they have the necessary fuel for peak performance.

Throughout this study, the aim was to determine the effect(s) of extending an athlete's sleep period by one hour on athletic performance and nutritional behaviors on female track and field athletes. To our knowledge, studies assessing the effects of sleep extension in female athletes relating to the impact on physical performance and nutrition behaviors have not been undertaken.

STUDY OBJECTIVES

The study's primary objective(s) was to recruit 18 - 24 year old West Virginia University (WVU) female track and field athletes for the SleEP iN study and investigate the effects of sleep extension (1 hour more) on performance, as measured by the Wingate Anaerobic Test (WAnT), Psychomotor Vigilance Test (PVT) and Profile of Moods States (POMS) and energy consumption as measured by total kilocalories, percent fat, protein and carbohydrate and total water using a self-report ASA-24 hour dietary multi-pass recall. Further, descriptive baseline anthropometric measures including: height, weight, body mass index (BMI), body fat percentage, waist circumference, blood pressure, and menstrual status were also collected.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this review is to determine the accomplishments and need in current research evaluating the known effects of sleep, both deprivation and extension, as it relates to physical and mental performance, as well as sleep's implications on nutritional behaviors in collegiate athletes.

The databases that were used in the search were PubMed, EbscoHost, Academic Search Complete, CINHAHL with text, MEDLINE, PsycINFO and SPORTDiscus. An initial search with text from 2000 to the present (2014) was done in adult subjects and then extended with further review. Reference lists of relevant reviews and all identified studies were examined and reviewed. Key words used in the search were sleep duration, extension, restriction, deprivation, athletes, nutrition, diet, exercise, physical activity and performance.

Sleep and Physical & Mental Performance

Sleep is an essential component of rest and recovery both physically and mentally. The National Sleep Foundation reports that adults should be receiving seven to nine hours of sleep per day [(9)]. According to the National Health Interview Survey performed between 2005 and 2007, 30% of adults reported sleeping six hours or fewer[(10)]. When a person does not receive an adequate amount of sleep, defined on average as seven hours or less per night [(11-13)], this is termed sleep deprivation [(1)]. Sleep deprivation can lead to anxiety, depression, stress and other psychological problems [(2, 3, 14)]. In athletes, sleep is important for several reasons; to limit the loss of cognitive and motor abilities, to organize the information received from training and to improve alertness and mood, which are needed to excel in performance [4]. Athletes are also more prone to physical stress on their bodies, causing a greater need for recovery. Healing is improved by getting adequate sleep [1, 15]. Some researchers suggest that athletes need more sleep than less active individuals [16] yet, they may be getting less [5]. Tsai and Li showed that "fit" individuals slept on average 20 minutes less than their "unfit" counterparts [17]. To date, there has been no other study that examined similar effects. Furthermore, college students (18-24) may be more sleep deprived compared to other adults [17]. Liguori et al. found college students (ages 18-26) slept an average of 7-8 hours per night yet reported feeling rested when they woke up less than 50% of the time [18].

Although research evidence supports the view that exercise training helps promote sleep[19], it is possible that participation in sport may hinder the ability to receive quality sleep. Leeder et al. showed Olympic athletes had comparable quantity of sleep to controls (6:55 ± 0:43 mins vs. 7:11 ± 0:25 mins) however, significant differences were observed in quality of sleep [20]. Athletes had longer sleep latency (18.2 ± 16.5 min vs. 5.0 ± 2.5 min) and lower sleep efficiency (80.6 ± 6.4% vs. 88.7 ± 3.6%) than controls [20]. Various factors may alter the efficiency of sleep in these athletes: training close to sleep influencing body temperature[21], traveling and jet lag[22], pre competition worry[23], or balancing life activities and sport. Despite these consequences, data presented by these researchers may be used as a reference for sleep intervention studies on the athlete.

Performance in athletes is highly regulated by the sleep-wake cycle [16]. Basic components of exercise such as temperature, flexibility, vigilance, muscular strength, and metabolic functions are driven by the body clock or the circadian cycle [16, 24] that may be altered with disturbances of sleep. Sleep can be divided into two main states serving different functions; non-rapid eye movement (NREM), and rapid eye movement sleep (REM) [1, 16]. In NREM, the brain reduces activity and neurons synchronize [16]. Additionally, metabolic activity is low and the pituitary gland is releasing growth hormone (GH) in order to stimulate protein synthesis, maintain blood glucose, repair muscle, promote fat burning, and build bone [1, 16, 25]. During REM sleep, the brain becomes very active, motor activity decreases and muscles are in total relaxation [1, 16]. If athlete's basal sleep is not achieved it can lead to a general decline in performance where they are not as refreshed and alert the following day.

Sleep deprivation has been well-documented with respect to performance in athletes and young adults (ages 18-26) [16, 26]. It can affect the athlete's ability to perform optimally such as: reduction in cardiovascular performance, reaction time, ability to process information, emotional stability, and metabolic processes [1, 27]. Azboy and Kaygisiz reported increased resting oxygen uptake (VO_2) in ten male distance runners, age 17-18 years, during a self-paced treadmill protocol following 25-30 hours of sleep loss ($P < 0.05$) [12]. Ten male volleyball players were also examined and sleep loss significantly decreased time to exhaustion ($P < 0.01$). Another study investigated the effects of one night of sleep deprivation on treadmill endurance in 11 recreationally active young adult males, ages 17-23 [11]. Subjects acted as their own control by completing two randomized trials separated by seven days following normal sleep and 30 hours without sleep. Less distance was covered when subjects were sleep deprived compared to when they slept close to eight hours ($P = 0.02$). Maximal oxygen uptake (VO_2 max) was greater in the sleep deprived group following 30 minutes of exercise compared to when they slept eight hours ($P < 0.05$).

Although these studies examined performance measures based on endurance, a recent crossover design examined 30 hours of sleep deprivation on an intermittent-sprint performance and muscle glycogen [27]. Ten male athletes in team sports, ages 18-24, underwent two consecutive-day experimental trials separated by a normal night's sleep or no sleep. Subjects performed a 30-minute exercise run and 50-minute intermittent-sprint exercise protocol. Muscle biopsies were taken before and after exercise during baseline and intervention trials. The authors reported slower pacing strategies, reduced intermittent-sprint performance, and reduced muscle glycogen following sleep deprivation. Perception was also measured throughout both trials and more negative perceptions following sleep deprivation such as being less alert, less energetic, and more fatigued. While these studies investigated negative consequences of sleep deprivation on psychological and physiological factors, there are studies that reported no affect of sleep loss on these factors [28-30]. Hil et al. showed no affect of one night's sleep loss, 25-30 hours, when seven male and seven female college students, ages 19-25, performed to their limit on a cycling test [31]. Researchers speculated that the sleep restriction period (one night's sleep loss) might not be enough to show affects on the cycling test. They also noted that a short task (all-out cycling) requires anaerobic, or "quick energy", which may not be affected by sleep deprivation. More research is needed to examine the effects on sleep loss on aerobic and anaerobic energy production during all-out exercise tasks of different durations.

Not all athletes may experience high levels of sleep loss in a small time frame that is simulated in sleep deprivation studies. This suggests that sleep deprivation can accumulate over time [15], referring to the concept of sleep debt. Sleep debt is defined as the accumulated sleep that is lost to poor sleep habits, sickness, awakenings from environmental factors or other causes [9] that is registered by the brain [32]. Researchers suggests that sleep debt could account for hours of sleep lost that occurred a month ago or a week ago, and it does not resolve spontaneously [32]. Walter stated that an athlete who needs eight hours of sleep each night yet receives only six, would incur a substantial amount of sleep debt to hinder performance levels [1]. Dement suggests the anecdote is to obtain extra sleep beyond habitual nightly sleep in order to lower sleep debt [32]. However, it has been noted that extra sleep can only equivocate to the amount of sleep incurred as a result of sleep debt [32].

In support thereof, a laboratory study of eight adult men examined the effects of duration of time spent with the lights on, regarding mood and emotion for 35 consecutive days [33]. During the first seven days, subjects reported baseline sleep of less than 8 hours. Then for 28 days, subjects were in bed in the dark for 14 hours every night. When switched to 14 hours, sleep time increased to 12 hours on the first night then gradually declined. At about midway in the experiment, average nightly sleep was around 8.5 hours. Results showed that subjects entered the study with sleep debt and gradually decreased the amount of accrued debt when extra sleep was given. The gradual decline shows that extra sleep can only be obtainable to the total amount of sleep lost. Equally important, the subject's mood and energy levels increased following extended sleep. Hence, there is a need for extending sleep in athletes to limit their sleep debt.

Although it is understood that sleep deprivation plays a role in under-performance (or poor performance) in athletes [4, 34], there is little research that shows the impact of sleep extension [32, 35-38]. Several studies have reported adverse reactions with increased night's sleep

[39-41]. In one study, twelve college students performed a pinball task after normal and extended sleep of two hours. However, there were decrements in reaction time and average pinball score after extended sleep which the researchers attributed the effect to increased wakefulness in the extended sleep condition [39]. Harrison and Horne reported reductions in auditory vigilance and increased Multiple Sleep Latency (MSLT) scores following 10 hours of extended sleep for 14 days in healthy college students [40]. In examining reaction time on 61 volunteers following three, five, seven, and nine hours in bed for seven consecutive days [41], those who slept nine hours showed no improvement in performance, although it is possible that extra sleep was not substantial enough to counterbalance the sleep debt incurred.

Alternatively, other studies report benefits of sleep extension in healthy young adults [42, 43]. Roehrs et al. found significant improvements in Multiple Sleep Latency Test (MSLT) and reaction times after extending bedtime to 10 hours for six consecutive days [43]. Recently, researchers investigated daytime alertness, vigilance and mood in fifteen healthy female and male college students, ages 18-23. Significant increases were reported in MSLT and PVT scores, and improvements to mood using the POMS questionnaire when subjects were encouraged to sleep as much as possible [38]. Even a small amount of extra sleep such as a nap has been shown to improve mood and vigilance levels. Hayashi et al. examined seven young adults (age 20-21), who took a 20 minute nap and were tested on mood, performance and self-rating on performance [44]. Improved subjective sleepiness, performance level and self-confidence on task performance were seen following the nap. Pierce et al. showed greater ability to use oxygen more efficiently, lower VO_2, through the first two stages of a graded exercise test (Bruce Protocol) when subjects received a nap lasting 60-90 minutes [37]. The authors speculated that the participants had decreased physiological arousal upon awakening from a bout of sleep. Therefore it is possible that the subjects given a nap were less anxious in the early stages of the protocol and were able to decrease VO_2.

While most sleep extension research observes the relationship between extra sleep and cognitive functioning, little explore the effects on physical performance. Only one study examined sleep extension on athletic performance using performance measures outside the laboratory [36]. At the Stanford Sleep Disorders Clinic and Research Laboratory, eleven healthy male college basketball players maintained their habitual sleep patterns for 2-4 weeks followed by a 5-7 week sleep extension period with a goal of 10 hours of sleep, including naps. Measures of athletic performance specific to basketball were determined. In addition, reaction time, daytime sleepiness, and mood were monitored. A faster timed sprint ($P< 0.001$), improvements in shooting accuracy ($P< 0.001$), as well as decreased reaction times and sleepiness scores ($P< 0.01$) were seen following sleep extension. Subjects also experienced increased vigor and decreased fatigue with sleep extension ($P< 0.001$). Investigators concluded that extending sleep in healthy collegiate basketball players leads to optimal performance; the only limitation being there was no control group. Although much of the research conducted on sleep extension and performance illustrate that getting enough sleep is important for athletes, the precise definition of how much sleep is enough and what measures of performance should be used does not exist and therefore, more research is needed.

See Table 1 for review of studies.

Table 1: Sleep and Performance Research Articles

Title and Author(s)	Participants (n)	Objective(s)	Measures/Tools	Results/Conclusions
Sleep Extension				
The effects of an acute bout of sleep on running economy and VO2 max. Pierce et al. (1992)	Seven male, healthy, active volunteers (age 23±6.3 years)	Investigate the effects of an acute bout of sleep on submaximal (running economy) and maximal oxygen consumption.	Acute sleep bouts (60-90 minutes) took place in a laboratory; Bruce treadmill protocol; RER, spirometry techniques	No difference between groups for running economy or VO2. Those who received the 1-hour sleep bout had greater running economy through the first two stages of the protocol, while the control group yielded a greater running economy throughout the remaining stages
A Two-Week Sleep Extension in Sleepy Normals. Roehrs et al. (1996)	34 healthy men and women (age 21-35)	Assess the effects of sleep extension in sleepy normals. The study extended bedtime to 10 hours for a 2-week period and used a sleepy control group maintained on their own habitual sleep schedules for the 2-week period.	Polysomnography, sleep logs, Multiple Sleep Latency Test (MLST)	Those who extended their sleep ↑ sleep latency relative to those who maintained habitual sleep. The ↑ in sleep latency was associated with a gradual decline in sleep efficiency over the 14 nights. Those showing no increase in average daily sleep latency had an immediate drop in sleep efficiency when bedtime ↑ to 10 hours, suggesting unable to sleep longer during extension. Removed sleep debt.
Long-term extension to sleep- Are we really chronically sleep deprived? Harrison and Horne (1996)	Eleven subjects (seven women, four men; M=23.6 years old; range=18-36 years)	Investigating the effects of a prolonged period of extended nocturnal sleep (10 hours a night for 14 consecutive nights) in a home setting in terms of a number of specific questions: does longer nighttime sleep lead o less daytime	Multiple Sleep Latency Test, vigilance performance (Wilkinson Auditory Vigilance Task), subjective daytime, sleepiness	During extended sleep, subject slept longer, but sleep latency and interim wakefulness ↓. Extended sleep produced no improvements to mood or subjective sleepiness. Vigilance test showed a small but significant ↓ in reaction time following

		sleepiness? Does this coincide with improved performance? Can this be sustained for many nights? Is there increased daytime alertness, and if so, any potential benefit to daytime functioning?	(Karolinska Sleepiness Scale), mood(POMS) and nighttime sleep. wrist actigraphy, sleep diary	extended sleep compared to baseline and recovery sleep. Multiple Sleep Latency Test scores ↓ during extended sleep.
The effects of a 20 minute nap in the mid-afternoon on mood, *performance and EEG activity.* Hayashi et al. (1999)	Seven university students (3 male and 4 female) with good health participated (20-21 years)	To examine the effects of a 20 minute nap in the mid-afternoon on mood, performance and EEG activities.	Sleep logs, Sleep Habit Inventory and Morning-Evening Questionnaire, Performance Tasks (logical reasoning, addition, visual detection, auditory vigilance), EEG	A 20 minute nap improved subjective sleepiness, performance level and self confidence on their task performance. The nap suppressed EEG alpha activity during eye-open wakefulness
The impact of extended sleep on daytime alertness, vigilance, and mood. Kamdar et al. (2004)	Fifteen healthy college students (4 women, 11 men) aged 18-23 years old.	To measure the effects of prolonged sleep extension (sleep as much as possible) on daytime alertness, vigilance, and moos in healthy young adults.	Epworth Sleepiness Scale, wristwatch-like actigraphs (Ambulatory Monitoring), sleep logs, Multiple Sleep Latency, Psychomotor Vigilance Test (PVT), Profile of Moods	5 of the 8 PVT measures improved with sleep extension with respect to baseline. POMS vigor and fatigue scores showed a similar improvement. 7 subjects achieved a MSLT score or 20 and 6 subjects showed substantial improvements while 2 subjects obtained little extra sleep and showed little or no improvements. The extension group had exceptional improvements in vigilance and POMS ratings.
The Effects if Sleep Extension of Athletic Performance of	Eleven healthy Stanford University male varsity	To investigate the effects of sleep extension (10 hours) over multiple weeks (5-7) on specific	Actigraphy (Actiware software), sleep journals,	Subjects demonstrated a faster timed sprint following sleep extension. Shooting accuracy

