5-2009

RELATIONSHIP BETWEEN TIME OF EATING AND INJURIES IN STUDENT ATHLETES

Yasuaki Okawa
Clemson University, kata809@yahoo.com

RELATIONSHIP BETWEEN TIME OF EATING AND INJURIES IN STUDENT ATHLETES

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Food, Nutrition and Culinary Sciences

---

by
Yasuaki Okawa
May 2009

Accepted by:
Dr. Elizabeth Kunkel, Committee Chair
Dr. Gail Delicio
Dr. Angela Fraser

ABSTRACT

There is a significant body of research on the relationships between exercise and nutrition for enhancing athletic performance. However, there is a deficit of research on the relationship between time of eating and athletic injuries. Thus, the purpose of this study was to explore the relationship between the time of eating and athletic injuries in collegiate student-athletes. Given the potential relationship between night eating, sleep disruption, and impaired wound healing, the hypothesis of this research is that eating late at night increases the incidence of chronic athletic injuries.

Data from a convenience sample of 34 student-athletes, 8 male and 26 female, were collected at Clemson University, an NCAA Division 1 school, in Fall 2008. The student-athletes completed a survey regarding incidence of chronic and acute injuries within the past 3 months and a 3-day record of sleeping times and food consumed. The results from a logistic regression analysis indicated that the odds ratio for energy intake and chronic injury is 1.009, meaning that the odds of sustaining a chronic injury were estimated to increase by a factor of 1.009 for every calorie consumed between 9 pm and 12 am, although calories is not a significant predictor of the incidence of awaking during the night (p=0.65). Other findings were that student-athletes

consumed less energy than the national average for their ages. Also, more than 80% of male and female student-athletes in the total study sample did not meet the Recommended Dietary Allowance (RDA) for Vitamin E, magnesium, and potassium. None of the males met the RDA for folate. On the other hand, male student-athletes consumed 194% of the daily value for sodium, while female student-athletes consumed 168% of the daily value. There are opportunities for student-athletes to improve their nutrient intake without regard to time of eating even though there is a slight increase in risk of a chronic injury associated with increased energy intake at night.

DEDICATION

I would like to dedicate this work to my family and Ayako. Without their help and support over the past 27 years of my life none of this would have been possible. They have opened doors for me and have enabled me to do things that bring me joy in my life. I am forever indebted to all of them for the love, assistance, and guidance they have provided for me.

ACKNOWLEDGMENTS

First I would like to acknowledge all student-athletes who completed the survey using their time. Without their help this research would not have been possible. I also would like to acknowledge Danny Poole for allowing me to work on this thesis in the athletic training room. I would like to thank all of my fellow graduate assistant athletic trainers. These people have helped me so I could complete this study. I would like to thank Dr. Beth Kunkel, Dr. Gail Delicio, Dr. Fraser, and Dr. Julia Sharp for allowing me to take up so much of their valuable time so that this study could be completed.

TABLE OF CONTENTS

Table of Contents (Continued)

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

Through the 20th and 21st century, the percentage of people who are involved in sports has increased. People not only watch sports for entertainment, but also participate for their own enjoyment and health. However, along with the increased participation in sports comes an increase in acute and chronic injuries among all classes of athletes. Collegiate student athletes have unique mental, physical, and time challenges related to timing of events, meals, and classes that may affect their health and may contribute to chronic injury. Therefore, this study focused on the relationship between the timing of the last eating occasion of the day and the incidence of athletic injuries.

Many physiological functions are subject to circadian rhythm. "In mammals, circadian rhythmicity is a genetically regulated adaptation to daily variations of light, temperature, and other living conditions" (1). According to Illi et al. (2), central regulation of the autonomous circadian clock is through hypothalamic suprachiasmatic nuclei (SCN) and is reset mainly by light signals captured by the retina. The molecular mechanisms of the clocks involve self-sustaining transcriptional/translational feedback loops (3). McCarthy et al. (4) categorized the clock genes as core clock genes (CLOCK, BMAL1, Period, Cryptochrome, Rev-erbα, Rev-erbβ, and Rora) and clock-controlled genes (CCGs). CCGs often encode transcription factors for proteins that control rate-limiting steps in metabolic pathways (4). McCarthy et al. (4) studied the clock genes in skeletal muscle and found that the transcriptome included components of the core clock genes, CCGs, and numerous other genes with muscle-specific functions. They concluded that, since genes that regulate many muscle-specific functions are under circadian control, circadian rhythms have a central role in the regulation of skeletal muscle function and cellular homeostasis (4).

Light is not the only way to reset the circadian rhythm. Sheward et al. (5) found that mice fed only during the daytime demonstrated activity patterns and corticosterone secretion prior to feeding that was driven by a circadian clock located outside the SCN. They concluded that "food intake is an effective signal capable of coordinating circadian rhythms even in the absence of a functional SCN clock" (5). This supports the hypothesis that the timing of the last eating occasion of the day may affect regulation of circadian clocks leading to sleep interruption and delayed recovery from injury. Therefore, timing of food intake, through its effect on circadian rhythm, is important for both preventing and aiding recovery from athletic injuries to skeletal muscle.

There are many behaviors related to night eating, such as night eating syndrome, bulimia nervosa, binge eating disorder, and sleep-related eating disorder. Although night eating syndrome (NES) has not been officially classified as a disorder, Striegel-Moore et al. (6) state that “most definitions of night eating syndrome include 3 core symptoms: morning anorexia, evening hyperplasia, and sleep disturbance.” They also explain that “efforts to operationalize evening hyperplasia typically involve two components: (1) the time of day or the timing relative to the last meal of the day when eating occurs, and (2) the amount consumed” (6).

O’Reardon et al. (7) concluded that a key clinical feature of night eating syndrome is a phase delay in the timing of food intake that results in sleep disruption. One of NES’s symptoms is sleep disturbance, so the timing is important. People with NES are at increased risk of obesity and of clinical depression (7). O’Reardon et al. (7) also noted that symptoms of night eating syndrome seemed to worsen with stress and to possibly resolve with “removal of the person from the stressful environment.” Student-athletes who are competing in college sports are subjected to stressors from both academics and athletics and may be at increased risk of development of NES as well as of sustaining an unfocused injury.

In addition to the impact of circadian rhythms on muscle function, and eating, other physiological systems, such as sleep, may be affected. Berger and Hobbs (8) explained that disruption in circadian cycles may result in sleep disturbance, gastric complaints, poor performance, and fatigue. Reilly and Edward (9) explained that sleep deprivation results in impairment of the immune and endocrine systems and delays the recovery process. They stated that good quality sleep could be the single best recovery for athletes. Halson (10) recommended that “appropriate recovery may result in decreased inflammation and pain, and increased ability to sleep, particularly in recently injured athletes.” Similarly, Haack and Mullington (11) suggested that chronically insufficient sleep may result in the onset or amplification of pain. During sleep, protein synthesis, cell division and growth hormone release are increased (12, 13). Similarly, sleep deprivation was associated with reduced growth hormone (14), NF-kappa β (15), and hepatic phosphatidylcholine synthesis (16). It is also associated with increased activation of the sympathetic nervous system (17), activation of the hypothalamic-pituitary-adrenal (HPA) axis (18,19) and alteration of host defense responses (20-22). Ranjbaran et al. (23) found that “a substantial body of published evidence” indicates that sleep disturbances can worsen chronic inflammation pain and fatigue, increase disease activity, and lower quality of life.

