2015

THE EFFECT OF TRAINING AND NUTRITION ON THE BODY COMPOSITION OF COLLEGE FOOTBALL PLAYERS

Lindsey Marie Goderwis
University of Kentucky, lmgo223@g.uky.edu

STUDENT AGREEMENT:

I represent that my thesis or dissertation and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained needed written permission statement(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine) which will be submitted to UKnowledge as Additional File.

I hereby grant to The University of Kentucky and its agents the irrevocable, non-exclusive, and royalty-free license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless an embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

REVIEW, APPROVAL AND ACCEPTANCE

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's thesis including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Lindsey Marie Goderwis, Student

Dr. Janet S. Kurzynske, Major Professor

Dr. Kelly Webber, Director of Graduate Studies

THE EFFECT OF TRAINING AND NUTRITION ON THE
BODY COMPOSITION OF COLLEGE FOOTBALL PLAYERS

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Agriculture, Food and Environment
at the University of Kentucky

By

Lindsey Marie Goderwis, RD, LD

Lexington, Kentucky

Director: Dr. Janet S. Kurzynske, PhD, RD, Extension Professor of Dietetics and
Human Nutrition

Lexington, Kentucky

2015

ABSTRACT OF THESIS

THE EFFECT OF TRAINING AND NUTRITION ON THE
BODY COMPOSITION OF COLLEGE FOOTBALL PLAYERS

The body size of American football players has changed over time. The known health implications of overweight and obesity make it important for football players to understand how to increase size without increasing body fat. The purpose of this study was to evaluate the effect of an increased emphasis on training and nutrition on the body composition of college football players. The sample included 68 football players. Paired t-tests were performed to compare percent fat and body mass index (BMI) at three points in time, all of which were during the off-season. A significant decrease in percent fat and BMI was found from January of 2013 to May of 2013 and a non-significant increase in percent fat and BMI was found from May of 2013 to August of 2013. A significant decrease in percent fat and BMI was found for the duration of the data collection period, or between January of 2013 and August of 2013. Results suggest that increasing the emphasis on training and nutrition among college football players leads to the improvement of body composition.

KEYWORDS: Body Composition, College Football Players, BOD POD®, Football Training, Nutrition

Lindsey Marie Goderwis

April 22, 2015

THE EFFECT OF TRAINING AND NUTRITION ON THE
BODY COMPOSITION OF COLLEGE FOOTBALL PLAYERS

By

Lindsey Marie Goderwis

Janet Kurzynske, PhD, RD
Director of Thesis

Kelly Webber, PhD, MPH, RD, LD
Director of Graduate Studies

April 22, 2015

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1: Introduction

In the late 1970s and early 1980s, amendments to the rules of the game of football changed the qualifications of the players forever (Tucker, et al., 2009). Permitting more use of hands in both pass and run blocking by offensive linemen put an importance on speed and swiftness, not just size (Tucker, et al., 2009). During the past 30 years, the body mass index (BMI) of both offensive and defensive linemen has increased significantly (Kraemer, et al., 2005). In 2003, BMIs classified as obese were reported in more than 25% of National Football League (NFL) players (Harp & Hecht, 2005). Statistics such as these create concern for the consequences of large size among not only NFL players, but college players who aspire to be drafted by a professional team. In fact, a recent study found that the body weight of college football players in all positions groups has also increased significantly over time (Anzell, et al., 2013). The known health implications of overweight and obesity make it important for players and football team staff to understand how to increase size without increasing body fat.

Chapter 2: Literature Review

The purpose of this study was to assess the effect of an increased emphasis on training and nutrition on the body composition of college football players. The following review of literature will discuss the current information on overweight and obesity in football players, issues with the BMI measurement of the body composition of athletes, the BOD POD® as a measurement of the body composition of athletes, and the dietary practices of college athletes.