Collegiate Basketball Players. Mah et al. (2011)	basketball players (mean 19.4 ± 1.4 years)	measures of athletic performance as well as reaction time, mood, and daytime sleepiness	Epworth Sleepiness Scale, POMS, performance measures (timed sprint and shooting accuracy), PVT	improved and PVT reaction time and ESS ↓ following sleep extension. POMS scored improved with ↑ vigor and ↓ fatigue subscales. Subjects also reported improved overall ratings of physical and mental well-being during practices and games.
Sleep Restriction				
Effects of Total Sleep Loss on Sleep Tendency. Carskadon and Dement (1979)	Six undergraduate volunteers (2- women, 4- men) ages 18- 21 years	Validate the multiple sleep latency approach to measuring daytime function and to demonstrate the relative sensitivity of sleep tendency to sleep loss	Wilkinson Addition Test and the Serial Alteration Task, a mood scale, Stanford Sleepiness Scale, Multiple Sleep Latency Tests	Wilkinson test ↓ following sleep loss and recovered after one or two full nights of sleep. Performance of Alteration task ↓ following sleep loss. Mood and sleepiness declined during sleep loss. Sleep latency fell to about 1 minute and remained low during the sleep loss period. Baseline levels were not achieved until the second sleep recovery day.
Meta-Analysis of the Relationship Between Total Sleep Deprivation and Performance. Koslowsky and Babkoff (1991)	70 studies found that testes total sleep deprivation (TSD). 27 studies with 429 subjects met the criteria.	To test general notions and to provide a numerical measure of strength of the relationship between TSD and performance.	Manual Examination of al *Psychological Abstracts* between 1969-1983 and a computerized search between 1984-1988.	The results are consistent with the "lapse hypothesis". The correlations implied that under long TSD or work-paced stimuli rather than short TSD or self-paced stimuli, subjects are more likely to be affected by sleep loss
Patterns of performance degradation and restoration during sleep restriction	66 volunteers (16-women, age 24-55, mean =43 years; and 55-	Determine the effects of several levels of restricted (3, 5, or 7 for 7 days) and one level of augmented sleep (9	Psychomotor Vigilance Test, Polysomnography, Night-time sleep recorded	3 hour group-relapses ↑ and speed ↓ in the PVT. Speed and lapses recovered during the recovery period.

and subsequent recovery: a dose dependent study. Belenky et al. (2002)	men, age 24-62, mean = 37 years)	hours for 7 days) over seven consecutive days on objective and subjective alertness and objective performance; and determine the extent to which 3 days of subsequent recovery sleep (8 hours) restored performance and alertness to baseline levels.	by six technicians, sleep latency test, Stanford Sleepiness Scale	5 and 7 hour group-speed initially declined then stabilized and lapses ↑ in 5 hour group. Recovery remained stable for speed and lapses in the 5 hour group. 9 hour group-speed and lapses remained at baseline for both augmentation and recovery periods
The Effects of Sleep Restriction and Extension on School-Age Children: *What a difference and hour makes.* Sadeh et al. (2003)	77 children (age: M=10.6 years; range = 9.1-12.2 years) 39-boyrs 38-girls	Assess the effects of modest sleep restriction or extension (1 hour for one day) on children's neurobehavioral functioning (NBF)	Actigraphy, Daily sleep-wake diaries, NBF by Neuropsychological Evaluation System	Sleep restriction improved sleep quality but ↓ reported alertness; Sleep extension improved performance on memory and reaction time.
Effects of sleep deprivation on cardiorespiratory functions of the runners *and volleyball players during rest and exercise.* Azboy and Kaygisiz (2008)	10 male distance runners (age 18.1±0.35) and volleyball players (age 17.8±0.36)	Investigated the possible effect of one night sleep loss on the resting spirometric, resting and exercise cardiorespiratory parameters of the runners and volleyball players	Spirometric tests at rest and then incremental test on ergometer	Sleep loss ↑ resting VO2 in the runners and resting VCO2 in both the runners and volleyball players. HR, R, VE, and SaO2 unchanged in both groups. Sleep loss ↓ time to exhaustion in the volleyball players. Sleep loss did not alter HR, SaO2, VO2, VCO2, and R, but ↓ exercise VE in both groups.
One night of sleep deprivation decreases treadmill endurance performance. Oliver et al. (2009)	11 recreationally active healthy males (Mean (SD): age 20 (3) years)	To test the hypothesis that one night of sleep deprivation (30 hours w/o sleep) will impair pre-loaded 30 minute endurance performance and alter the cardio-respiratory,	Continuous incremental exercise test on a motorized treadmill; DXA; Accelerometer (ActiGraph LLC,	Less distance covered after sleep deprivation compared with control. Sleep deprivation did not alter core temperature at rest or thermoregulatory responses during the preload. Respiratory

		thermoregulatory and perceptual responses to exercise.	Florida)	parameters, RPE and speed were not different between trials during preload or distance test.
Intermittent-Sprint Performance and Muscle Glycogen after 30 h of Sleep Deprivation. Skein et al. (2010)	Ten male team-sport athletes (age 21±3 years	To determine the effects of 30 hours of sleep deprivation on consecutive-day intermittent-sprint performance and muscle glycogen content	30 minute graded exercise run (GXR) on a motorized treadmill and 50-minute intermittent-sprint exercise protocol; Maximal isometric voluntary contraction (MVC), urine samples, muscle biopsies, sleep diaries and Actiwatch actigraphs, POMS	Mean sprint times were slower during trial 2 sleep deprivation compared with trial one sleep deprivation or trial 2 baseline. Distance covered during self-paced exercise ↓ during trial 2 sleep deprivation during the initial 10 min compared with trial 1 sleep deprivation and during the final 10 minutes compared to trial 2 control. Muscle glycogen was lower in trial 2 sleep deprivation compared to trial 2 control. Sleep loss negatively affected POMS ratings.

Sleep and Nutrition

Due to the high prevalence of obesity and the rapid decline of sleep in U.S. citizens, many researchers have examined the correlation between sleep deprivation and obesity in the non-active healthy population [45-51]. In a six-year longitudinal study of 276 adults, age 21-64 years old, investigators examined the relationship between fat gain, body weight and sleep [50]. Individuals who slept 5-6 hours instead of the normal 7-8 hours gained 1.98 kg more (95% CI: 1.16-2.82) weight over the six years. In a meta-analysis by Cappuccio et al., the relationship between short sleep (≤5 hours for adults) duration and obesity (BMI≥ 30kg/m² for adults) was investigated [47]. In order to estimate the quantitative relation between short sleep duration and obesity, an odds ratio (OR) was obtained. For adults, 15 year and older, the pooled ratio between short sleep and obesity was 1.55 (95% CI: 1.43-1.68, P< 0.001) which suggested an increased risk of being obese or gaining weight with short sleep. These findings led many researchers to investigate the underlying causes of sleep duration on body weight regulation.

Sleep loss has been linked to many pathways associated with obesity: increased ghrelin and decreased leptin levels, increased time to eat and lower energy expenditure due to increased fatigue and decreased physical activity [45]. However, little research explores the association of sleep loss to obesity [45] yet some have examined the effects of sleep deprivation on the metabolic and endocrine systems [45, 52-57]. Redwine et al. investigated the effects of sleep deprivation on interleukin-6 (IL-6), growth hormone (GH), cortisol, and melatonin levels in humans [57]. IL-6 is a pro-inflammatory cytokine released by macrophages in response to infections to help aid in the immune response [57]. It also stimulates the pituitary gland of the hypothalamus to secrete cortisol and GH [58]; which regulate metabolism and anabolism, respectively. Decreased IL-6 and GH was seen with sleep loss, which may affect the integrity of the immune system and possibly increase the risk of inflammatory diseases [57]. On the other hand, decreases in GH with sleep loss can hinder fat breakdown, protein and bone growth as well as increase muscle mass, which can diminish athletic performance levels. Investigators showed no changes in cortisol levels with sleep loss. The researchers argued that IL-6 may be one of several physiological factors stimulating adrenal cortisol production during the night. In contrast, another study reported different results [52]. Six, male, healthy volunteers, 18-21 years old, were deprived of continuous, 72 hours of sleep and underwent a series of performance tasks of minimal physical activity and mostly cognitive in nature, along with collecting urine samples[52]. Following sleep deprivation, urinary cortisol levels decreased slightly (33 μ g/L), however there was no significant effect between the different days of sleep deprivation and urinary cortisol ($P > 0.05$). Urinary glucose declined steadily over the days ($P < 0.05$) and urea excretion increased significantly from 48 and 72 hours of sleep deprivation compared to the control group ($P < 0.05$). The researchers suggested that sleep deprivation required glucose be obtained from protein to meet metabolic demands. However, a limitation of the study was that food, water intake, and physical activity were not monitored, which could affect protein catabolism and increased urea excretion. Redwine et al. also provided no indication of having measured or monitored food intake [57].

Sleep has been shown to play an important role in energy balance, whereby the loss of sleep promotes changes in hormonal signals that influence hunger and satiety [55, 56, 59]. These hormones are leptin and ghrelin, which reduce and stimulate appetite respectively [60]. Taheri conducted a large scale study on 1,024 male and female volunteers, ages 44 to 60, to investigate sleep duration on metabolic hormones and body mass index (BMI). Sleeping less than 8 hours was associated with low serum leptin levels (P= 0.01 for slope) and high serum ghrelin levels (P< 0.01 for slope) [(56)]. Researchers also found lower predicted serum leptin levels (15.5%) and higher predicted serum ghrelin (14.9%) levels for nocturnal sleep of 5 hours versus 8 hours independent of BMI. In a crossover study with a goal to determine whether sleep loss alters appetite regulation in 12 healthy men, 20 to 24 years old, [(55)] caloric intake and physical activity were controlled using a research setting and two groups of participants were asked to undergo two days of sleep extension (10 hours in bed) or sleep restriction (4 hours in bed) in randomized order. After six weeks of subjects maintaining normal sleep habits, subjects were brought back in the lab to be crossed to the other intervention group. Ratings of hunger and appetite were reported and blood serum leptin and ghrelin were taken. Compared to those who spent 10 hours in bed, subjects who slept 4 hours had 18% lower serum leptin (P< 0.05) and 28% higher serum ghrelin (P< 0.05). Sleep restriction relative to sleep extension was associated with 24% increase in hunger ratings (P< 0.01) and 23% increase in appetite ratings (P= 0.01). Additionally, an increase in hunger was proportional to the increase in ghrelin-to-leptin ratio (r = 0.87). Altogether, these findings suggest that sleep loss can affect hunger and appetite. Although obesity may not be an issue for athletes, these individuals may feel hungry as a consequence of expending more calories than they are eating, or feeling hungry from the imbalance of satiety hormones. Either instances were found to contribute to engaging in unhealthful behaviors to satisfy appetite.

College students report frequently engaging in unhealthful behaviors: poor sleeping habits, frequent drinking, smoking, risky sexual behaviors, and disordered eating patterns [(61-64)].

In examining sleep behaviors, college students have reportedly slept less than the recommended amount of 8-10 hours [18, 61, 65], leading to detrimental effects on academic performance and other performance. College students' nutritional behaviors are of interest due to their unique circumstances such as: dining hall food choice, cost, convenience, lack of cooking skills or utensils and location. One study examined 101 men and 158 women, 19-24 years old, enrolled at a mid-western university. It observed sex differences in fast-food consumption, nutrition self-assessments, and beliefs [63]. Males ate at fast food restaurants more often than females ($P < 0.01$), where 74% of males and 60% of females indicated eating out 1 to 3 times a week. When asked if nutrition content of food was important, there was a significant difference ($P<0.001$) where 51% of females and 24% of males strongly agreed. Dietary behaviors among female college students is important, with high prevalence of these individuals developing eating disorders in order to maintain low body weight [64, 66, 67]. One study examined the prevalence of eating disorders and disordered eating among 204 female collegiate athletes from 17 different sports in 3 universities [66]. Twenty-five percent of the athletes experienced disordered eating and 2% had an actual eating disorder (3 classified as having subthreshold bulimia and 1 as having nonbinging bulimia).

Proper nutrition has been shown to enhance exercise performance where adequate energy consumption is needed to maintain appropriate weight and body composition, but also fuel performance [6]. Although this is evident, many investigators have demonstrated low energy intake of athletes; carbohydrate intake less than 60% and high fat intake greater than 30% of total energy [68-70]. Cole et al. examined the dietary practices of 28 Division I football athletes and found energy intake to be significantly lower ($P < 0.05$) than the estimated 4,000 to

5,300 kcal amount recommended [71]. A similar study examined the same population and found that athletes were eating 3.6 times per day, eating out 4.8 times per week and consuming a minimal amount of fluid throughout a workout [72]. This evidence supports the importance of investigating the athletes' nutritional behaviors and how sleep may be a factor impacting nutritional choices.

Little research has examined the impact of sleep and its role on nutritional behaviors [73-78], whereby most have showed inconsistent results. Schmid et al. examined sleep loss (4 hours of sleep for two consecutive days)on physical activity and food in 15 healthy men, ages 20-40 [76]. Short-term sleep loss did not significantly alter food intake or feeling of hunger and appetite. The investigators argued that their results with unchanged serum leptin and plasma ghrelin are attributed to the amount of sleep duration between conditions and that other investigators showed elevated plasma ghrelin concentrations after sleep restriction because of study design differences. The study by Schmid et al. may have had too small differences in sleep duration between conditions to elicit detectable effects on concentrations of plasma ghrelin and serum leptin. In contrast, Nishiura et al. investigated dietary patterns and short sleep duration on healthy Japanese male workers, ages 40-59 [78]. Participants who slept less than six hours compared to those who slept seven to eight hours were more likely to skip breakfast ($P= 0.01$), eat out ($P< 0.001$), and had a higher preference for fatty foods ($P< 0.01$). Similarly, participants, ages 18-71, who were late sleepers (midpoint of ≥5:30 am) consumed more calories after 8:00 pm ($P< 0.01$), had higher fast-food ($P< 0.05$), full-calorie ($P< 0.001$) and lower fruit and vegetable consumption ($P< 0.001$) than normal sleepers (midpoint of <5:30 am) [77].