There are many reasons why athletes are injured, including training regimens and nutrient intake. Most nutrition research has focused on types of foods that enhance athletic performance, while very little has focused on the timing of eating outside the pre-game and post-game framework. Given the potential relationship between night eating, sleep disruption, and impaired wound healing, the hypothesis of this research is that eating late at night increases incidence of chronic athletic injuries.

CHAPTER TWO
MATERIALS AND METHODS

This study was designed to investigate the possible relationship between injury and dietary behaviors. Student-athletes from Clemson University, an NCAA Division 1 school, were asked to complete a survey regarding incidence of chronic and acute injuries within the past 3 months and to complete a 3-day record of sleeping times and food consumption (Appendix A). This study was approved by the Institutional Review Board of Clemson University (Appendix A). The study was described to student-athletes when they came into the sports medicine facility in the central athletic facility and they were provided with a copy of an informational letter describing the study (Appendix A). Those who indicated an interest in participating were given an opportunity to ask additional questions about the study. Those who agreed to participate were provided with copies of the survey tools and instructions for completion of those tools. After completion of the record, student-athletes returned the diet record and survey to the sports medicine facility.

The final study sample consisted of a total of 34 student-athletes from cheerleading, women's rowing, women's swimming, women's soccer, men's tennis, women's tennis, and men's track and field.

The diet records were analyzed with Genesis®R&D (ESHA Research, Salem, OR). Where participants failed to provide sufficiently specific information, standard assumptions were made in coding the data. For example, medium apple was entered when a student-athlete recorded just "apple." Each day's diet record was segmented into three time periods; day (5 am – 5 pm), evening (5 pm – 9 pm), and night (9 pm – 12 am). No student-athletes reported consuming food between 12 am and 5 am. Intakes of energy, protein, carbohydrates, sugar, fat, saturated fat, monounsaturated fat, polyunsaturated fat, vitamin A, vitamin B_6, vitamin C, vitamin E, folate, iron, magnesium, potassium, sodium, and zinc were calculated for each time period and for each day. The average intake over the 3 days of each record for each time period and for each day was used for all statistical analyses.

SAS version 9.1 for Windows ™ and SPSS ™ were used to perform all the statistical analyses for this study. Frequency distributions were determined for demographic information, such as gender, year in school, team, incidence of injury, and incidence of awaking during night. Logistic regression was used to determine whether eating late night meals contributes to a student athlete's proneness to chronic injury. The probability of a type I error was set at 5%.

CHAPTER THREE
RESULTS AND DISCUSSION

Student-athletes were invited to participate in this study upon visiting the sports medicine facility for Clemson University athletics. Those who indicated interest in participating in this study were asked to complete a survey regarding incidence of chronic and acute injuries within the past 3 months and to complete a 3-day record of sleeping times and food consumed. The resulting convenience sample consisted of 34 student-athletes who completed and submitted the survey.

Demographic Information

There were 26 female and 8 male student-athletes who participated in this study (Fig 1). There were 6 freshmen, 12 sophomores, 10 juniors and 6 seniors (Fig 2). The mean number of years in school for all of the athletes was 2.5±0.99. There were 2 student-athletes from women's cheerleading, 10 from women's rowing, 3 from women's swimming, 5 from women's soccer, 4 from men's tennis, 6 from women's tennis, and 4 from men's track and field (Fig 3).

Ten (38%) of the student-athletes reported not sustaining an injury in the past 3 months. Fifteen (44%) of the student-athletes reported having a chronic injury while 19 reported no chronic injury in the past 3 months. Thirteen (38%) of the student-athletes reported sustaining an acute injury, while 21 reported no acute injury in