Overweight and Obesity in Football Players

It is apparent that the body size of American football players has changed over time. Several studies have been conducted to assess if this increase in body size has come with an increase in body fat. The *Journal of Strength and Conditioning Research* documented the changes in height, weight, and body composition of American football players from 1942 to 2011. Fifty-five studies were reviewed. The data were divided into three groups: mixed linemen, mixed offensive backs, and mixed skilled players. It was found that the average change in height for every year was -0.048 to 0.502 cm for mixed offensive backs, 0.034 to 0.188 cm for mixed linemen, -0.073 to 0.119 cm for mixed skilled, and -0.011 to 0.112 cm for all positions combined. The average change in weight was 0.089 to 0.208 kg for mixed offensive backs, 0.338 to 0.900 kg for mixed linemen, 0.078 to 0.334 kg for mixed skilled, and 0.160 to 0.570 kg for all positions combined. The average change in body composition was -0.133 to 0.127% fat for mixed offensive backs, 0.046 to 0.275% fat for mixed linemen, -0.053 to 0.164% fat for mixed skilled, and 0.030 to

0.278% fat for all positions combined. These changes represented a significant increase in height for mixed lineman, a significant increase in weight for mixed lineman, mixed skilled players, and all players combined, and a significant increase in percent body fat for mixed lineman and for all players combined (Anzell, et al., 2013). Results of this research show there was a significant increase in weight and percent body fat among college football players from 1942-2011.

Noel, et al. (2003) assessed the body composition of 69 division I football players and compared the findings with data from previous studies. Compared to players in studies from the 1980s and 1990s, current players were found to have greater total body mass and percent body fat. It was found that on average, linemen and tight ends had body fat percentages of greater than 25%. It was also found that most of this fat was accumulated in the abdominal region. Because recent research suggests a correlation between abdominal obesity and heart disease and stroke, it was concluded that more emphasis needs to be put on the way in which players increase body mass to decrease health issues in the future (Noel, et al., 2003).

The prevalence of overweight and obesity among football teams has also been studied. In 2008, eighty-five players from an NCAA Division I football team were assessed through BMI, percent body fat, and waist circumference measurements (Mathews & Wagner, 2008). Using BMI measurements, it was found that 81% of the players were overweight and 35% were obese. However, when compared to percent body fat measurements, 26 players had been misclassified as overweight and 15 had been misclassified as obese. This supports the position that BMI is not an accurate assessment of body composition in athletes. A measurement that includes an estimate of percent body fat is recommended. This being said, there is still reason for concern. After accounting for the inflation from the BMI measurements, 14 players (16%) and the average offensive linemen still surpassed the at-risk level for all three assessments- BMI > 30 kg/m^2, waist circumference > 102 cm, and percent body fat > 25%. The average percent body fat among the team was also found to be higher than players in similar studies over the past ten years (Mathews & Wagner, 2008). This supports the assertion that increases in body mass in American football players are indeed accompanied by increases in percent body fat. It also indicates that college football players are at risk for not only obesity, but obesity-related diseases.

Issues with the BMI Measurement

BMI, or Body Mass Index, is an indicator of body fatness that compares weight to height. It is calculated by the following formula: weight (kg) / [height (m)]^2. According to the American Council on Exercise, a BMI of less than 18.5 is considered underweight, a BMI of 18.5-24.9 is considered normal weight, a BMI of 25.0-29.9 is considered overweight, a BMI of 30.0-34.9 is considered grade I obesity, a BMI of 35.0-39.9 is considered grade II obesity, and a BMI of greater than 40 is considered grade III obesity (ACE, 2015). The effect of larger than average amounts of muscle mass on the BMI of athletes may misclassify them as overweight or obese. Because of this, using percent fat to assess the body composition of athletes may be more effective (Ode, et al., 2007). To examine the association between BMI and percent fat assessments in athletes, Lambert, et al. (2012) compared division 1-A college football players to an age-matched/gender-matched control group. The researchers used regression analysis to predict percent fat from BMI in both groups. BMI was found to predict percent fat differently between groups. The higher percentage of overweight and obesity among the football players was found to be due to larger amounts of fat-free mass. This indicates that the BMI measurement may misclassify athletes, specifically division 1-A college football players, as overweight and obese. A more accurate measurement should be used when assessing the body composition of athletes.