Recently, investigators have found an increase in fat intake when sleep duration was less than eight hours [73, 74]. Weiss et al. reported adolescents, ages 16 to 19, who slept less than eight hours on weekdays consumed higher proportions of calories from fats (35.9 ± 6.7%) and lower proportions of calories from carbohydrates (49.6 ± 8.2%) compared to those who slept eight or more hours (33.2 ± 6.9% $P = 0.004$; 53.3 ± 8.3% $P = 0.001$, respectively). Another study investigated dietary nutrients related to objective and subjective sleep and napping in 459 post-menopausal women for one week sleep duration [74]. Total sleep time with actigraph measurements was negatively associated with fat intake ($P = 0.0004$), however a large number of comparisons would result in stricter Type-1 error control. These researchers suggest that amount of sleep may affect energy consumption and overall dietary choices, but the influence of sleep deprivation on energy intake remains unclear, especially for athletes.

If sleep deprivation causes individuals to make poor nutritional choices and may lead to obesity, then the impact of sleep extension on weight, caloric intake, energy expenditure, the endocrine system and body composition is also of interest. One such study is currently investigating the topic, by increasing sleep (30-60 minutes per night) in obese individuals [79]. Still, little is known about the outcome of sleep extension on nutrition in athletes.

See Table 2 for review of studies.

Table 2: Sleep and Nutrition Research Articles

Title and Author(s)	Participants (n)	Objective(s)	Measures Used	Conclusions
Sleep Extension				
Treatment of Obesity with extension of sleep duration: a randomized, prospective, controlled trial. Cizza et al. (2010)	Study participants are 18-50 year old obese, sleep deprived (avg. sleep less than 6 1/2 hours) men and pre-menopausal women.	To assess the feasibility of increasing sleep duration to a healthy length (approx. 7 1/2 hours) and to determine the effect of sleep extension on body weight. Secondary objective: to examine the long-term effects of sleep extension on endocrine (leptin and ghrelin) and immune (cytokine) parameters; the prevalence of metabolic syndrome, body composition, PVT, mood and quality of life.	Activity monitors (Actiwatch and Actical) for sleep, energy expenditure, and caloric intake and food recall questionnaires. DXA, computerized tomography, and indirect calorimetry, ESS, glucose intolerance tests, psychological assessments, blood samples	Study is currently in progress
Both				
Brief Communication: Sleep Curtailment in Healthy Young Men Is Associated with Decreased Leptin Levels, Elevated Ghrelin Levels, and Increased Hunger and Appetite. Spiegel et al. (2004)	12 healthy men (mean age ± SD, 22 ± 2 years)	To determine whether partial sleep curtailment (2 days of sleep extension and 2 days of sleep restriction), an increasingly prevalent behavior, alters appetite regulation.	Daytime profiles of plasma leptin and ghrelin levels and subjective ratings of hunger and appetite.	Sleep restriction was associated with average reductions in the leptin and increases in ghrelin. Sleep restriction also increased hunger and appetite, especially for calorie-dense foods with high CHO content

Relationships among dietary nutrients and subjective sleep, objective sleep, and napping in women. Grandner et al. (2010)	459 post-menopausal women (mean age 68 ± 7.76, range = 50-81)	To describe which dietary nutrient variables are related to subjective and objective habitual sleep and subjective and objective napping.	Objective sleep using actigraphy (Actillume) and subjective sleep with sleep diaries. Food frequency questionnaires for dietary nutrients.	Actigraphic nocturnal sleep duration was negatively associated with total fat, MUFA, trans fat, saturated fat, PUFA, calories, gamma-tocopherol, cholesterol, and alpha-tocopherol-eq. Subjective napping was significantly related to fat and meat intake.
The Association of Sleep Duration with Adolescents' Fat and Carbohydrate Consumption. Weiss et al. (2010)	240 adolescents (mean age 17.7± 0.4 years)	To investigate the relation between sleep duration and energy consumption in an adolescent cohort.	Daily 24-hour food recall and wrist actigraphy (Octagonal Sleep Watch).	Subjects sleeping less than 8 hours consumed a higher proportion of calories from fats and lower proportions from carbohydrates.
Role of Sleep Timing in Caloric Intake and BMI Baron et al. (2011)	52 (25 females) volunteers (mean age 31±12, range 18-71)	To evaluate the role of sleep timing in dietary patterns and BMI.	Sleep logs, food logs, actigraphy (AW-L Actiwatch)	Late sleepers (midpoint of sleep ≥ 5:30AM) consumed more calories at dinner and after 8pm, had higher fast food, full-calories soda and lower fruit and vegetable consumption.
Sleep Restriction				
Effects of 72 Hours of Sleep Deprivation on Urinary Cortisol and Indices of Metabolism. Kant et al. (1984)	Six male volunteers (18-21 years old)	Cortisol, urea, glucose, electrolytes, and other compounds were measured in 5 consecutive 24 h urine collections during a 72 hour sleep deprivation study.	Performance tasks, laboratory monitoring of sleep, urine samples	During sleep deprivation, cortisol decreased slightly, urea rose, glucose decreased and electrolytes decreased markedly.
Effects of Sleep and Sleep Deprivation on	31 male volunteers	To evaluate the effects of	Blood samples, sleep measured by	IL-6 may serve to decrease nocturnal IL-

Interleukin-6, Growth Hormone, *Cortisol, and Melatonin Levels in Humans.* Redwine et al. (2000)	(mean = 35.8 ± 10.12, range =25-65)	nocturnal sleep, partial night sleep deprivation, and sleep stages on circulating concentrations of interleukin-6 (IL-6) in relation to the secretory profiles of GH, cortisol, and melatonin.	ECG polysomnography	6, having implications of hurting the integrity of immune system functioning
Short Sleep Duration is Associated with Reduced Leptin, Elevated Ghrelin, and *Increased Body Mass Index.* Taheri et al. (2004)	1024 volunteers from the Wisconsin Sleep Cohort Study	To investigate the association among sleep duration (acute and habitual), metabolic hormones, and BMI in the population-based Wisconsin Sleep Cohort Study.	Polysomnography, questionnaire on usual sleep, hormone and metabolite assays, sleep diaries	In subjects sleeping less than 8 hours, they showed ↑ BMI proportional to ↓ sleep. Short sleep associated with low leptin and high ghrelin, independent of BMI.
Short Sleep Duration is Associated with Reduced Leptin Levels and Increased *Adiposity: Results from the Quebec Family Study.* Chaput et al. (2007)	323 and 417 women (ages 21-64).	To explore cross-sectional associations between short sleep duration and variations in body fat indices and leptin levels during adulthood in a sample of men and women involved in the Quebec Family Study.	Anthropometric measures, plasma lipid-lipoprotein profile, plasma leptin concentrations, and total sleep duration	Lower adiposity for those sleeping 7-8 hours compared to 5-6 hours. OR for obesity was 1.38 for 9-10 hours and 1.69 for those sleeping 5-6 hours. The expected measured leptin levels were significantly lower than predicted values for short duration sleepers (5-6 hours)

Conclusion

The purpose of this comprehensive literature review was to address the present research about the effects of sleep deprivation and extension on physical and psychological performance and nutritional behaviors in collegiate athletes. In reviewing the research, there are few studies that have investigated the effects of sleep extension on psychological and physical performance as well as nutritional behaviors in collegiate athletes. Additionally, these studies show inconsistent data. Therefore further research is needed to better understand the implications of extending sleep in athletes.

CHAPTER III

STUDY TIMELINE & DESIGN

Timeline of SleEP iN Study

The proposal for the research project took place in November of 2012, which consisted of committee members from nutrition, exercise physiology, and the psychology department. A meeting was held with WVU's women's track and field coach early January in order to get consent to recruit his athletes. The SleEP iN intervention study took place in March 2013 and January 2014. The recruitment process began in early March 2013 (Trial 1) of the study and lasted for one week due to spring break interference at the end of the month. A second recruitment wave (Trial 2) because of a small sample size from wave one. Trail 2 started in December 2013 and lasted a month. Baseline assessments took place mid-March of 2013 (Trial 1) and early January of 2014 (Trail 2) once participants responded to the screening survey and an email to participate in the study. The intervention of extending sleep one hour more of baseline sleep was mandated over a one week period.

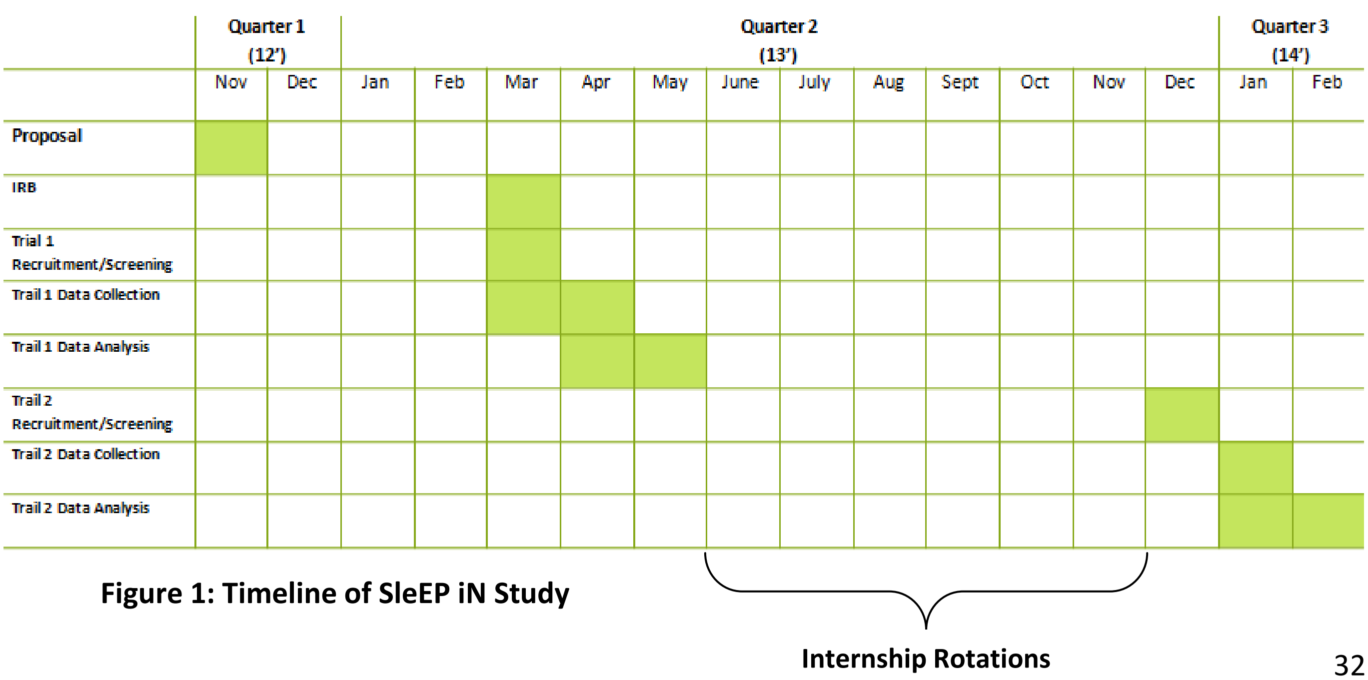

Figure 1: Timeline of SleEP iN Study

SleEP iN Study Design

Recruitment and screening of individuals was done after IRB approval and lasted for one month. Individuals were contacted if willing to participate in the study and a consent time was scheduled at the Human Performance Lab. Habitual sleep was assessed for one week then baseline data were measured (T0). Baseline data were followed by a one week sleep extension period, then post measurements were taken (T1).

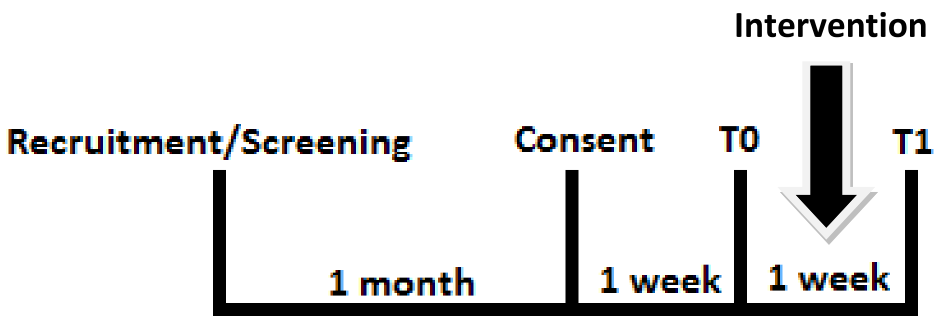

Figure 2: SleEP iN Study Design

CHAPTER IV

METHODOLOGY

IRB and Training of Research Team

The Institutional Review Board (IRB) at WVU approved the screening survey and the SleEP iN Study in March 2013 (Appendix A). Undergraduate and graduate nutrition and exercise physiology students were recruited to train for the data collection of baseline and post-assessment for the SleEP iN Study research team. All research members were required to complete the Collaborative Institutional Training Initiative (CITI) training; attend all scheduled meetings and trainings; participate in inter-rater reliability (IRR) training to maintain consistent data measures, collection and recording at baseline and post-assessment.

Recruitment

The aim of the study was to recruit 20 WVU female track and field athletes, with emails sent targeting that group. A screening survey was sent to students' mix accounts, which were provided by the assistant WVU track and field coach. Emails were also sent to the undergraduate exercise physiology students' mix accounts provided by the secretary of the department. The reason for the inclusion of the exercise physiology department was to reach additional athletes through the department. Class announcements were also made to the classes in the departments. The inclusion criteria for the study was: 18-24 years old, female, defined as a WVU track athlete, full-time student, free from life threatening illness, pregnancy, or diet and/or activity-related medical restrictions and limited drug and alcohol intake. The screening survey was distributed to mix accounts of the students and athletes, consisting of sleep, physical activity, eating attitudes, and menstrual history questions. The survey asked the participant whether they agreed to be contacted by the study team and to provide contact information so they could be scheduled to be consented at the Human Performance Lab (HPL).