Figure 1. Number of participants by gender

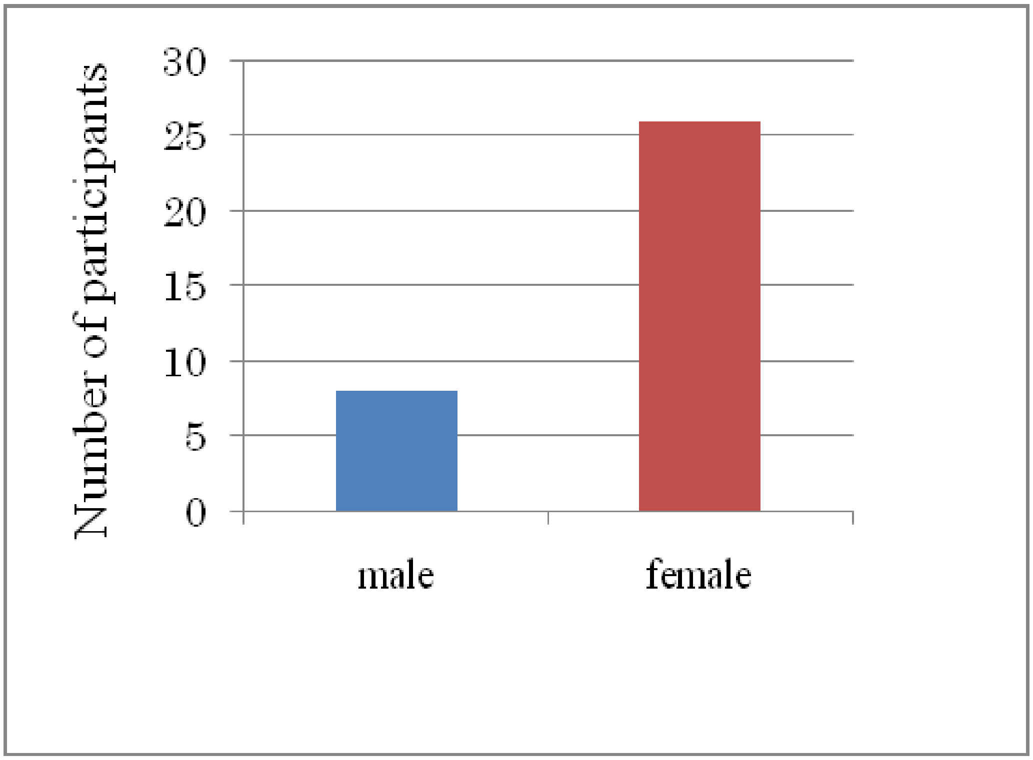


Figure 2. Number of participants by class

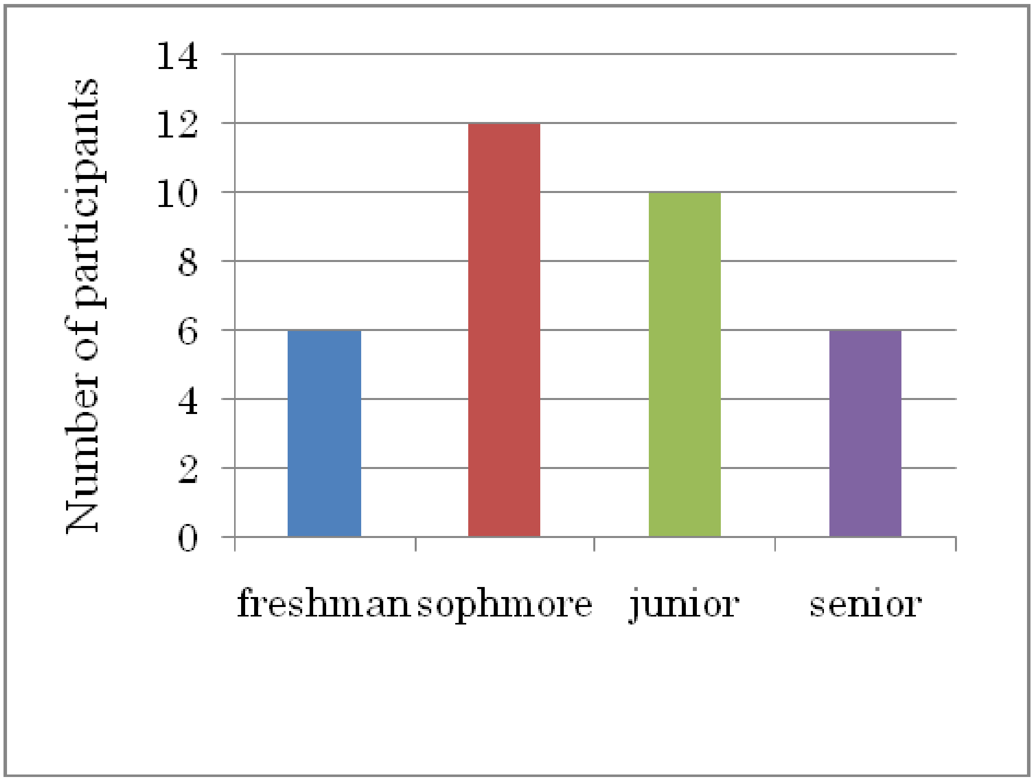
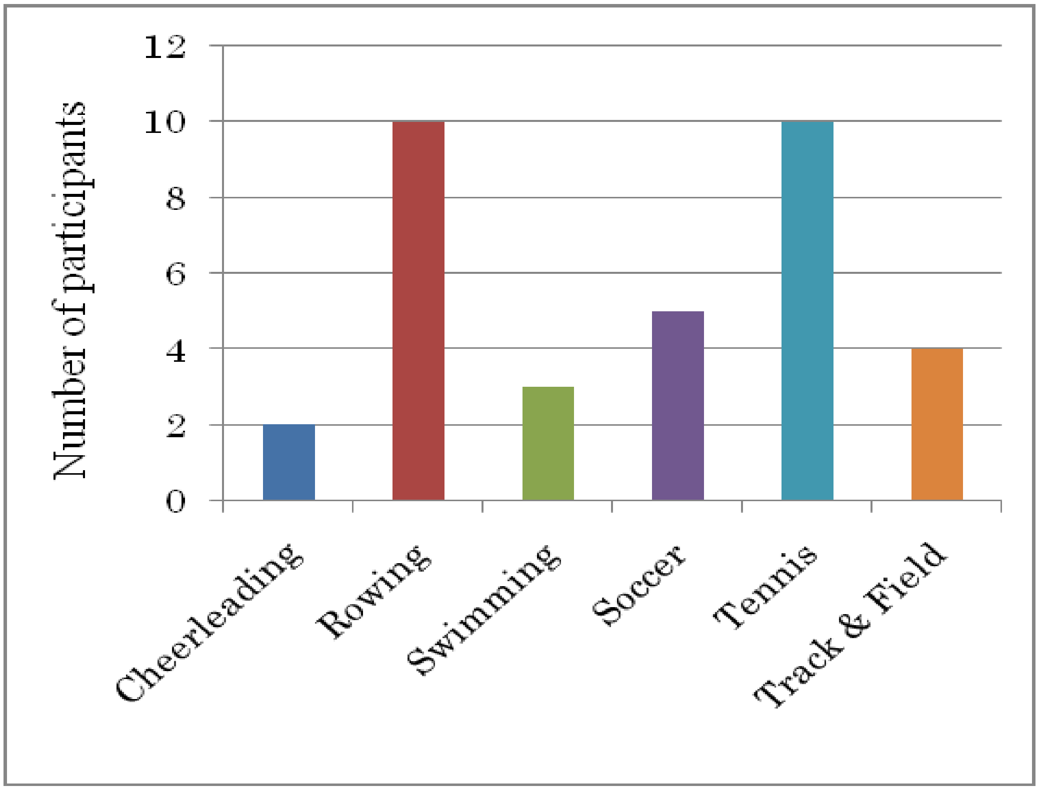


Figure 3. Number of participants by sports



the past 3 months (Fig 4). Five (63%) of the male student-athletes had a chronic injury and three (38%) had an acute injury. Ten (38%) of the female student-athletes had a chronic injury and ten (38%) had an acute injury. Seventy-five percent of the participating student-athletes from track and field and 67% of those from swimming reported having a chronic injury while 60% of those from soccer reported having an acute injury. The high rate of injury among student-athletes participating in women's soccer is consistent with results of a 2003-2004 survey by the National Collegiate Athletic Association Injury Surveillance System (NCAA ISS), in which student-athletes participating in women's soccer were second to football in injury rate during practices (24).

In response to a question asking if they wake up during the night, 13 (38%) answered yes and 21 answered no (Fig 5). Two (25%) of the male student-athletes reported waking up during the night including one who did not report a chronic injury and one who did report a chronic injury. Eleven (42%) of the female student-athletes reported waking up during the night. Five of those reported having a chronic injury and six (38%) did not report a chronic injury.