Informed Consent Process/Health History Questionnaire

All athletes were verbally consented and signed the informed consent that was approved by WVU's IRB prior to scheduling their physical assessment. By protocol of the HPL, a review of their health history questionnaire was performed on all participants by a staff member of the HPL. After consenting was completed and their health history collected and approved, the athlete's anthropometrics including: height, weight (Bioelectrical Impedance Analysis), BMI calculated, and waist circumference were taken. An actigraph was initialized and put on the athlete's wrist and a sleep log was given in order to assess their baseline sleep. Actigraphy is an accepted method used to quantify sleep-wake activity based on subject movement[(80)] in healthy young adults[(81)]. Actigraphy devices were worn around the wrist of the subject's dominant hand 24h/day except during times were it may be immersed in water (showers or swim) and during training or competition if subject requested so (ActiGraph GT3X, Actilife 6.0 Software Pensacola, FL). Athletes were then prompted to schedule their physical assessment date.

Data Collection/Assessments

Participants of the SleEP iN Study completed a total of two assessments (baseline and one week post-assessment). All assessments were performed at the HPL at WVU's Health Sciences Campus. There were a total of four stations to complete with different physical, psychological and nutritional measures collected (Table 1).

During assessments, anthropometrics and questionnaires were completed. Body composition, by BodPod, was only completed during the baseline assessments. Prior to assessments, the participant was instructed to remove the actigraph, where it was re-charged and re-calibrated in order to assess intervention sleep. Each anthropometric measurement was taken following standard procedures by trained research team members using calibrated equipment and recorded immediately. The Wingate Anaerobic Test (WAnT) and the BodPod protocol were completed by a staff member of the HPL to assure standard procedures were met. The WAnT is the most widely used test to evaluate anaerobic power[82, 83]. Anaerobic power is an important measure for competitive athletic events which largely depend on anaerobic power[83, 84]. POMS (Appendix E) was completed by the participant by hand and the PVT (Appendix E), PSS (Appendix E), Automated Self Administered (ASA) 24-diet recall and the CDC Quality of Life (Appendix E) were completed on the computer and overseen by members of the research team. After completion of all assessments, the participant was given their actigraph and sleep diary and prompted to schedule their post assessment date at least one week later, with no more than a couple days past the week deadline. Subjects were instructed to get one more hour of sleep by such methods: putting themselves to sleep earlier than usual, forming healthy sleeping habits (dark room, no distractions, etc), or waking up later than usual. Subjects received a text message of how many hours of sleep they should be aiming for from their baseline sleep data. The post-assessments consisted of the same procedures (excluding the BodPod) and the only data analyzed were from subjects who completed both pre- and post-tests. The primary investigator was responsible for imputing the data into the Excel database and a research team member verified all data recorded using a two-pass data entry method.

Table 3: Description of the Tools/Measurements

Measure/Unit(s)	Equipment/Manufacturer	Protocol
Stage 1: Anthropometrics		
Height	Model 235 Heightronic Digital Stadiometer Issaquah, WA	1. Have participants remove shoes and socks. Hair ornaments to be removed if necessary. 2. Instruct participants to look straight ahead and maintain four points of contact (heels, buttocks, shoulder blades, back of head) with the wall 3. Have participant take a deep breath and stand tall 4. Move the stadiometer top slide and fix it in place, make sure it is firmly against participant's head 5. Record height to the nearest 0.01 cm 6. Repeat until measures are within 0.2 cm 7. Record average to two decimal places
Weight (kg) BMI (kg/m^2) Body Fat Percentage (%)	Model TBF- 300A Tanita Electronic Scale Arlington Heights, IL	1. Zero the scale 2. Have participants remove excess clothing and empty bladder 3. Ask participant to center both feet on the scale while standing still 4. Record weight to the nearest 0.01 kg 5. Repeat until within 0.2 kg 6. Record average to two decimal points 7. Record BMI calculated during each weight assessment
Waist Circumference	Gulick tape	1. Have participant raise their shirt and lower their shorts directly below the top of the iliac crests (hip bones) 2. Palpate for the top of the participant's iliac crests (hip bones) and place gulick tape measure accordingly 3. Have participants take a deep breath and exhale; measure at the end of the expiration 4. Tighten the tape gently 5. Repeat until two measures are within 0.5 cm 6. Record average to two decimal places

Stage 2: Physical Assessment/Anthropometrics/Questionnaires		
Blood pressure	Blood pressure cuffs ADC (American diagnostic corporation) model CE0197 cuff size 11 and 12 Hauppauge, NY 11788	1. Locate pulse by lightly pressing index and middle fingers slightly to the inside center of the bend of your elbow (brachial artery) 2.Secure the cuff, making sure that the stethoscope head is over the artery. The lower edge of the cuff should be about 1 inch above the bend of your elbow. Place the stethoscope in your ears. 3. Inflate and deflate cuff using Close the airflow valve on the bulb by turning the screw clockwise. Inflate the cuff by squeezing the bulb with your right hand. Watch the gauge. Keep inflating the cuff until the gauge reads about 30 points (mm Hg) above expected systolic pressure. Keeping your eyes on the gauge, slowly release the pressure in the cuff by opening the airflow valve counterclockwise. Listen carefully for the first pulse beat. As soon as you hear it, note the reading on the gauge. Continue to slowly deflate the cuff. Listen carefully until the sound disappears. As soon as you can no longer hear your pulse, note the reading on the gauge. Allow the cuff to completely deflate.
Wingate Test	Monark bike peak bike ergomedic 894E Vansbro, Sweden Monark anabolic test software.	To be done by a trained exercise physiologist
Bod Pod (body fat %)	Bod Pod Life Measurement Inc Concord, CA model bod pod 2000a software version 2.14	To be done by a trained professional

*Reaction Test *Same hardware and software used	Tiredness Test Welcome Collection 183 Euston Road, London	1. Go to http://www.wellcomecollection.org/tiredness/index.html 2. Instruct participant to click on "Launch Tiredness Test" 3. Participant will react as quickly as possible to numbers that pop up on screen by clicking right side of mouse. 3. Record the duration, signals missed, false starts and average reaction time.
Diet Recall	Automated Self-Administered 24-hour Dietary Recall (ASA24) Westat Rockville, MD	1. Go to https://asa24.westat.com/ 2. Give participant username and password combination that is already assigned on the "ASA-24 Username/Password" worksheet 3. Have participant fill out the entire recall, making sure participant also fills out supplements.
Moods States	Profile of Moods Questionnaire Multi-Health Systems, Inc North Tonawanda, NY	1. Give participants a Profile of Moods questionnaire 2. Have participant put their ID number on the questionnaire. ID numbers can be found on the "Subject's name and ID numbers" worksheet 3. Have participant fill out the entire questionnaire, staying around to answer any questions on a specific mood. Definitions of the words can be found on "POMS Definitions Worksheet"

Quality of Life	Health Related Quality of Life (HRQOL) Centers for Disease Control and Prevention Atlanta, GA	1. Go to http://wvu.qualtrics.com/SE/?SID=SV_4OsvT2wqrG87Rel 2. Have participant fill out the survey using their ID numbers. This can be found on the "Subject's name and ID numbers" worksheet
Self-Perception on Stress	Perceived Stress Scale Mind Garden, Inc Menlo Park, CA	1. Go to http://wvu.qualtrics.com/SE/?SID=SV_4OsvT2wqrG87Rel 2. Have participant fill out the survey using their ID numbers. This can be found on the "Subject's name and ID numbers" worksheet
Stage 3: Accelerometer Destitution		
Actigraph	ActiGraph GT3X Actilife 6.0 Software Pensacola, FL	1. Record the last 4 digits of the accelerometer number below the barcode on the participant's data sheet 2. Initialize accelerometer by entering the participant's height (inches), weight (pounds), birth date and ethnicity 3. Provide a throughout explanation regarding how/when to wear the device 4. Device should not be submerged in water (i.e. shower, swimming) 5. Instruct participant to wear accelerometer for 7 days

Data Analysis/Handling

The research conducted was a qualitative and quantitative experiment using mixed methodology. The dependent variables were the WAnT measurements, POMS, PVT scores, and amount of calories with percent of fat and carbohydrate distribution. The independent variable was the sleep extension of one hour more from baseline.

Statistical analysis was performed using SAS 9.3 statistical software for baseline and one week post-assessment data. Descriptive data were conducted on continuous variables (age, height, weight, body fat percent, and waist circumference) with percent and frequencies analyzed for categorical variables (position on team, menstrual status, race, and year in school). The matched paired t-test was run to determine significance between the assessments and scores from pre and post data, resulting in understanding if sleep extension had an effect on physical performance and nutritional behaviors of the female athletes. The significance level was set at an alpha of $P \leq 0.05$. Adjustment of p values by Bonferroni correction was used to reduce Type I error. T-test assumptions of equal variance were tested and 95% Confidence intervals of the means were reported and also assessed for significance. Effect sizes of Cohen's d was calculated by g*power and a power analysis was conducted using SAS 9.3.

Power Analysis

A power analysis was run for each research question on our outcome variables (power output, fatigue index, total calories, percent fat intake) to determine statistical significance for Trial 1 of the study. Statistical significance was not achieved (0.58-0.65) on any research question , therefore an ad hoc power analysis was conducted to examine the power needed by obtaining a larger sample size. After running the power analysis to see the appropriate sample size to lower our Type II error, five additional athletes were needed to achieve a power between 0.77 and 0.83, leading to Trail 2.

CHAPTER V

RESULTS

Descriptive Statistics

Subject Characteristics

The descriptive statistics of the athletes are shown in Tables 4 and 6. After recruiting and collecting data from 25 female track and field athletes, only 21 females were included in the results. One of the four participants dropped out of the study due to injury, two subjects had no baseline sleep data due to error of initialization of actigraphs, and one subject did not wear the actigraph at night.

Most of the athletes were Caucasian (90.5%), followed by 4.8% African American and 4.8% other (Table 4). About 71.0% of the athletes were long distance athletes, 14.3% ran short distance and the remaining 14.3% participated in a field event (shot-put, discus, etc). Of the 21 female athletes, most were freshman and senior (33.3% equally), followed by 19.1% Sophomore, 9.5% Junior and one student (4.8%) was a fifth year. In comparing menstrual status, 15 (71.4%) of the athletes were classified as being eumenorrheic (periods every 28-30 days) with a small percentage being oligomenorrheic (23.8%; periods longer than >35 days) or amenorrheic (2.8%; absence of periods) (Table 4). Of those who were reported normal menstrual cycles, 47.6% were long distance runners followed by sprinters (14.3%) and field participants (9.5%) (Table 5). All of the participants who were considered oligomenorrheic were long distance runners (Table 5).

The average age of the participants was 20.2 ± 1.8 years old (Table 6). Average weight of the athletes was 61.6 ± 17.3kg, with an average BMI of participants being 22.8 ± 5.1, indicating normal BMI. In examining body fat percentage of the athletes by the BodPod, average body fat percentage was 19.4 ± 8.1%, with a minimum percentage of 8.7% and a maximum percentage of 40.4% (Table 6). Depending on the position in track, a healthy range of body fat percentage for female athletes may vary from 12% (i.e. sprinters and distance runners) to 22% (i.e. throwing, shot-put, and discus)[85]. However, no accepted percentage body fat standards exist for athletes.

Inferential Statistics

Total Sleep Time

According to the Pittsburgh Quality of Sleep Index conducted during screening of participants, they reported receiving 6.5-7.5 hours of sleep at night. Subject sleep logs showed a trend towards increased total time in bed by 17 minutes (0.08) (Table 8). After running a matched paired t-test, participants increased total daily sleep time from baseline to sleep extension according to objective actigraphy (Table 8, Figure 3). Sleep time significantly increased during the sleep extension period compared to baseline by 22 minutes (429.3 ± 38.4 vs. 451.3 ± 44.8, p = 0.03). The 95% confidence interval of the mean difference (41.35 to 2.66) indicated statistical significance (i.e., the confidence interval did not include 0). Cohen's d effect size suggested this difference was medium (d=0.53). Sleep efficiency increased following sleep extension (91.7% vs. 92.1%), however this was not significant (p = 0.39).

Physical Performance

No significant differences were seen in any indices assessing physical performance using the WAnT (Table 9). Athletes showed improvement in maximal power output on the WAnT test from baseline to end of the sleep extension period (692.9 ± 213.16 watts vs. 713.5 ± 214.59

watts; p = 0.07; d = 0.10). Fatigue index slightly declined when athletes slept more than habitual nightly sleep as seen by an increase in percentage from baseline (37.3% vs. 38.3%; p = 0.28).

Mental Performance

During sleep extension compared to baseline, subjects showed no change in PVT performance (Table 10). Total Mood Disturbance Score by POMS significantly decreased following sleep extension (p = 0.01). The 95% confidence interval of the mean difference (1.87 to 14.22) also indicated statistical significance and the effect size suggested this difference was small (d=0.32). All POMS subscale scores demonstrated improvement with marked changes seen in POMS anger, tension, and depression (Table11), however none were significant after Bonferonni adjustment.

Nutrient Intake

Total energy intake and percent macronutrient distribution during baseline and sleep extension are shown in Table 10 and Figure 5. Longer sleep duration was associated with an increase in caloric intake, with an increase in percent fat (29.8 vs. 31.7%) and a decrease in percent carbohydrate (54.8 vs. 53.8%) (Table 12). No differences were seen in percent caloric intake from protein following sleep extension (Figure 5). In addition, athletes decreased water intake after the sleep intervention (Table 13).

Other Outcomes

Number of unhealthy days (physical and mental) for baseline and sleep extension was assessed with the CDC's Quality of Life survey (Figure 6). A decrease in unhealthy days was shown from baseline to the sleep extension period. A similar trend was shown on the Cohen's

Stress Scale with perceived stress scores (Figure 7), however there was no significant differences seen in either.

Table 4: Athlete Characteristics		
	Frequency (n=21)	**Percent (%)**
Race		
Caucasian	19	90.5
African American	1	4.8
Other	1	4.8
Year in School		
Freshman	7	33.3
Sophomore	4	19.1
Junior	2	9.5
Senior	7	33.3
Other	1	4.8
Position in Track		
Sprinter	3	14.3
Long Distance	15	71.4
Field	3	14.3
Menstrual Status		
Eumenorrheic	15	71.4
Oligomenorrheic	5	23.8
Amenorrheic	1	4.8

Table 5: Menstrual Cycle by Position in Track		
	Frequency (n=21)	**Percent (%)**
Sprinter		
Eumenorrheic	3	14.3
Oligomenorrheic	0	-
Amenorrheic	0	-
Long Distance		
Eumenorrheic	10	47.6
Oligomenorrheic	5	23.8
Amenorrheic	0	-
Field		
Eumenorrheic	2	9.5
Oligomenorrheic	0	-
Amenorrheic	1	4.8

Table 6: Descriptive and Anthropometrics of Athletes		
(n=21)	**Mean (Standard Deviation)**	**Range**
Age (years)	20.2 (1.8)	18-23
Height (cm)	162.4 (7.1)	147.8-179.0
Weight (kg)	61.6 (17.3)	45.8-117.7
Waist (cm)	77.7 (11.3)	67.5-110.0
BMI (kg/m^2)	22.8 (5.1)	18.2-39.1
Body Fat (%)	19.4 (8.1)	8.7-40.4

Table 7: Subject Profile (Track Position, Medications, Menstrual Status, Body Composition)					
	Position in Track	**Medications**	**Menstrual Status**	**Fat Mass (%)**	**Lean Mass (%)**
Subject 1	Sprinter	Yaz, Multivitamin	Eumenorrheic	27.6	72.4
Subject 2	Long Distance	Iron, Vitamin C	Oligomenorrheic	19.6	80.4
Subject 3	Long Distance	Iron, Calcium, Vitamin D	Eumenorrheic	17.1	82.9
Subject 4	Field	Folic acid & B Vitamins, Depo provera, Advil PRN	Amenorrheic	25.8	74.2
Subject 5	Long Distance	Pulmicort, Multivitamin, Vitamin C	Eumenorrheic	8.7	91.3
Subject 6	Long Distance	Multivitamin	Eumenorrheic	11.5	88.5
Subject 7	Sprinter	Acne Medication, Multivitamin	Eumenorrheic	12.2	87.8
Subject 8	Field	Fish Oil, Calcium	Eumenorrheic	40.4	59.6
Subject 9	Long Distance	Multivitamin, Vitamin D3	Eumenorrheic	11.8	88.2
Subject 10	Field	Muscle Relaxer PRN, Ortho Tri-cyclen, Multivitamin	Eumenorrheic	32.7	67.3
Subject 11	Sprinter	Lamictal	Eumenorrheic	12.1	87.9
Subject 12	Long Distance	Multivitamin, Vitamin D	Oligomenorrheic	21	79
Subject 13	Long Distance	Multivitamin, Claritin PRN, Iron	Eumenorrheic	18.2	81.8
Subject 14	Long Distance	None	Eumenorrheic	14	86
Subject 15	Long Distance	Singulair, Prozac, Loestrin, Symbicort, Omeprazole, Allegra, Mucinex	Eumenorrheic	29.9	70.1
Subject 16	Long Distance	Calcium, Multivitamin, Iron, B complex	Oligomenorrheic	20.1	79.9
Subject 17	Long Distance	Nasal Spray	Eumenorrheic	19.7	80.3
Subject 18	Long Distance	Vimpat, Keppra, Iron, Multivitamin, Omega 3	Oligomenorrheic	11.9	88.1
Subject 19	Long Distance	Multivitamin	Eumenorrheic	13.2	86.8
Subject 20	Long Distance	Flonase, Iron, Multivitamin, Vitamin C, B complex	Oligomenorrheic	22.2	77.8
Subject 21	Long Distance	None	Eumenorrheic	16.9	83.1

Table 8: Total Sleep Time per Night During Baseline and Sleep Extension				
	Baseline	**Sleep Extension**	**95% CI Mean (95% CI SD)**	**p**
Total Bed Time (min) by Subject Sleep Logs	465.6 ± 48.1	482.6 ± 50.7	0.60 to -0.04 (0.54 to 1.02)	0.08
Total Sleep Time (min)	429.3 ± 38.4	451.3 ± 44.8	41.35 to 2.66 (32.51 to 61.37)	0.03*
Total Sleep Efficiency (%)	91.7 ± 3.2	92.1 ± 2.5	1.48 to -0.61 (1.76 to 3.31)	0.39

***Significant after Bonferroni adjustment**
Data presented as mean ± standard deviation

Table 9: Physical Performance During Baseline and Sleep Extension				
	Baseline	**Sleep Extension**	**95% CI Mean (95% CI SD)**	**p**
Power Output (Watts)	692.9 ± 213.2	713.5 ± 214.6	43.27 to -2.10 (38.13 to 71.97)	0.07
Fatigue Index (%)	37.3 ± 10.6	38.3 ± 8.4	4.28 to -1.29 (4.69 to 8.84)	0.28

Data presented as mean ± standard deviation

Table 10: Mental Performance During Baseline and Sleep Extension				
	Baseline	**Sleep Extension**	**95% CI Mean (95% CI SD)**	**p**
Total Mood Disturbance Score	20.2 ± 24.5	12.2 ± 25.7	1.87 to 14.23 (32.51 to 61.37)	0.01*
Mean reaction time (ms)	302. 7 ± 20.2	302. 8 ± 23.5	10.08 to -9.79 (16.70 to 31.52)	0.98

***Significant after Bonferroni adjustment**
Data presented as mean ± standard deviation

Table 11: POMS Distribution Scores				
	Baseline	**Sleep Extension**	**95% CI Mean (95% CI SD)**	**p**
Vigor	18.8 ± 4.4	19.4 ± 4.9	2.35 to -1.11 (2.91 to 5.49)	0.46
Fatigue	8.1 ± 6.1	6.0 ± 4.4	0.54 to 3.55 (2.53 to 4.78)	0.01
Tension	10.3 ± 5.6	8.3 ± 5.8	0.05 to 3.86 (3.21 to 6.05)	0.05
Depression	7.1 ± 6.9	5.5 ± 7.3	0.25 to -3.39 (3.06 to 5.77)	0.09
Anger	6.5 ± 5.5	5.7 ± 5.7	1.28 to -2.90 (3.52 to 6.64)	0.43
Confusion	7.1 ± 4.6	6.1 ± 4.3	0.67 to -2.77 (2.89 to 5.45)	0.22

Data presented as mean ± standard deviation

Table 12: Total Energy and Percent Macronutrient Distribution During Baseline and Sleep Extension				
	Baseline	**Sleep Extension**	**95% CI Mean (95% CI SD)**	**p**
Total energy (kcal)	2107.0 ± 681.8	2126.3 ± 744.7	252.2 to -213.8 (391.6 to 739.2)	0.87
Percentage from Fat (%)	29.8 ± 9.0	31.7 ± 7.8	5.19 to -1.39 (5.53 to 10.44)	0.24
Percentage from Carbohydrate (%)	54.8 ± 8.6	53.8 ± 8.7	2.70 to -4.83 (6.33 to 11.94)	0.56

Data presented as mean ± standard deviation

Table 13: Water Intake (g) Baseline & Sleep Extension	
Pre	**2606**
Post	**2571**

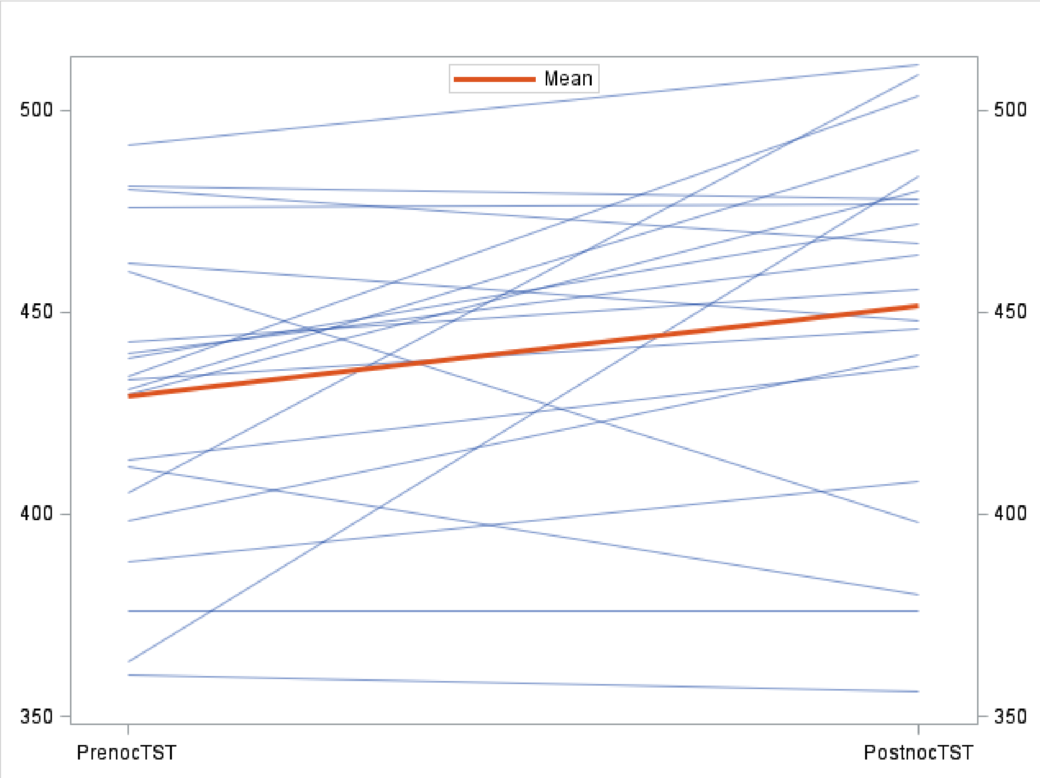

Figure 3: Subject Profiles for Pre and Post Total Time in Bed (minutes)