Figure 4. Incidence of chronic injury and acute injury

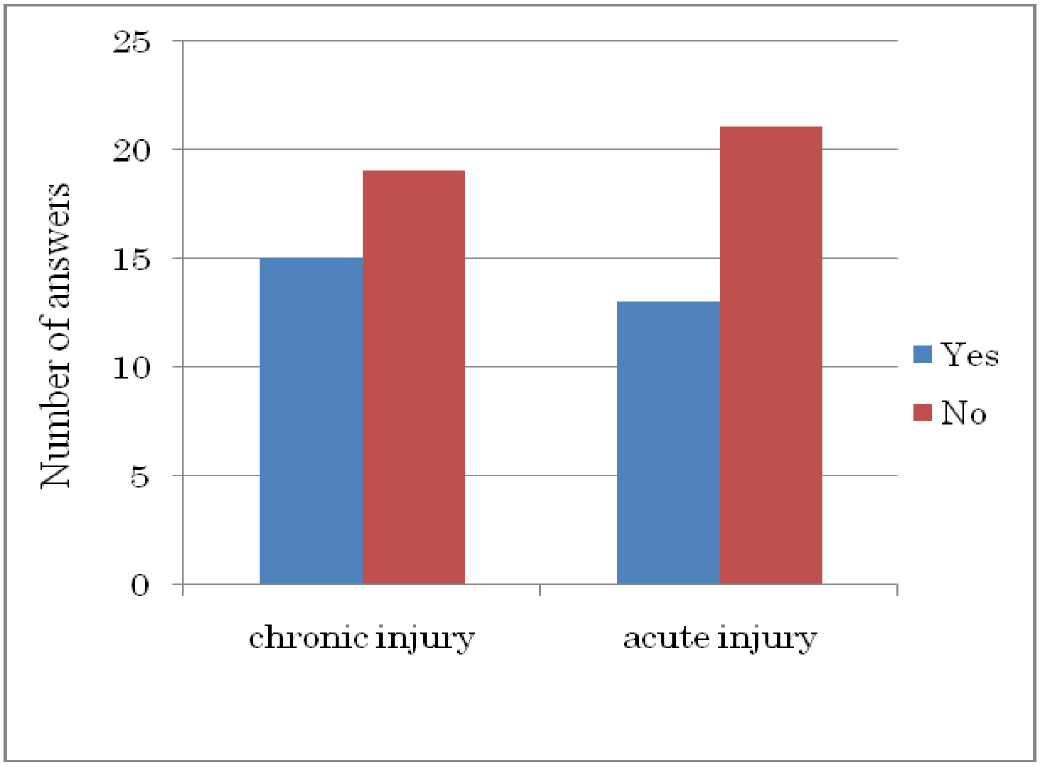
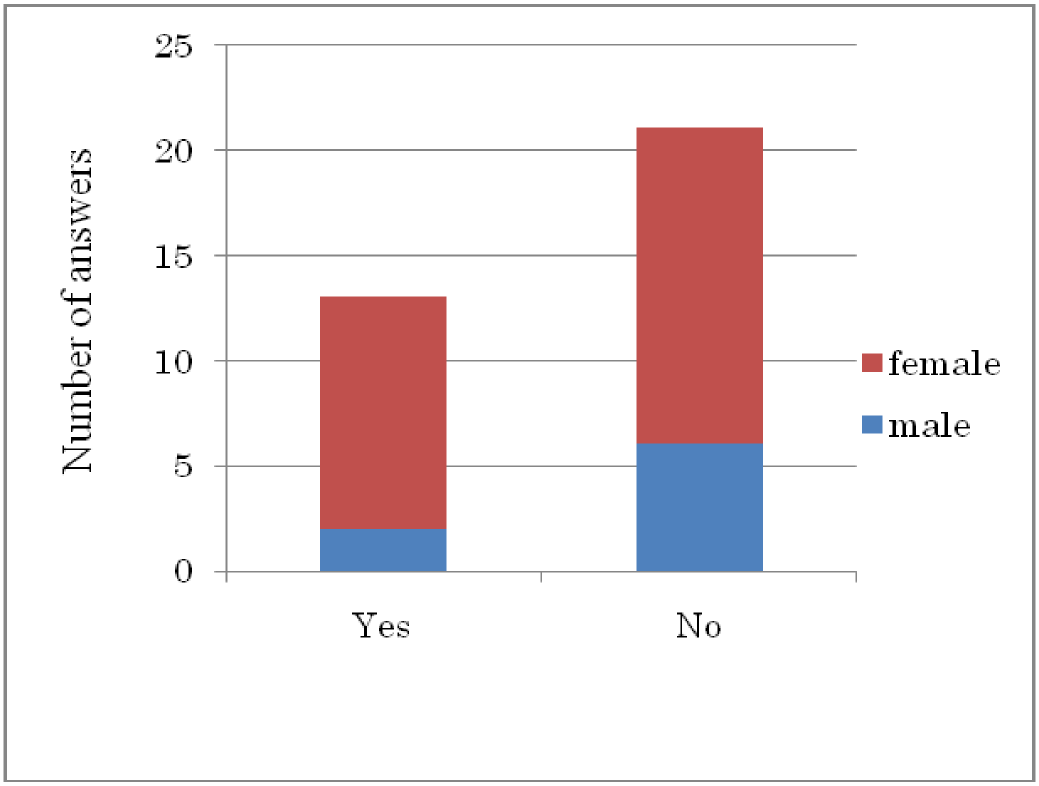


Figure 5. Number of athletes who wake up during night



Body Composition

Student-athletes who participated in this study were asked to self-report body height and weight; body mass index (BMI) was calculated from those self-reported data. Dekkers et al. (25) found that self-reported BMI were satisfactorily accurate even though body weight was under-reported and height was over-reported. The average BMI for males was 23.1±1.3 and for females was 23.7±3.1. According to the Centers for Disease Control and Prevention (CDC), during 2003-2006, the mean BMI of 20-29 year old males in the U.S. was 26.5 and of females was 27.0 (26). Thus, the student-athletes who participated in this study had lower BMI than the national average. There was no correlation between BMI and incidence of chronic injury. However, in both males and females, average height, weight, and BMI were noticeably higher in student-athletes with a chronic injury than in those with no chronic injury (Table 1). This finding could be explained by the characteristics of chronic injury. Repeated over stress is one of the causes of chronic injury. Since taller and heavier athletes have more biomechanical stress on their muscles and joints, they may be expected to sustain more injuries.

Dietary Macronutrient Intake

Acceptable macronutrient distribution ranges (AMDR) established by the

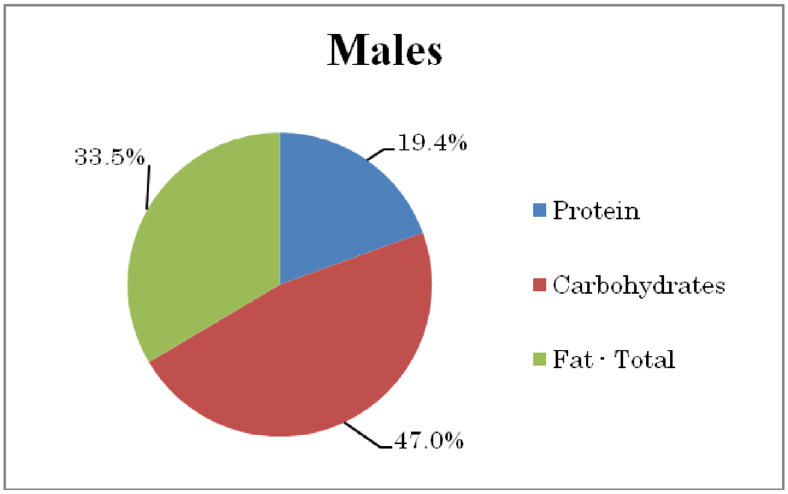
Table 1. Body Composition of Student-Athletes