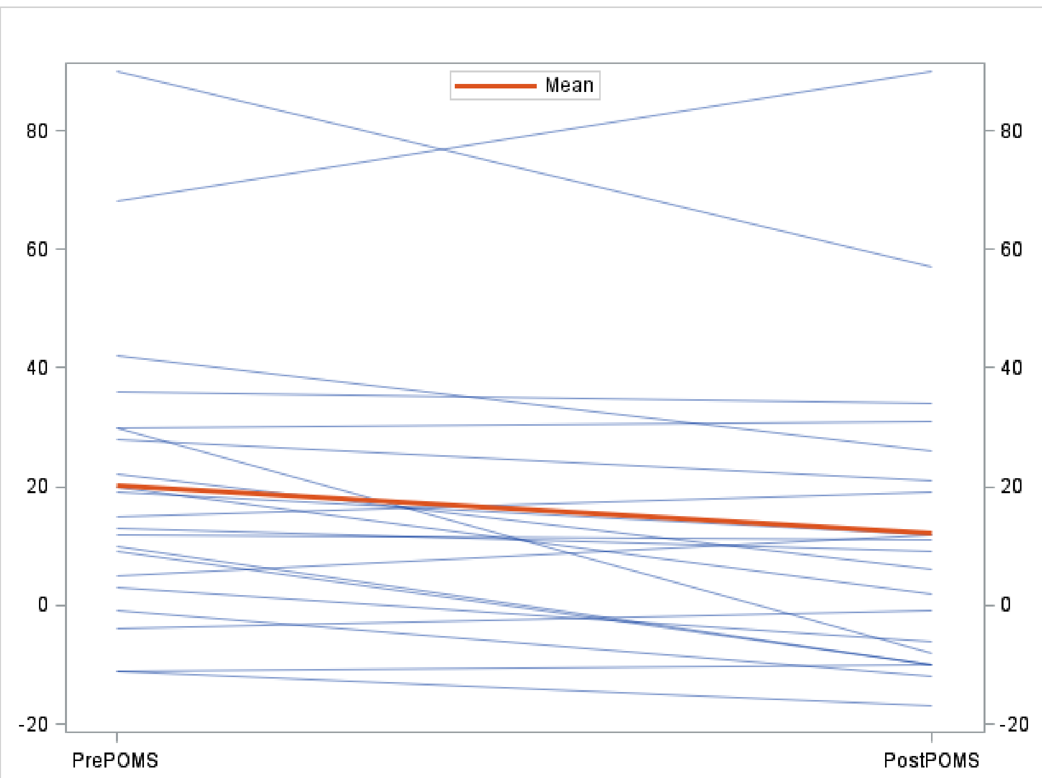

Figure 4: Subject Profiles for Pre and Post Total Mood Disturbance Scores

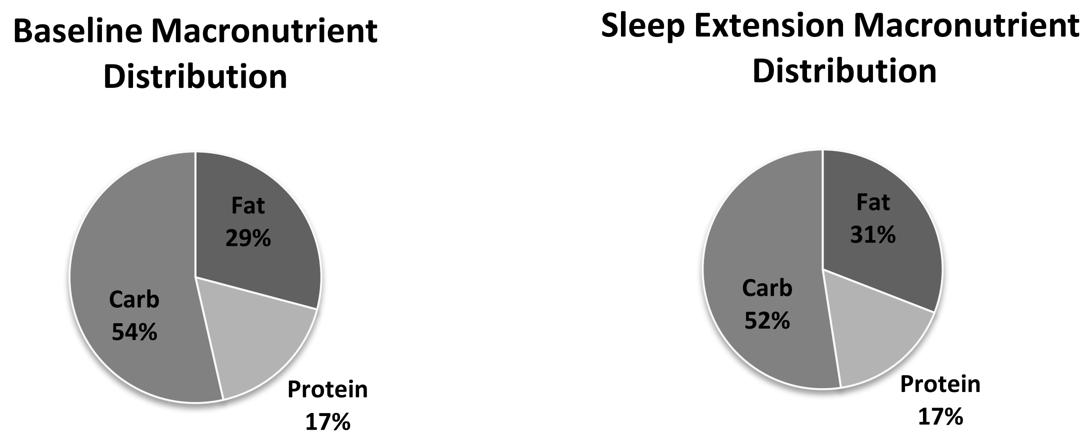

Figure 5: Macronutrient Distribution Baseline and Sleep Extension

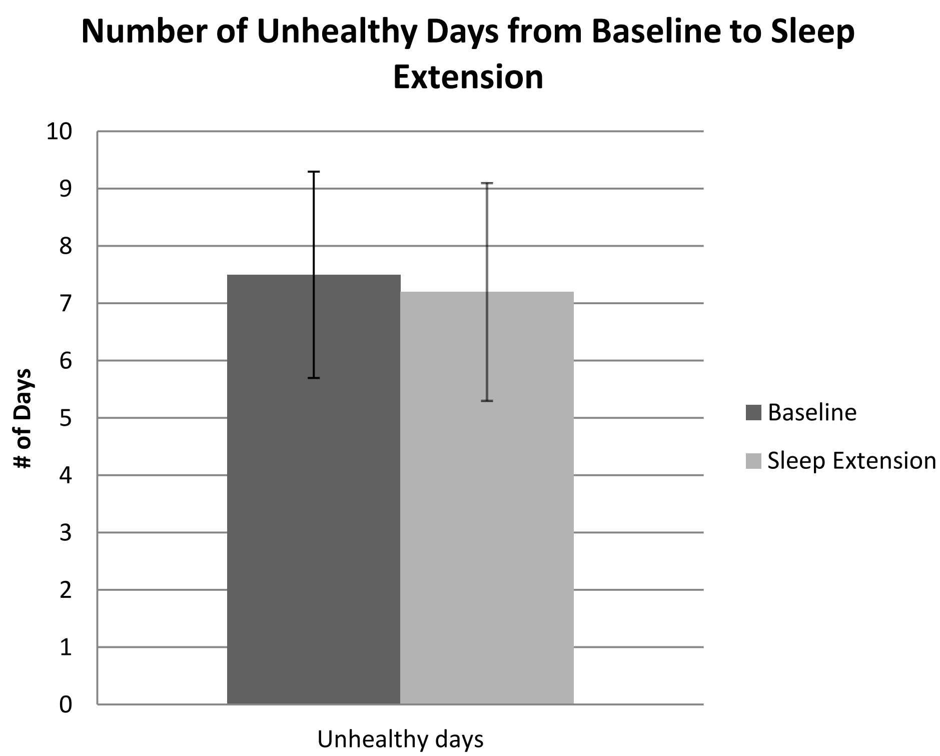

Figure 6: CDC's Quality of Life Baseline and Sleep Extension

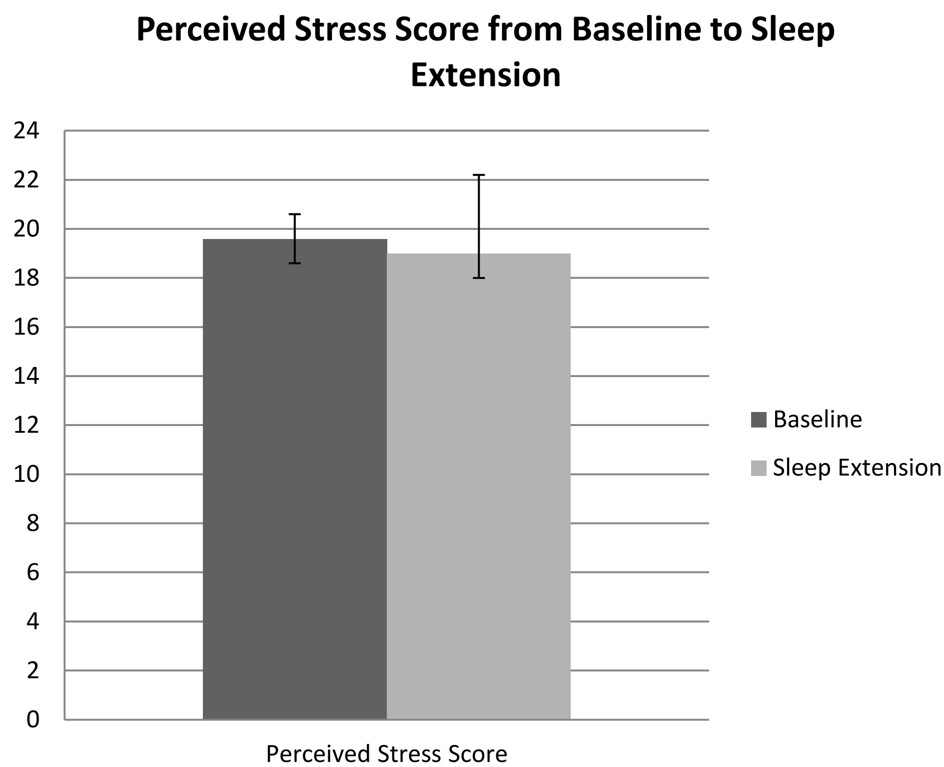

Figure 7: Cohen's Stress Baseline and Sleep Extension

CHAPTER VI

DISCUSSION

This study was conducted under the premise that collegiate athletes carry a sizeable sleep debt from chronic sleep deprivation, due to many time commitments and busy schedules from being both a student and an athlete. In addition, studies have shown that female college students exhibit more sleep disturbances than males, with reports of more difficulty falling asleep, more frequent nocturnal awakenings, and poorer overall sleep quality than male counterparts[86]. Total nightly baseline sleep in our study (7.16 h) is consistent with the findings by Leeder et. al. (2012), showing highly trained athletes in a range for healthy sleep[20]. Although our athletes were within the healthy range compared to young adults who are shown to be sleep deprived[87, 88], research has argued in favor of athletes receiving added sleep for its physiological and psychological restorative effects that occur with training and competition[32].

Nonetheless, our subjects were able to significantly increase total nightly sleep during sleep extension (7.52h), showing that sleep debt was present before extra sleep was given. Based on self reported sleep logs from baseline and sleep extension, subjects increased total time in bed by about 20 minutes, presumably spending all of that extra time sleeping since total sleep time by actigraphy increased by 22 minutes. This shows that subjects had small sleep pressure and could have slept longer periods due to unchanged sleep efficiency. Still, this is subjective data and no good sleep onset latency measurement was utilized. Furthermore, the sleep logs illustrates that subjects did not follow the sleep protocol, where many reported sleeping later than going to bed earlier, but still not getting an additional hour of sleep. However, it is still worth mentioning that no strict procedures were given to the athletes because we wanted them to sleep by implementing it into their schedules and not experience insomnia-like symptoms. Thus, the extra 22 minutes from baseline shows that the subjects were able to increase sleep in addition to fulfilling personal time, work and sport activities.

Participants of the WVU female varsity track and field team experienced no significant improvements or decrements in physical performance, but demonstrated significant improvements in psychological performance after sleep extension over one week. A vast majority of the literature on sleep deprivation and performance has been well documented in this population. These studies have shown that subjects who have disruptions in their normal sleep cycles by varying amounts of sleep deprivation have decreased reaction time on the PVT[41], less positive mood[42], decreased endurance[11], increased resting oxygen uptake[12], and lower sprint times[27]. In lieu of these findings, current research has looked to examine the consequence of increasing a subject's sleep on measures of performance.

Kamdar et. al. (2004) reported significant increases in MSLT scores, improvements in reaction times and POMS ratings when 15 healthy college students (male and females) slept as much as possible[38]. While this current study showed no change in reaction time from baseline to sleep extension, subjects showed significant improvements in mood, where vigor increased and fatigue, depression and tension decreased with extra sleep. These results parallel those seen in 11 National Collegiate Athletic Association (NCAA) male basketball players, who lowered POMS fatigue scores and improved POMS vigor scores[36]. The indication of these mood scores may help eliminate the assumption that athletes bear a generous amount fatigue throughout their sport's season. This study also looked at quality of life measures and stress scores and showed improvements after 20 more minutes of extra sleep. Since most of the females of this study train year long, it may contribute to increased stress and fatigue where treatment by sleep extension may help add to athletic performance by benefiting overall well-being and mental approach.

To our knowledge only two studies have been published to examine the effects of extended sleep on physical performance measures; both looking exclusively at male participants. Pierce et. al. (1993) examined endurance exercise performance and showed greater running economy (VO_2) through the first two stages of a treadmill protocol after a 60-90 minute sleep bout, while the control group of the study yielded greater economy through the remaining stages[37]. The researchers proposed that the cognitive benefits of sleep produced less anxiety in the patients for the first two stages of the protocol, with exercise duration increasing physiological arousal and limiting performance. The same proposed hypothesis may explain the differential effect of power output found in our subjects. While no significant changes were seen from baseline, subjects were able to slightly increase maximum power (692.9 ± 213.2 watts vs. 713.5 ± 214.6) and demonstrated decrements in maintaining fatigue index (37.3 ± 10.6 watts/sec vs. 38.3 ± 8.4) as the test duration increased. Although a possible explanation could be a difference in levels of anxiety as a result of treatment, another explanation could be familiarity of the test. No pre-test was given to subjects before baseline measurements, however detailed and consistent instruction and encouragement from researchers was given for both baseline and post-assessment.

Even though our study showed no significant differences in physical performance with sleep extension, Mah et. al. (2011) found significant improvements in physical performance measures related to basketball[36] (faster sprint time and improved shooting accuracy) with a minimal goal of 10 hours in bed each night for five to seven weeks. This brings to question whether the sleep extension period of this study was sufficient duration (dosage) to reveal improvements in performance and eliminate all sleep debt. Without utilizing MSLT by polysomnography, it is difficult to determine if sleep debt was eliminated. Therefore, it is likely that a longer period of sleep extension is crucial for obtaining such significant measures.

While this study's investigation focused specifically on assessing physical performance in the lab, future research may benefit from more valuable measures of performance to the sport of interest in their athletes. Although there are many advantages that exist with the WAnT test (accurate determination of load, direct assessment of maximal capacity tailored to the participant, and standard laboratory conditions) it lacks the transformation of results into field conditions and it relies on individual will and motivation from the participant. Thus, potential studies may benefit from athletic performance measures specific to the sport and during actual competition rather than practice.

As far as we are aware, this is the first study to address the impact on sleep extension on nutritional consumption. More specifically, this study looked to address the impact on increased sleep on nutrition in the athletic population, knowing that optimal performance is enhanced by proper nutrition[6]. Current knowledge on the topic of sleep and nutrition stems from research carried out over the past few decades, examining the link between the global trend in increasing obesity and sleep deprivation in children and adults[47]. Many pathways have been made known that could mediate an adverse effect of sleep loss on the risk of obesity including increases in sympathetic nervous system activity[52], impact on hormones involved in appetite regulation[56], and poor eating habits[73, 74, 77]. Studies have shown an increase in fat consumption and decrease in carbohydrate consumption with sleep loss[73]. In the current study, no significant differences were seen in macronutrient distribution from baseline to sleep extension in the female track and field athletes. Since this is a novel study looking at sleep extension and dietary behavior, no research has been documented that indicates why such results may occur. Due to administration of only one 24 hour dietary recall at baseline and again at post, this could limit the chance to see significant differences after extending sleep. Although multiple-pass 24-hour diet-recall approach is considered to be a gold standard for nutrition epidemiology[89], ideally, 24-hour recalls should be administered over multiple periods to maximize reliability. Further this is a measure of self-report rather than controlled feeding or even measured intake and output, but self-report is more realistic in the cost-effective need to do this type of research.

Although little increases in calories consumed from fat and decrease in calories consumed from carbohydrate were seen in our study population after sleep extension, the overall macronutrient distribution breakdown at baseline and sleep extension leaned toward a healthy balanced diet for endurance athletes[6]. The findings of this study may be attributed to the amount of nutritional resources available to these female athletes (access to a sports dietitian and nutrition courses offered) leading to sound nutritional practices in their diets. It is believed that many of the individuals of this study have met with or currently visit with the sports dietitian. In contrast, healthy eating behaviors have also been a result of the influence of neurotransmitters, more specifically serotonin levels[90]. It has been determined that the serotonergic system helps determine hunger, satiety, and feeding behavior where decreased levels of serotonin increase need for carbohydrates rich in sugars and refined starches in order to produce positive mood[91]. With increasing serotonin levels seen with exercise and adequate sleep, it is possible that our subjects decreased the amount of carbohydrate rich foods due to elevated serotonin levels with sleep extension and increased activity. Nevertheless, there is still conflicting data that shows the athletes in our study mimicking the trend towards pro-obesogenic (increase in fat intake) behaviors seen in subjects who were sleep deprived. While this behavior may have occurred, no biochemical data were taken (i.e. urine excretion, blood samples) and levels of cravings were not assessed to further examine why such results would occur. Thus, future studies would look to invest in such methods to further examine nutrient intake.

Our results are consistent with a study on female collegiate athletes where the majority (72.5%) of the athletes were asymptomatic of disordered eating and engaged in healthy eating behavior[66, 92]. However, it is warranted whether these athletes were truly asymptomatic of an eating disorder. Investigators have demonstrated athletes of lean-sports (gymnasts, endurance athletes, figure skaters) are at high risk for disordered eating[93]. Although an eating attitude survey was distributed during screening to our subjects, no data were seen from the survey or food diaries of the subjects to suggest disordered-eating symptoms were prevalent.

It should also be noted that a trend was evident for a negative association between increased sleep and decreased water intake in our subjects. This is consistent with another study where the same effect was seen with post-menopausal women[74]. A possibility of the decrease in intake could be due to water being a diuretic that may disrupt sleep. Another possibility could be that increasing sleep time may leave less time for water intake.

In spite of the findings from this study, more research is needed to examine these potential links to the extent that it exists among female athletes. Furthermore, more studies would benefit from examining whether sleep extension as a lifestyle intervention for healthy eating is only beneficial for those who are sleep deprived and show signs of unhealthy eating patterns.

Limitations

In interpreting the results of this study, several limitations must be acknowledged. One limitation being a convenience sample was used. Due to limitations in incentives for NCAA athletes, all reported measures are subject to socially desirable responding by the subjects willing to participate in the study. Several steps were taken to encourage honest responding and participation through subjects: informed of the confidential nature of their responses, no coaches or athletic department personnel present during data collection, and participant understanding there were no right or wrong answers. Also, participants were given access to individual data if requested.

In regards to study design, study length was seven days which may be considered short and it was conducted in-season on the assumption that the subjects entered the study at a high performance level after training the previous semester. This would eliminate differences in baseline and post-intervention due to training and not the treatment of sleep extension. However, the short study length may have been insufficient in order to alter sleep debt enough to show significant differences in performance and nutrition. The researchers in this study felt a one hour increase in sleep extension was adequate as the subjects entered the study at a fairly healthy sleep range (approximately 7 hours). However, greater effects on performance and nutrition from the additional hour of sleep may have been better suited to a population that was more sleep deprived and receiving less than seven hours of sleep at baseline.

A third limitation of this study was the enrollment of a small sample size. Although the sample was representative of the female track and field athletes at WVU, and was slightly larger than previous studies that have studied this population, future studies would benefit for a larger study population with the addition of a control group. A traditional control arm in a study on collegiate athletes in the same team may be difficult due to small team sizes. Therefore future studies desiring a control arm are likely feasible with a population outside of one athletic team.

In looking at the study's subject breakdown, most of the athletes recruited were long distance runners. Thus, another limitation of the study was the protocol used to measure physical performance (WAnt test). Although some researchers suggest that an endurance athlete with the best suited anaerboic system may establish the margin in a race[94], it is arguable that this test is designed for anaerobically trained athletes who possess more fast twist muscle fibers. Implementation of this protocol could explain no significant differences in physical performance seen with sleep extension as most subjects were aerobically trained. Even though the researchers in the study established the protocol before knowing the breakdown of their subjects, future research would profit by assessing physical performance with measures related to physiological status (i.e. fiber type, lactate threshold, muscle enzyme profile, etc).

Lastly, although a novel part of this research looked at the treatment of sleep extension on performance and nutrition in females, there is research to demonstrate the impact on certain phases of the menstrual cycle on sleep quality [95]. In this study, menstrual cycle was assessed in the screening and recruitment of the subject, however it was not taken into account during data collection. Future investigation is still warranted for more studies focusing on females in this field; ideally matching like menstrual cycles among female participants in a control/intervention design would help investigators to better answer their research questions.

CHAPTER VII

SUMMARY AND CONCLUSION

The purpose of the study was to investigate the effectiveness of sleep extension on physical and psychological performance and nutritional outcomes of female college athletes. The findings from this study demonstrate that these female athletes, ages 18-24, were able to increase sleep regardless of their time-consuming schedules. Although literature suggests that increasing sleep duration in this population will enhance performance, the findings of this study show no significant differences in pre and post physical performance measures when one more hour of sleep was given. In addition, there was no significant difference in nutritional outcomes of the female athletes after the sleep extension period. As shown in other studies, sleep deprivation leads to obesogenic behaviors, not favorable for an athlete. To our knowledge, this was the first study to examine increasing sleep duration on nutritional behaviors in this population.