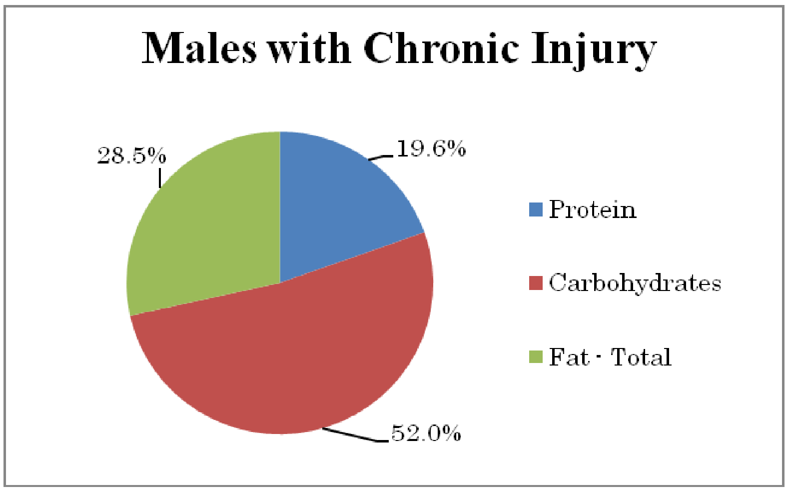
	Number	height (cm)	weight (kg)	BMI
Males	8	180.7±9.2	75.5±9.8	23.1±1.3
Males with chronic injury	5	184.9±8.9	79.6±9.9	23.2±1.3
Males with no chronic injury	3	173.6±3.9	68.8±5.3	22.8±1.7
Females	26	168.3±7.3	66.9±9.5	23.7±3.1
Female with chronic injury	10	170.0±7.8	69.4±10.4	24.1±3.8
Females with no chronic injury	16	167.2±7.0	65.4±8.8	23.4±2.6

Institute of Medicine indicate that no more than 30% of energy should come from fat and no more than 15% should come from protein, and the remaining percentage should come from carbohydrates. Male student-athletes in this study consumed 47.0±1.8% of their energy from carbohydrates and 33.5±1.4% from fat, which compares favorably to the national average of 50.0% and 32.1%, respectively (27). Female student-athletes consumed 49.6±3.8% of their energy from carbohydrates and 33.8±1.4% from fat, while the national averages are 52.6% from carbohydrates and 32.3% from fat (27). The mean percent of energy from protein for the student-athletes participating in this study was 19.4±1.2% for males and 16.5±1.2% for females; these data are higher than national averages for 20-39 year old males of 14.9% and 14.6% for 20-39 year old females (27). The American College of Sports Medicine recommends a protein intake for power (strength or speed) athletes of 1.6-1.7 g/kg/day and for endurance athletes of 1.2-1.6 g/kg/day. Mean protein intake for the male student-athletes in the present study was 1.6±0.5 g/kg/day and for females was 1.3±0.4 g/kg/day, which are consistent with those recommendations (Fig 6).

Athletes have a greater need for energy than more sedentary individuals. The student-athletes in the present study consumed less than the recommended energy intake of 3000 kcal for male and 2400 kcal for females aged 19-30 years. The males

Figure 6. Macronutrient Distribution Percentages for male student-athletes.





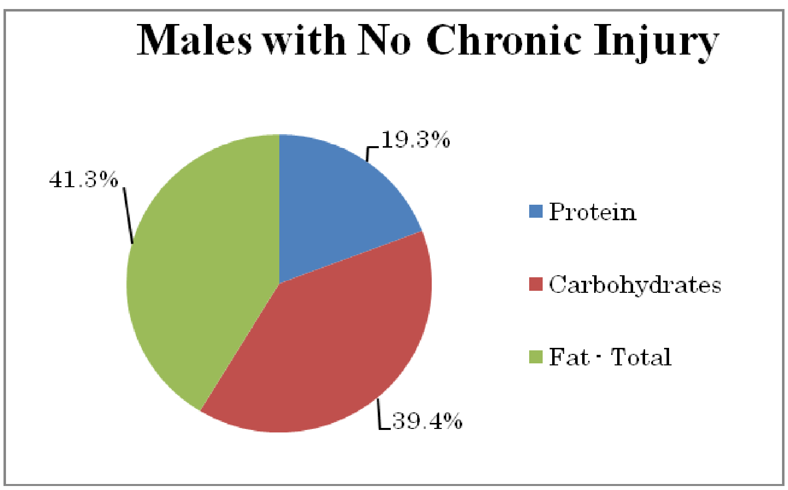
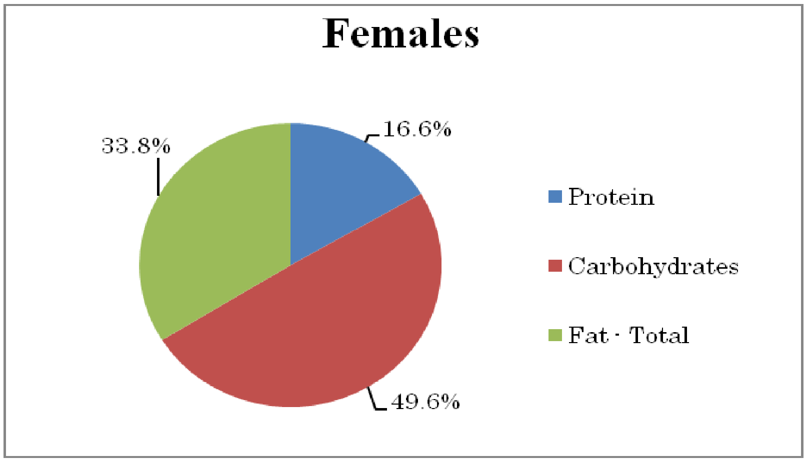
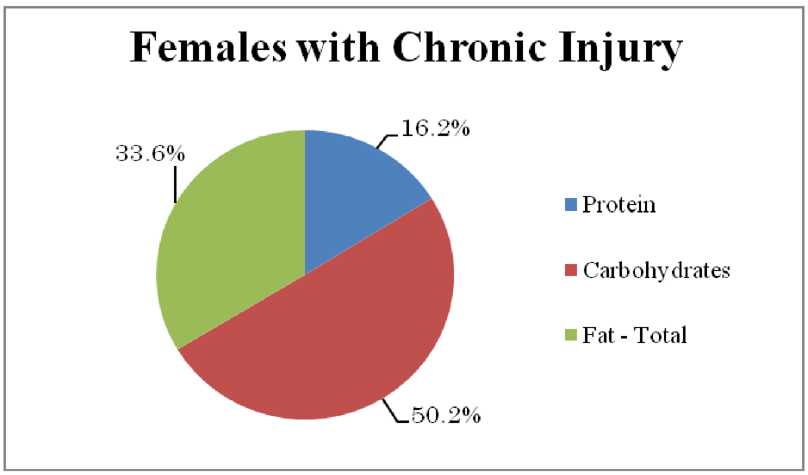
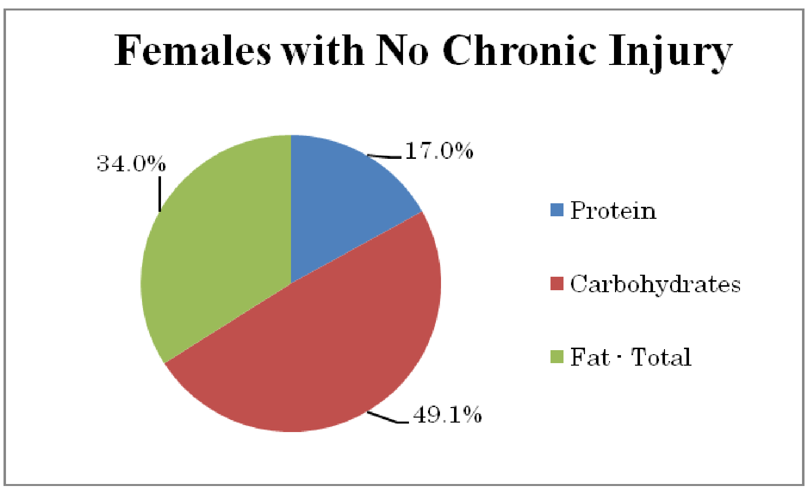


Figure 7. Macronutrient Distribution Percentages for female student-athletes.







consumed 2410.8±368.5 kcal (80.4±12.3%) and the females consumed 1990.2±514.4 kcal (82.9±21.4%). These numbers are also less than the 2825 kcal energy intake for males and the 2028 kcal energy intake for females in the 20-39 age group reported by CDC from 1999-2000 (27).

Nutrient Intake

Intake of energy, protein, carbohydrates, sugar, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, vitamin A, vitamin B_6, vitamin C, vitamin E, folate, iron, magnesium, potassium, sodium, and zinc were calculated and compared to the Dietary Reference Intakes (Table 2). Males consumed 5613.8±1473.4 mg (194.0±40.6% DV) while females consumed 4018.5±1481.2 mg (168.3±30.5% DV) of sodium. These values were higher than the 4329 mg of sodium consumption for males and 3161 mg for females age 20-39 years reported by CDC (27). Although it is recommended that some athletes replace electrolytes lost during sweating, the student-athletes from this study consumed more sodium than would be required for electrolyte replacement.

According to CDC (27), mean iron intake for the 20-39 year age group in 1999-2000 was 17.9 mg for males and 13.7 mg for females while male student-athletes consumed 15.1±4.0 mg (69.8±9.5% DV) and female student-athletes

Table 2. Nutrient Intake as a Percentage of the Recommended Daily Intake by Student-Athletes

	Males (n = 8)	Males with chronic injury (n = 5)	Males with no chronic injury (n = 3)	Females (n = 26)	Females with chronic injury (n = 10)	Females with no chronic injury (n = 16)
Calories	80.4±11.5	78.2±13.2	84.0±6.2	82.9±11.2	96.6±7.6	74.4±12.3
Protein	197.3±27.9	164.7±23.7	195.3±19.7	170.1±21.2	165.7±17.6	173.7±22.5
Carbohydrates	79.6±8.6	72.9±8.9	66.7±2.9	84.7±11.4	85.9±9.5	83.8±11.9
Fat - Total	116.3±21.2	82.0±15.0	143.3±18.2	118.5±19.5	117.9±14.3	119.1±21.9
Saturated Fat	111.9±17.2	79.9±12.8	136.2±11.2	109.8±18.1	106.7±13.9	112.4±20.9
Vitamins						
Vitamin A	134.6±76.3	161.1±81.3	42.0±2.5	121.2±71.5	75.7±27.0	158.1±90.3
Vitamin-B6	70.1±14.0	60.0±12.2	66.8±11.7	74.2±19.9	65.4±12.7	81.3±25.1
Vitamin C	158.4±48.4	146.2±49.5	130.7±30.4	105.8±34.1	94.4±23.2	115.0±42.6
Vitamin E	23.3±6.8	20.2±6.2	21.6±5.5	30.3±9.0	24.2±4.0	35.3±12.1
Folate	39.1±9.6	35.6±9.6	33.1±5.7	71.5±24.3	70.5±21.9	72.3±26.5
Minerals						
Iron	69.8±9.5	62.6±9.3	60.9±4.2	91.4±21.0	91.0±21.0	91.7±20.2
Magnesium	57.1±11.4	51.4±11.5	49.6±7.0	54.0±9.4	45.5±5.9	60.9±11.3
Potassium	59.3±11.8	52.5±11.2	53.1±7.2	52.3±8.1	44.8±6.9	58.3±9.2
Sodium	194.0±40.6	159.7±41.9	196.5±17.5	168.3±30.5	164.7±23.1	171.2±33.7
Zinc	67.7±14.4	58.0±13.2	64.1±11.3	56.1±11.2	45.2±7.5	65.0±13.8

Yellow cells indicate consumption is less than 67% of the Daily Value while blue cells indicate consumption exceeds the Upper Tolerable Level.

consumed 16.4±8.7 mg (91.4±21.0% DV). For zinc, CDC (27) reported a mean intake for males of 14.8 mg and for females of 10.1 mg while male student-athletes consumed 12.2±5.2 mg (67.7±14.4% DV) and female student-athletes consumed 8.4±3.3 mg (56.1±11.2% DV).

None of the student-athletes who participated in this study met the Recommended Dietary Allowance (RDA) for potassium. More than 85% of the student-athletes failed to meet the RDA for Vitamin E (87.5% of males and 96.2% of females) and magnesium (87.5% of males and 88.5% of females). None of the male student-athletes met the RDA for folate. The mean folate intake for male student-athletes was 188.4±112.2 mcg, which was 43% of the 435 mcg intake reported for males by the CDC aged 20-39 years (27).

Times of consumption of nutrients were compared between athletes who reported chronic injuries and those who reported no chronic injuries. Intakes were calculated for day (5am – 5pm), evening (5pm – 9pm), and night (9pm – 12am) time periods. There were no significant differences in intake of any nutrient at any time period between athletes who reported chronic injuries and those who reported no chronic injury ($\alpha=0.05$).

Night Snack, Sleep Disturbance, and Chronic Injury

Energy intake late at night has been reported to cause sleep disturbance (7). However, a logistic regression analysis indicated that calorie intake was not a significant predictor of the incidence of awaking during the night (p=0.65). That may be because the average consumption (130.2±263.1 kcal in males and 113.2±89.7 kcal in females) at the night time period were not enough energy to cause sleep disturbance or to cause a sleep disturbance that resulted in waking. Contrarily, an athlete could wake up because of fatigue, stress, or reasons other than energy intake.

However, energy intake at night was a good predictor of chronic injury. A logistic regression analysis indicated that the odds ratio for energy intake between 9 pm and 12 am was 1.009, this means that the odds of sustaining a chronic injury were estimated to increase by a factor of 1.009 for every calorie consumed between 9 pm and 12 am (Table. 3). The odds ratio jumps up to 6.542 when a student-athlete consumes 100 kcal during the time period. This increase may be associated with greater height, weight, and BMI in athletes who have chronic injuries. It is not certain why the odds of chronic injury increased with calories consumed at night since calorie intake was not a significant predictor of the incidence of awaking during the night. However, results of this study suggest that not eating late at night may be beneficial in decreasing the incidence of chronic injury.

A logistic regression analysis was conducted to determine the relationship between calorie intake at the night snack and incidence of chronic injury. The odds ratio associated with a one unit increase in calorie intake at the night time snack was 1.009 ($p < .05$). As an example of how this may be applied in our study sample, a 100 calorie night time snack is expected to increase the odds of sustaining a chronic injury by a factor of 6.542. The following logistic model developed in this study produced a single logit for every individual student athlete. The predicted logit below was used to compute the probability of sustaining chronic injury.