Collegiate athletes have full schedules, balancing class commitments, training schedules and leisure time. When it comes to achieving optimal performance, sleep should be considered just as important as training and eating right. Future research would benefit from longer sleep extension periods with previously identification of sleep deprivation.

Finally, this study was implemented on an extreme physically fit and nutritionally sound group of people. A future implication of this study may be to treat an unhealthy population (i.e. obese individuals) and investigate sleep extension on lifestyle behaviors.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL AND CONSENT AND INFORMATION FORM

WVU IRB Approved Protocol H-24544 Title: SleEP iN Study: Sleeping Longer to Enhance Exercise Performance in Nutrition on March 1, 2013

The 56 page document including consent can be found in the BRAAN 2 system with the tracking number 24544.

APPENDIX B

SIGNED LETTER OF APPROVAL BY WVU WOMEN'S TRACK AND FIELD COACH

MOUNTAINEERS
West Virginia University
Intercollegiate Athletics
PO Box 877
Morgantown WV 26507-0877

To the WVU IRB Review Committee:

I have met with the "Sleep In" Research Investigators that are examining the effects of sleep extension on exercise performance and nutritional behaviors in female athletes, and I support the need for research in this area. My understanding is that there will be a one week sleep intervention study that will not affect the subjects negatively. I see this study as beneficial to the athletes and the sport, therefore the researchers of this study have my provision to go along and recruit and assess the females of WVU Track and Field. It is also my understanding that this research will be completely voluntary and that the subjects will be asked to consent to participate and can leave the study at any time. Also, the data being collected from the study will be confidential and will be kept between participants and researchers.

Sean Cleary

Head Coach of WVU Women's Track and Field

APPENDIX C

PROJECT DIRECTORY

Melissa Olfert, Ph.D., R.D. PI	Melissa.olfert@mail.wvu.edu	304-293-1918
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Dr. Randall Bryner, Committee Advisor	rbryner@has.wvu.edu	304-293-0441
Dr. Sean Cleary, Head Coach Women's Track and Field	sean.cleary@mail.wvu.edu	304-293-2101

APPENDIX D

SCREENING QUESTIONNAIRE

WestVirginiaUniversity.

Before you access the SLEEP survey, you must meet the following criteria:

- Between the ages of 18-24
- Student in exercise physiology OR West Virginia University track and field athlete
- Full-time student
- English-speaking
- Have regular access to the internet

If you meet ALL of the following criteria, check YES to continue on to the survey.

- ○ Yes (I meet the criteria)
- ○ No (I do not meet the criteria)

Sleep Survey

Survey Powered By Qualtrics

>>

WestVirginiaUniversity.

Dear Participant,
This letter is a request for you to take part in a research survey to assess how many hours of sleep you receive regularly. This project is being conducted by Melissa Olfert, DrPH, Remi Famodu, graduate MS nutrition student, and Randy Bryner, PhD in the Office of Research Compliance at WVU with supervision of Dr. Melissa Olfert, an assistant professor in the Davis College of Agriculture, Natural Resources and Design. Your participation in this survey is greatly appreciated and will take approximately 5 minutes to fill out the attached survey.
Your involvement in this project will be kept as confidential as legally possible. All data will be reported in the aggregate. You must be 18 years of age or older to participate. You participation is completely voluntary. You may skip any question that you do not wish to answer and you may discontinue at any time. Your class standing will not be affected if you decide either not to participate or withdraw. West Virginia University's Institutional Review Board acknowledgement of this project is on file.
I hope that you will participate in this research survey, as it could be beneficial in understanding the impact of grades on student life. Thank you for your time. Should you have any questions about this letter or research survey, please feel free to contact Remi Famodu at (612)281-1908 or by email at oafamodu@mix.wvu.edu.
Thanks you for your time and help with this project.

If you have any questions pertaining to this survey, please contact Remi Famodu at 612-281-1908 or Dr. Melissa Olfert, Department of Human Nutrition and Foods, Davis College of Agriculture, Natural Resource, and Design, 304-293-1918.

Thank you for your assistance.

If you are willing to participate in the survey and are willing to be contacted for future research, please check the appropriate box below.

○ Yes I consent ○ No I do not consent

Sleep Survey

>>

Name (First Name, Last, Name)

Email Address

Age

- 18 years or younger
- 18-24 years
- 24 years and above

Ethnicity

- Caucasian
- African-American
- Native American
- Asian-American
- Latin-American
- Pacific Islander
- Other
- Choose not to answer

Residency

- On Campus
- Off Campus
- Other

Year of Schooling

- Freshman
- Sophomore
- Junior
- Senior
- Graduate Student
- Other

Height (inches)

Weight (in lbs)

Do you smoke?

- Yes
- No

Do you use illicit drugs? (i.e. marijuana, cocaine)

- Yes
- No

Do you consume alcohol?

- Yes
- No

Sleep Survey

West Virginia University

Do you consume caffeine?

- Yes
- No

Sleep Survey

Survey Powered By Qualtrics

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During the past month, what time have you usually gone to bed?

Time [▼]

During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

Minutes [▼]

During the past month, what time have you usually gotten up in the morning?

Time [▼]

During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

Hour(s) [▼]

During the past month, how often have you had trouble sleeping because you...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
Cannot get to sleep within 30 minutes	○	○	○	○
Wake up in the middle of the night or early morning	○	○	○	○
Have to get up to use the bathroom	○	○	○	○
Cannot breathe comfortably	○	○	○	○
Cough or snore loudly	○	○	○	○
Feel too cold	○	○	○	○
Feel too hot	○	○	○	○
Had bad dreams	○	○	○	○
Have pain	○	○	○	○
Other (please explain) [ ]	○	○	○	○

During the past month, how would you rate your sleep quality overall?

- Very Good
- Good
- Poor
- Very Poor

During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

- Not during the past month
- Less than once a week
- Once or twice a week
- Three or more times a week

During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

- Not during the past month
- Less than once a week
- Once or twice a week
- Three or more times a week

During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

- Not a problem at all
- Only a very slight problem
- Somewhat of a problem
- A very big problem

Do you have a bed partner or room mate?

- No bed partner or room mate
- Partner/room mate in other room
- Partner in same room, but not same bed
- Partner in same bed

Sleep Survey

WestVirginiaUniversity.

If you have a room mate or bed partner, ask him/her how often in the past month you have had...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
Loud snoring	○	○	○	○
Long pauses between breaths while asleep	○	○	○	○
Legs twitching or jerking while you sleep	○	○	○	○
Episodes of disorientation or confusion during sleep	○	○	○	○
Other restlessness while you sleep; please describe ______	○	○	○	○

Use the following scale to choose the most appropriate response for each situation:

	would never doze or sleep	slight chance of dozing or sleeping	moderate chance of dozing or sleeping	high chance of dozing or sleeping
Sitting and reading	○	○	○	○
Watching TV	○	○	○	○
Sitting inactive in a public place	○	○	○	○
Being a passenger in a motor vehicle for an hour or more	○	○	○	○
Lying down in the afternoon	○	○	○	○
Sitting and talking to someone	○	○	○	○
Sitting quietly after lunch (no alcohol)	○	○	○	○
Stopped for a few minutes in traffic while driving	○	○	○	○

Sleep Survey

WestVirginiaUniversity

The following questions are about the time you spent being physically active in the last 7 days. They include questions about activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport. In answering the questions, vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Please answer each question even if you do not consider yourself to be an active person.

During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling? Think about *only* those physical activities that you did for at least 10 minutes at a time.

Days [▼]

How much time total did you usually spend on one of those days doing vigorous physical activities?

Time [▼]

During the last 7 days, on how many days did you do moderate physical activities like bicycling at regular pace, swimming at regular pace,and double tennis in your leisure time?

Days [▼]

How much time in total did you usually spend on one of those days doing moderate physical activities?

Time [▼]

Do you play a sport?

- Yes
- No

Sleep Survey

West Virginia University

What type of sport do you play?

- Soccer
- Track and Field
- Softball
- Tennis
- Volleyball
- Football
- Basketball
- Other

At what level is the sport you mentioned above?

- Club Collegiate
- Varsity Collegiate
- Semi-Professional
- Professional
- Leisure
- Other

Is the sport that you play sport organized by West Virginia University?

- Yes
- No

How many hours a day do you train in the sport that you mentioned?

- 0-1
- 1-2 hours
- 3 or more hours

Please check the response that best reflects the extent to which you agree or disagree with each statement in relation to your own sport participation.

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
I consider myself an athlete	○	○	○	○	○	○	○
I have many goals related to sport	○	○	○	○	○	○	○
Most of my friends participate in sport	○	○	○	○	○	○	○
Sport is the most important part of my life	○	○	○	○	○	○	○
I spend more time thinking about sport than anything else	○	○	○	○	○	○	○
Other people see me as an athlete	○	○	○	○	○	○	○
I feel bad about myself when I play poorly in practice or competition	○	○	○	○	○	○	○
Sport is the only important thing in my life	○	○	○	○	○	○	○
When I am participating in sport, I am happy	○	○	○	○	○	○	○
My family expects me to participate in sport	○	○	○	○	○	○	○
I feel badly when I fail to meet my athletic goals	○	○	○	○	○	○	○
Being an athlete is who I am and want to make a career of sport	○	○	○	○	○	○	○
It is important that other people know about my sport involvement	○	○	○	○	○	○	○

I get a sense of satisfaction when participating in sport

My participation in sport is a very positive part of my life

I typically organize my day so I can participate in sports

I would be very depressed if I were cut from the team and could no compete in sport

I participate in sport for recognition/fame

Being an athlete is an important part of who I am

I feel good about myself when I play well in practice or competition

Sleep Survey

Survey Powered By Qualtrics

>>

WestVirginiaUniversity.

Please select the appropriate response to each statement. All answers will be kept confidential.

	Always	Usually	Often	Sometimes	Rarely	Never
I am terrified about being overweight	○	○	○	○	○	○
I avoid eating when I am hungry	○	○	○	○	○	○
I find myself preoccupied with food	○	○	○	○	○	○
I have gone on eating binges where I feel that I may not be able to stop	○	○	○	○	○	○
I cut my food into small pieces	○	○	○	○	○	○
I am aware of the calorie content of foods that I eat	○	○	○	○	○	○
I particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes)	○	○	○	○	○	○
	Always	Usually	Often	Sometimes	Rarely	Never
I feel that others would prefer I eat more	○	○	○	○	○	○
I vomit after I have eaten	○	○	○	○	○	○
I feel extremely guilty after eating	○	○	○	○	○	○
I am preoccupied with a desire to be thinner	○	○	○	○	○	○
I think about burning calories when I exercise	○	○	○	○	○	○
Other people think that I am too thin	○	○	○	○	○	○
I am preoccupied with the though of having fat on my body	○	○	○	○	○	○

fat on my body

	Always	Usually	Often	Sometimes	Rarely	Never
I take longer than others to eat my meals						
I avoid foods with sugar in them						
I eat diet foods						
I feel that food controls my life						
I display self-control around food						
I feel that others pressure me to eat						
I give too much time and thought to food						
	Always	Usually	Often	Sometimes	Rarely	Never
I feel uncomfortable after eating sweets						
I engage in dieting behavior						
I like my stomach to be empty						
I have the impulse to vomit after meals						

Sleep Survey

>>

WestVirginiaUniversity.

Please complete the following information as accurately as possible. Some of these questions deal with personal information. Please be assured that your questions will remain confidential.

What is your gender?

- Male
- Female

Sleep Survey

Survey Powered By Qualtrics

>>

WestVirginiaUniversity.

When was your last period? (Indicate first day of last period)

How often have you had menstrual periods in the last year?

- Once every 20 days or less
- Every 21-27 days
- Every 28-35 days
- Every 36-50 days
- Every 3-4 months
- Very irregular; sometimes monthly, sometimes skip several months
- Other (please specify)

Periods usually last how many days?

Number of periods in the last 12 months.

Do you keep track of your menstrual history?

- Yes
- No

Would you be willing to record your menstrual cycle?

- Yes
- No

Are you pregnant?

- Yes
- No

Is there a possibility that you could be pregnant?

- Yes
- No

Do you take any type of estrogens (i.e oral contraceptives)

- Yes (please explain)
- No

Sleep Survey

WestVirginiaUniversity.

Do you have a history of stress fractures?

- Yes
- No

Have you had any recent injury within the past 3 years?

- Yes (please explain)
- No

Sleep Survey

Survey Powered By Qualtrics

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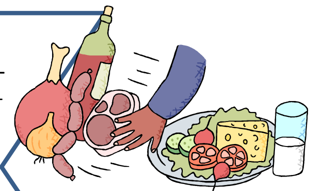
APPENDIX E

QUESTIONNAIRES/PROTOCOLS/ASSESSMENT TOOLS

Intervention Log/Spiral Notebook

NAME______________________________
Address____________________________
____
____
____
Phone_____________________________
____
E-mail_____________________________



SleEP iN STUDY

SleEP iN Study

Thank you for participating in the **S**le**EP** i**N** study!

Please use this notebook to track your sleep, exercise and nutrition for one week. Please be as specific as possible.

Oluremi Famodu
Research Coordinator
oafamodu@mix.wvu.edu
612-281-1908
Ag. Sci Building Rm. #1032
Melissa Olfert DrPH,MS,RD,LD
Principle Investigator
melissa.olfert@mail.wvu.edu
304-293-1918

3

Date 01/14/2013 **M** T W TH F S Su SleEP IN O STUDY

Food Log EXAMPLE

Time	Food & Drink Description (BE SPECIFIC!)
9:30am	Breakfast: 1 cup Raisin Nut Bran with ½ cup of 1% milk 1 cup of hot tea with 1 tbsp of honey
10:30am	Snack: 6 oz vanilla yogurt (Dannon Light and Fit) with ¼ cup of frozen raspberries
12:30pm	Lunch: 3 tbsp of peanut butter (Jif) and 2 tbsp of raspberry jelly on 2 slices of oatnut bread 1 cup of baby carrots 1 macintosh apple
3:00pm	Snack: 1 cup of baby carrots with ¼ cup of roasted red pepper humus (Sabra)
6:30pm	Dinner: 6oz salmon with ½ cup of green beans 1 cup of spring mix salad with ¼ cup of cucumber and tomato with 1 tbsp of Italian dressing (Kraft)
	Snack: NA

Notes:
Throughout the day I drank 51 oz of water

4

Exercise Log EXAMPLE

Time	Activity Description (BE SPECIFIC!)
Start:8:30am Stop:9:30am	Yoga for stress relief
Start: 3:00pmStop:3:20pm	Ran 2 miles on treadmill
Start: Stop:	

Sleep Log

Time To Bed	11:00 PM		
Time Fell Asleep	11:15PM		
Time Woke Up	8:00AM		
Nap Times	Time: ___:___AM/PM Duration:	Time: ___:___AM/PM Duration:	Time: ___:___AM/PM Duration:

Please use the sleepiness scale below to rate how you are feeling at the given times.