Predicted logit of (SUSTAINING CHRONIC INJURY) = -1.2310+ (1.009)*CALORIES

Table 4 shows three tests of the overall model fit, which suggest that the logistic model is more effective than the null model (one containing only the intercept). The c statistic was computed to assess the predicted probabilities produced by the logistic regression equation. The resulting c statistic of 0.712 indicates that for 71.20% of all possible pairs of student-athletes, the model correctly assigned a higher probability of sustaining a chronic injury to those who actually reported sustaining one. (In making this interpretation, one member of the pair is hypothesized to have reported having a sustained chronic injury and the other member is hypothesized as not having reported one.) The c statistic can be used to compare this model applied to different datasets, or to compare different models applied to this dataset.

Table 3. Logistic Regression Summary

Variable	Effect	S.E.	Odds Ratio		
			Estimate	95% Confidence Interval	
Calories	0.00903*	0.00413	1.009	1.001	1.017
Constant	-1.2310				

*Significant at 0.05 level.

Table 4. Goodness of Overall Model Fit

Test	Chi Square	DF	p
Likelihood Ratio	7.0511	1	0.0079
Score	5.6443	1	0.0175
Wald	4.7931	1	0.0286
Hosmer-Lemeshow	4.1170	6	0.6610 ns

Note: In this study, the Hosmer-Lemeshow statistic is based on grouping individual student athletes with respect to their probability of sustaining chronic injury. When the null is not rejected, expected frequencies of incurring chronic injury tend to match the observed frequencies, and model fit is supported.

CHAPTER FOUR
CONCLUSION

Of the student-athletes who participated in the present study, 44% reported having a chronic injury and 38% reported sustaining an acute injury in the past 3 months. Eighty-eight percent of the male and 65% of the female student-athletes reported either a chronic or acute injury.

Average BMI was within normal ranges for both male and female student-athletes and, while BMI is not a significant predictor of the incidence of chronic injury, average BMI was noticeably higher among those athletes who reported a chronic injury.

The student-athletes consumed slightly more of their energy from protein and slightly less from carbohydrate than the recommendations, but are within the American College of Sports Medicine guidelines for protein intake per unit body weight. Overall, student-athletes consumed less energy, potassium, magnesium and vitamin E than recommended; male participants also failed to meet the recommended folate intake. Intake of sodium was much higher than the recommendations. Nutrient intakes during the day, evening, and at night did not differ among the student-athletes or by injury status. However, there was an increased odds ratio for energy intake at night and the incidence of chronic injury.

CHAPTER FIVE
IMPLICATIONS AND RECOMMENDATIONS

The majority of student-athletes are living independently for the first times in their lives. This also means that they have complete control over their food intakes for the first time. Many also have a limited knowledge of nutrition. Providing nutrition education that addresses many of the potential deficiencies identified in this study during their orientation as student-athletes may improve their nutrient intake and their performance. Also, providing nutrition education for athletic trainers who work with the student-athletes every day can have a great impact on student-athletes and can further prepare the athletic trainers for their important role as an allied health care profession.

This study could be improved by recruiting student-athletes from variety of sports, such as football linemen. Many of the participants in this study were endurance athletes and inclusion of power athletes could strengthen the results. Also, the accuracy of the food intake records could be improved by interviewing student-athletes regard to their food intake record when they turn it in.

APPENDIX

Script for introducing study.

"We want to let you know about a new study on the relationship of eating and sleep patterns on incidence of injury in student athletes that I am conducting. This study will be the basis of my masters degree thesis in nutrition and will help us understand if there are relationships between time of eating, amount of sleep you get and incidence of injuries. If you might want to participate in this study, please let me know before Thanksgiving.
Thanks!"

Physical and Nutritional Health Survey

I would like to ask you a few questions about your basic information and three days of daily food intake as part of my research project. Result of this study will help us understand the relationship between the timing of food intake and athletic injuries in college athletes. You and others who are in the Clemson athletic teams will be asked to participate in this voluntary study. I am asking you to fill out this survey and record your food intake for 3 days. The total time to participate in this study will be about 1 hour.

You may choose not to answer any question that you do not wish to answer. You may also choose not to complete the survey. To make sure your answers are not identifiable, please do not put your name on the survey. Your decision to participate in the study or not will not affect your future relationship with Clemson University or the athletic department.

If you have any questions about this study, please contact Yasuaki Okawa (athletic training room: 864-656-1952) or Dr. Beth Kunkel (864-656-5690). If you have any questions about your rights as a research participant, please contact the Clemson University Institutional Review Board at 864-656-6460. Thank you for your help with this research project.

Sincerely,

Yasuaki Okawa

This survey is going to be used for my research about the relationship between the timing of eating food and injury. Therefore, please be accurate recording the time and food that you eat.

Please answer the following questions.

1. Are you: ____ male ____ female
2. What is your student classification?
   ____freshman
   ____sophomore
   ____junior
   ____senior
3. What is your current height in inches? ____________________
   What is your current weight in pounds? ________________________
4. In what sport(s) do you compete? ______________________
5. Do you wake up during the night?
   Yes No
6. If yes, how many times do you wake up each week? ______________
7. Have you had any chronic injury* in the past 3 months?
   Yes No

   *chronic injury: gradual onset, a long duration.
   Ex. My lower back hurts, My shoulder hurts when I throw.

8. If yes, which body part? when did it start? How long does it last?
   Ex. Shoulder / the beginning of August / 3 weeks

9. Have you had any acute injury* in the past 3 month?
   Yes No

   *acute injury: Usually you know what happened and short period.
   Ex. A baseball hit my knee, someone kicked my shin…

10. If yes, which body part?, when did the injury occur?
   Ex. Knee / August 5

Food Record Example

Date	10/21		
Wake up time	5:30 AM		
Time	food consumed	preparation method	amount consumed
6:00 AM	egg biscuit Whole Miik	scrambled baked	1 3 inch 8 oz
12:30 PM	cheese burger french fries coke	Burger King	1 1 small 16 oz
6:30 PM	salad ranch dressing pasta meat source orange juice	café	1 plate 1 table spoon 1 plate 2 c 8 oz
10:30 PM	PB&J coffee cream sugar	 starbucks	2 slice white bread 1T PB, 1T grape jelly 8 oz 1 table spoon 1 pkt
Time to bed	11:00 PM		
Time of practice (or work out)	7:00am - 8:00am	3:30pm - 6:00pm	

Day 1

Date			
Wake up time			
Time	food consumed	preparation method	amount consumed
Time to bed			
Time of practice (or work out)			

Day 2

Date			
Wake up time			
Time	food consumed	preparation method	amount consumed
Time to bed			
Time of practice (or work out)			

Day 3

Date			
Wake up time			
Time	food consumed	preparation method	amount consumed
Time to bed			
Time of practice (or work out)			

Clemson University

Institutional Review Board (IRB)

Principal Investigator's Responsibilities

The Principal Investigator (PI) bears direct responsibility for the implementation of the research and for ensuring the protection of human participants in research. The PI must be knowledgeable about federal regulations and institutional policies and procedures related to the conduct of research. The following lists the major responsibilities of the PI. A more detailed description of the PI's responsibilities is included in the Investigator's Manual (document is posted on the IRB website: http://www.clemson.edu/research/orcSite/orcIRB.htm).

The PI must ensure that:

- all members of the research team comply with the findings, determinations, and requirements of the IRB.
- all student members of the research team are provided appropriate supervision.
- continuing review and approval of the research has been accomplished within the time frame stipulated by the IRB.
- any changes in research activity, including changes to the protocol, and/or consent form(s), completion or termination of the study, are promptly reported to the IRB. No change in approved research may be initiated without the IRB's approval except under conditions where it is necessary to eliminate apparent immediate hazards to human participants.
- no research is continued beyond the designated approval period.
- any unanticipated problems involving risk to subjects and others, and any adverse events are reported immediately to the IRB.

- any non-compliance with applicable regulatory requirements or determinations is reported immediately to the IRB.

- the protocol number and title of the research are cited in all correspondence to the IRB.

- any significant new information that may affect the risk/benefit ratio is submitted promptly to the IRB.

- for every expedited / full review IRB protocol, all signed consent forms (if applicable) are maintained for at least three (3) years after completion of the study and are available for Office of Research Compliance staff to review.

- only consent/assent/parental permission forms stamped with the current approval and expiration dates may be presented to the research participants.

- requests for information from the IRB are responded to in a timely fashion.

Clemson University

Institutional Review Board (IRB)

Responsibilities for Members of the Research Team

Co-investigators, research assistants, students, and all other research personnel must have IRB training and have a strict obligation to:

- Comply with research ethics and the protection of human subjects.
- Comply with all IRB determinations and procedures.
- Review the approved protocol.
- Adhere rigorously to all protocol requirements.
- Promptly inform the principal investigator of all adverse subject reactions or unanticipated problems.
- Ensure the adequacy of the informed consent process.
- Take measures necessary to ensure adequate protection for subjects.

Researchers and administrators at every level are responsible for notifying the IRB promptly of any non-compliance with any applicable IRB or University policies of which they become aware, whether or not they themselves are involved in the research.

REFERENCES

1. Badiu C. Genetic clock of biologic rhythms. *J Cell Mol Med*. 2003;7:408-416.

2. Illi B, Gaetano C, Capogrossi MC. How senescent vascular cells lose their clock age-dependent impairment of circadian rhythmicity in smooth muscle cells. *Circ Res*. 2006;98:119-126.

3. Mendoza J, Graff C, Dardente H, Pevet P, Challet E. Feeding cues alter clock gene oscillation and photic responses in the suprachiasmatic nuclei of mice exposed to a light/dark cycle. *J. Neurosci.* 2005;25(6):1514-1522.

4. McCarthy JJ, Andrews JL, McDearmon EL, Campbell KS, Barber BK, Miller BH, Walker JR, Hogenesch JB, Takahashi JS, Esser KA. Identification of the circadian transcriptome in adult mouse skeletal muscle. *Physiol Genomics*. 2007;31:86-95.

5. Sheward WJ, Maywood ES, French KL, Horn JM, Hastings MH, Seckl JR, Holmes MC, Harmar AJ. Entrainment to feeding but not to light: circadian phenotype of VPAC2 receptor-null mice. *J. Neurosci*. 2007;27(16):4351-4358.

6. Striegel-Moore RH, Franko DL, May A, Ach E, Thompson D, Hook JM. Should night eating syndrome be included in the DSM? *Int J Eat Disord*. 2006;39(7):544-549.

7. O'Reardon JP, Peshek A, Allison KC. Night eating syndrome diagnosis, epidemiology and management. *CNS Drugs*. 2005;19(12):997-1008.

8. Berger AM, Hobbs BB. Impact of shift work on the health and safety of nurses and patients. *CJON*. 2006;10(4):465-471.

9. Reilly T, Edwards B. Altered sleep-wake cycles and physical performance in athletes. *Physiology & Behavior*. 2007;90:274-284.

10. Halson SL. Nutrition, sleep and recovery. *European J of Sport Science*. 2008;8(2):119-126.

11. Haack M, Mullington JM. Sustained sleep restriction reduces emotional and physical well-being. *Pain*. 2005;119:56-64.

12. Adam K, Oswald I. Protein synthesis, bodily renewal and the sleep-wake cycle. *Clin. Sci.* (Lond.) 1983;65:561-567.

13. Sassin JF, Parker DC, Mace JW, Gotlin RW, Johnson LC, Rossman LG. Human growth hormone release: relation to slow-wave sleep and sleep-walking cycles. Science. 1969;165:513-515.

14. Van Cauter E, Caufriez A, Kerkhofs M, Van Onderbergen A, Thorner MO, Copinschi G. Sleep, awakenings, and insulin-like growth factor-I modulate the growth hormone (GH) secretory response to GH-releasing hormone. *J. Clin. Endocrinol. Metab*. 1992;74:1451-1459.

15. Irwin MR, Wang M, Ribeiro D, Cho HJ, Olmstead R, Breen EC, Martinez-Maza O, Cole S. Sleep loss activates cellular inflammatory signaling. *Biol psychiatry*. 2008;64:538-540.

16. Chang HM, Mai FD, Chen BJ, Wu UI, Huang YL, Lan CT, Ling YC. Sleep deprivation predisposes liver to oxidative stress and phospholipid damage: a quantitative molecular imaging study. *J. Anat*. 2008;212:295-305.

17. Irwin MR, Thompson J, Miller C, Gillin JC, Ziegler M. Effects of sleep and sleep deprivation on catecholamine and interleukin-2 levels in humans: clinical implications. *J. Clin. Endocrinol. Metab*. 1999;84:1979-1985.

18. Leproult R, Copinschi G, Buxton O, Van Cauter E. Sleep loss results in an elevation of cortisol levels the next evening. *Sleep*. 1997;20:865-870.

19. Spiegel K, Leproult R, Van Cauter E. Impact of sleep debt on metabolic and endocrine function. *Lancet*. 1999;354:1435-1439.

20. Benca RM, Quintans J. Sleep and host defenses: a review. *Sleep*. 1997;20:1027-1037.

21. Marshall L, Born J. Brain-immune interactions in sleep. *Int. Rev. Neurobiol*. 2002;52:93-131.

22. Opp MR, Toth LA, Neural-immune interactions in the regulation of sleep. *Front. Biosci*. 2003;8:d768-d779.

23. Ranjbaran Z, Keefer L, Stepanski E, Farhadi A, Keshavarzian A. The relevance of sleep abnormalities to chronic inflammatory conditions. *Inflamm. Res*. 2007;56:51-57.

24. Friery K. Incidence of injury and disease among former athletes: a review *J. Exercise Phys*. 2008;11(2):26-45.

25. Dekkers JC, Wier MFV, Hendriksen IJM, Twisk JWR, Mechelen WV. Accuracy of self-reported body weight, height and waist circumference in a Dutch overweight working population. *BMC Medical Research Methodology*. 2008;8(69):1-13.

26. Ogden CL, Fryar CD, Carroll MD, Flegal KM. Mean body weight, height, and body mass index, United States 1960–2002. Advance data from vital and health statistics; no 347. Hyattsville, Maryland: National Center for Health Statistics. 2004.

27. Wright JD, Wang CY, Kennedy-Stephenson J, Ervin RB. Dietary intake of ten key nutrients for public health, United States: 1999-2000. Advance data from vital and health statistics; no 334. Hyattsville, Maryland: National Center for Health Statistics. 2003.