1: Feeling active, vital, alert and wide awake
2: Functioning at a high level, but not at peak; able to concentrate
3: Awake, but relaxed; responsive, but not fully alert
4: Somewhat foggy
5: Foggy; losing interest in remaining awake; slowed down
6: Sleepy, woozy, fighting sleep; prefer to lie down
7: No longer fighting sleep. Sleep onset soon; having dream like thoughts
X: Asleep

9:00 am	1
11:00 am	1
1:00 pm	1
3:00 pm	2
5:00 pm	3
7:00 pm	4
9:00 pm	5
11:00 pm	7

5

Date__/__/____ M T W TH F S Su

Food Log

Time	Food & Drink Description (BE SPECIFIC!)
	Breakfast
	Snack
	Lunch
	Snack
	Dinner
	Snack

Notes

Exercise Log

Time		Activity Description (BE SPECIFIC!)
Start:	Stop:	
Start:	Stop:	
Start:	Stop:	

Sleep Log

Time To Bed	___:___AM/PM		
Time Fell Asleep	___:___AM/PM		
Time Woke Up	___:___AM/PM		
Nap Times	Time: ___:___AM/PM Duration:	Time: ___:___AM/PM Duration:	Time: ___:___AM/PM Duration:

Please use the sleepiness scale below to rate how you are feeling at the given times.

1: Feeling active, vital, alert and wide awake
2: Functioning at a high level, but not at peak; able to concentrate
3: Awake, but relaxed; responsive, but not fully alert
4: Somewhat foggy
5: Foggy; losing interest in remaining awake; slowed down
6: Sleepy, woozy, fighting sleep; prefer to lie down
7: No longer fighting sleep. Sleep onset soon; having dream like thoughts
X: Asleep

9:00 am	
11:00 am	
1:00 pm	
3:00 pm	
5:00 pm	
7:00 pm	
9:00 pm	
11:00 pm	

7

STANFORD SLEEPINESS SCALES

This is a quick way to assess how alert you are feeling. If it is during the day when you go about your business, ideally you would want a rating of a one. Take into account that most people have two peak times of alertness daily, at about 9 a.m. and 9 p.m. Alertness wanes to its lowest point at around 3 p.m.; after that it begins to build again. Rate your alertness at different times during the day. If you go below a three when you should be feeling alert, this is an indication that you have a serious sleep debt and you need more sleep.

An Introspective Measure of Sleepiness
The Stanford Sleepiness Scale (SSS)

Degree of Sleepiness	**Scale Rating**
Feeling active, vital, alert, or wide awake	1
Functioning at high levels, but not at peak; able to concentrate	2
Awake, but relaxed; responsive but not fully alert	3
Somewhat foggy, let down	4
Foggy; losing interest in remaining awake; slowed down	5
Sleepy, woozy, fighting sleep; prefer to lie down	6
No longer fighting sleep, sleep onset soon; having dream-like thoughts	7
Asleep	X

Centers for Disease Control and Prevention Health-Related Quality-of-Life 14-Item Measure

CDC HRQOL-14
"Healthy Days Measure"

Healthy Days Core Module	(4 questions)
Activity Limitations Module	(5 questions)
Healthy Days Symptoms Module	(5 questions)

Division of Adult and Community Health
National Center for Chronic Disease Prevention and Health Promotion

The standard 4-item set of Healthy Days core questions (CDC HRQOL-4) has been in the State-based Behavioral Risk Factor Surveillance System (BRFSS) since 1993 (see BRFSS Website http://www.cdc.gov/brfss). Since 2000, the CDC HRQOL-4 has been in the National Health and Nutrition Examination Survey (NHANES) for persons aged 12 and older. Since 2003, the CDC HRQOL-4 has been in the Medicare Health Outcome Survey (HOS)—a NCQA HEDIS measure. Standard Activity Limitation and Healthy Days Symptoms modules have also been available since January 1995. When used together, these measures comprise the full CDC HRQOL-14 Measure.

Healthy Days Core Module (CDC HRQOL-4)

1. Would you say that in general your health is:

Please Read

a. Excellent	1
b. Very good	2
c. Good	3
d. Fair	4
or	
e. Poor	5
Do not read these responses	
Don't know/Not sure	7
Refused	9

2. Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?

a. Number of Days	_ _
b. None	8 8
Don't know/Not sure	7 7
Refused	9 9

3. Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?

a. Number of Days	_ _	
b. None	8 8	**If both Q2 AND Q3 ="None", skip next question**
Don't know/Not sure	7 7	
Refused	9 9	

4. During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?

a. Number of Days	_ _
b. None	8 8
Don't know/Not sure	7 7
Refused	9 9

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Activity Limitations Module

These next questions are about physical, mental, or emotional problems or limitations you may have in your daily life.

1. Are you LIMITED in any way in any activities because of any impairment or health problem?

a. Yes	1	
b. No	2	**Go to Q1 of Healthy Days Symptoms Module**
Don't know/Not sure	7	**Go to Q1 of Healthy Days Symptoms Module**
Refused	9	**Go to Q1 of Healthy Days Symptoms Module**

2. What is the MAJOR impairment or health problem that limits your activities?

Do Not Read. Code Only One Category.

a. Arthritis/rheumatism	0 1
b. Back or neck problem	0 2
c. Fractures, bone/joint injury	0 3
d. Walking problem	0 4
e. Lung/breathing problem	0 5
f. Hearing problem	0 6
g. Eye/vision problem	0 7
h. Heart problem	0 8
i. Stroke problem	0 9
j. Hypertension/high blood pressure	1 0
k. Diabetes	1 1

l. Cancer 1 2
m. Depression/anxiety/emotional problem 1 3
n. Other impairment/problem 1 4
Don't know/Not sure 7 7
Refused 9 9

3. For HOW LONG have your activities been limited because of your major impairment or health problem?

Do Not Read. Code using respondent's unit of time.

a. Days 1 _ _
b. Weeks 2 _ _
c. Months 3 _ _
d. Years 4 _ _
Don't know/Not sure 7 7 7
Refused 9 9 9

4. Because of any impairment or health problem, do you need the help of other persons with your PERSONAL CARE needs, such as eating, bathing, dressing, or getting around the house?

a. Yes 1
b. No 2
Don't know/Not sure 7
Refused 9

5. Because of any impairment or health problem, do you need the help of other persons in handling your ROUTINE needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes?

a. Yes 1
b. No 2
Don't know/Not sure 7
Refused 9

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Healthy Days Symptoms Module

1. During the past 30 days, for about how many days did PAIN make it hard for you to do your usual activities, such as self-care, work, or recreation?

a. Number of Days _ _
b. None 8 8
Don't know/Not sure 7 7
Refused 9 9

2. During the past 30 days, for about how many days have you felt SAD, BLUE, or DEPRESSED?

a. Number of Days _ _
b. None 8 8
Don't know/Not sure 7 7
Refused 9 9

3. During the past 30 days, for about how many days have you felt WORRIED, TENSE, or ANXIOUS?

a. Number of Days _ _
b. None 8 8
Don't know/Not sure 7 7
Refused 9 9

4. During the past 30 days, for about how many days have you felt you did NOT get ENOUGH REST or SLEEP?

a. Number of Days _ _
b. None 8 8
Don't know/Not sure 7 7
Refused 9 9

5. During the past 30 days, for about how many days have you felt VERY HEALTHY AND FULL OF ENERGY?

a. Number of Days _ _
b. None 8 8
Don't know/Not sure 7 7
Refused 9 9

Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts **during the last month**. In each case, you will be asked to indicate by circling *how often* you felt or thought a certain way.

Name ______________________________ Date __________

Age ________ Gender (*Circle*): **M F** Other ______________________

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly?	**0**	**1**	**2**	**3**	**4**
2. In the last month, how often have you felt that you were unable to control the important things in your life?	**0**	**1**	**2**	**3**	**4**
3. In the last month, how often have you felt nervous and "stressed"?	**0**	**1**	**2**	**3**	**4**
4. In the last month, how often have you felt confident about your ability to handle your personal problems?	**0**	**1**	**2**	**3**	**4**
5. In the last month, how often have you felt that things were going your way?	**0**	**1**	**2**	**3**	**4**
6. In the last month, how often have you found that you could not cope with all the things that you had to do?	**0**	**1**	**2**	**3**	**4**
7. In the last month, how often have you been able to control irritations in your life?	**0**	**1**	**2**	**3**	**4**
8. In the last month, how often have you felt that you were on top of things?	**0**	**1**	**2**	**3**	**4**
9. In the last month, how often have you been angered because of things that were outside of your control?	**0**	**1**	**2**	**3**	**4**
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	**0**	**1**	**2**	**3**	**4**

Please feel free to use the *Perceived Stress Scale* for your research.

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References

The PSS Scale is reprinted with permission of the American Sociological Association, from Cohen, S., Kamarck, T., and Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24,* 386-396.

Cohen, S. and Williamson, G. Perceived Stress in a Probability Sample of the United States. Spacapan, S. and Oskamp, S. (Eds.) *The Social Psychology of Health.* Newbury Park, CA: Sage, 1988.

PROFILE OF MOOD STATES

Directions: Describe HOW YOU FEEL RIGHT NOW by checking one space after each of the words listed below:

FEELING	Not at all	A little	Mod.	Quite a bit	Extremely
Friendly	1	2	3	4	5
Tense	1	2	3	4	5
Angry	1	2	3	4	5
Worn Out	1	2	3	4	5
Unhappy	1	2	3	4	5
Clear-headed	1	2	3	4	5
Lively	1	2	3	4	5
Confused	1	2	3	4	5
Sorry for things done	1	2	3	4	5
Shaky	1	2	3	4	5
Listless	1	2	3	4	5
Peeved	1	2	3	4	5
Considerate	1	2	3	4	5
Sad	1	2	3	4	5
Active	1	2	3	4	5
On edge	1	2	3	4	5
Grouchy	1	2	3	4	5
Blue	1	2	3	4	5
Energetic	1	2	3	4	5
Panicky	1	2	3	4	5
Hopeless	1	2	3	4	5
Relaxed	1	2	3	4	5
Unworthy	1	2	3	4	5
Spiteful	1	2	3	4	5
Sympathetic	1	2	3	4	5
Uneasy	1	2	3	4	5
Restless	1	2	3	4	5
Unable to concentrate	1	2	3	4	5
Fatigued	1	2	3	4	5

Helpful	1	2	3	4	5
Annoyed	1	2	3	4	5
Discouraged	1	2	3	4	5
Resentful	1	2	3	4	5
Nervous	1	2	3	4	5
Lonely	1	2	3	4	5
Miserable	1	2	3	4	5
Muddled	1	2	3	4	5
Cheerful	1	2	3	4	5
Bitter	1	2	3	4	5
Exhausted	1	2	3	4	5
Anxious	1	2	3	4	5
Ready to fight	1	2	3	4	5
Good-natured	1	2	3	4	5
Gloomy	1	2	3	4	5
Desperate	1	2	3	4	5
Sluggish	1	2	3	4	5
Rebellious	1	2	3	4	5
Helpless	1	2	3	4	5
Weary	1	2	3	4	5
Bewildered	1	2	3	4	5
Alert	1	2	3	4	5
Deceived	1	2	3	4	5
Furious	1	2	3	4	5
Efficacious	1	2	3	4	5
Trusting	1	2	3	4	5
Full of pep	1	2	3	4	5
Bad-tempered	1	2	3	4	5
Worthless	1	2	3	4	5
Forgetful	1	2	3	4	5
Carefree	1	2	3	4	5
Terrified	1	2	3	4	5
Guilty	1	2	3	4	5
Vigorous	1	2	3	4	5
Uncertain about things	1	2	3	4	5
Bushed	1	2	3	4	5

APPENDIX F

DATE COLLECTION FORM

Demographics/Contact Information

<table>
<tr><td colspan="2">Name: Last, First

ID #:</td><td>Sport:</td></tr>
<tr><td colspan="2">Birthdate (mo/day/yr)

Age:</td><td>Year in School (circle) Freshman Sophomore Junior Senior Graduate</td></tr>
<tr><td colspan="3">Campus ADDRESS:</td></tr>
<tr><td>CELL PHONE # (with area code):</td><td colspan="2">EMAIL ADDRESS:</td></tr>
<tr><td colspan="3">BEST WAY TO CONTACT (check any applicable box):

☐ email ☐ day phone ☐ cell phone ☐ Other, specify:</td></tr>
</table>

Physical Assessment

Subject ID #	Baseline	1-Week Follow-up
Actigraph #:		
DATE		
TIME		
RESEARCHER who completed assessment		

	Measure 1	Measure 2	Average of 1 & 2**	Measure 1	Measure 2	Average of 1 & 2**
WEIGHT (kg)			*			*
HEIGHT (cm)			*			*
WAIST CIRCUMFERENCE (cm)			*			*
BLOOD PRESSURE (mm/Hg)			*			*
BMI Calculation						
% Body Fat (BodPod)						
Psychomotor Vigilance Test (PVT)	Test Duration: Signals Missed: False Starts: Avg. Rxtn Time:			Test Duration: Signals Missed: False Starts: Avg. Rxtn Time:		
Wingate Protocol Assessment (resistance, distance)						
Power Output *(Watts)* ***Fatigue Index*** *(Watts/sec)*						
CONCERNS FOR ERROR (for weight, height, waist circumference measures, blood pressure)						

* Enter these data on excel file for each participant

** Round the average of the two official measurements to two decimal places (e.g. 0.2 +0.3 = 0.5/2 =0.25).

CURRICULUM VITAE of Oluremi Famodu

I was born in Bloomington, MN. I graduated from John F. Kennedy High School in 2008 and began my undergraduate course work at Ohio University (OU) in Athens, OH in the fall of 2008. Being a member of the Varsity Women's Soccer Team for four years and having received the Ohio Collegiate Soccer Association Academic Recognition Second Team along with Ohio Academic All-MAC Honorable Mention in 2012, I bring a deep understanding to the dedication of an athlete. I became a member and publicity chair of the national honor society, Phi Upsilon Omicron, and also participated in the Health Sciences and Professions honors program in 2011. At OU I received a Bachelor of Science degree in Applied Nutrition and received the Outstanding Graduate in the college of Applied Health Sciences and Wellness in June 2012.

In August 2012, I was accepted into the Master's program in the Division of Animal and Veterinary Sciences at WVU, as well as receiving a part-time graduate assistantship, which continued until May 2013. This research work is in part fulfillment of earning a Master's degree projected for May 2014, followed by sitting for the national Registered Dietetics (RD) exam shortly thereafter.