The BODPOD Measurement

The American Council on Exercise also provides ideal body fat percentages. For men, they consider greater than 25% to indicate obesity, 18-24% to be acceptable, 14-17% to be ideal for fitness, and 6-13% to be ideal for athletes (ACE, 2015). The BOD POD® was developed to assess percent fat quickly and easily. It is a two-compartment analysis instrument that measures fat mass and non-fat mass through air displacement plethysmography. It has been shown to be both a valid and reliable method for measuring body composition for the general population (Peeters & Claessens, 2011). In order to test its validity and reliability for athletes, Peeters and Claessens conducted a study on the BOD POD® and division 1-A college football players. The researchers assessed body composition using two methods- hydrostatic weighing and the BOD POD®. The first method is reliable but difficult, as subjects must be submerged in a tank of water and blow out all of the air in their lungs. The researchers compared the body compositions of each player between the two methods and found no significant difference. It was concluded that not only is the BOD POD® quick and easy, it is also reliable (Collins, et al., 1999).

However, the BOD POD® assessment does have limitations. Isothermal air on the body surface, in the lungs, in scalp hair, and trapped in clothing results in an overestimation of body density and an underestimation of percent fat if not accounted for (Peeters & Claessens, 2011). The BOD POD® accounts for isothermal air on the body surface and in the lungs, but tight-fitting clothing and a swim cap must be worn to minimize isothermal air in scalp hair and trapped in clothing. Differences among clothing and swim caps may skew results.

College Athletes and Diet

Athletes that advance to the college level must learn to make appropriate food choices in a new physical, social, and cultural environment (Long, et al., 2011). It is important for team coaches, trainers, exercise physiologists, and dietitians to understand the factors that affect those food choices so that they can provide the appropriate support for their players. In 2011, a theoretical model explaining the food choice process of college football players was developed (Long, et al., 2011). Fifteen football players that represented different positions, class levels, and ethnicities were interviewed on their dietary habits. The food choice process was found to be circular with time being the core category. The surrounding categories included routines, planned hydration, macronutrients, money value, meal themes, quick-fix meals, healthy food choices, and food-related decisions, in order. For example, a player who entered the cycle at “meal themes” reported considering how to fix a meal quickly. The two factors that affected food choices the most were academic and athletic schedules. It was concluded that the players chose meals based on their schedules while also considering their hydration status and the nutritional value of the meal. Football team staff should use these findings in developing or amending their nutrition programs.

College athletes have been found to be a group that is not following dietary recommendations for fruit and vegetable consumption (Cole, et al., 2005). In order to assess the diets of college football players, three-day diet records were collected from 28 NCAA Division I football players (Cole, et al., 2005). The diet records were collected during a time period when team meals were not provided. There was 100% compliance in maintaining the records. The accuracy of the records, however, could not be determined. The records were compared with the United States Department of Agriculture Food Guide Pyramid to assess fruit and vegetable consumption. The average daily fruit and vegetable consumption was found to be less than two servings. It was concluded that college athletes, specifically college football players, would benefit from nutrition education and nutritional screening.

College football players, especially freshmen, are often encouraged to increase their body weight. The long-term effects of this weight gain, however, are many times ignored to reach the short-term goals of increased body weight, improved athletic performance, etc. (Kirwan, et al., 2012). To assess the effects of weight gain practices, both positive and negative, fifteen players that were attempting to gain weight were studied during an 8-week training program (Kirwan, et al., 2012). Three-day diet records, body composition, blood lipids, and performance measures were collected before and after the eight weeks. It was found that reported energy, carbohydrate, and protein intake significantly increased during the program. Energy intake increased by 45%, carbohydrate intake increased by 82%, and protein intake increased by 29%. Fat intake was 41% of energy when the program began and 32% when the program ended. Increases in strength, power, speed, total body mass, muscle mass, and fat mass were also found. The researchers noted cholesterol and LDL levels related to higher risk for cardiovascular disease. It was concluded that nutrition education to promote weight gain while protecting the lipid profile is needed. Though some programs have implemented nutrition education, the previous studies indicate that overall, there is still a lack of nutrition knowledge among college football players.

In 2001, Jacobson, et al. compared the nutrition knowledge of division I college athletes with similar data collected in 1992. Surveys were completed at sixteen universities. The surveys indicated that women receive more nutrition information than men. The primary sources of nutrition information for women were college classes and nutritionists, while the primary sources for men were strength and conditioning coordinators and athletic trainers. Only 3% of athletes correctly identified the recommended percent of total calories for protein, only 11.7% correctly identified the recommended percent for fat, and only 29.5% correctly identified the recommended percent for carbohydrates. When compared with the surveys from1992, very little difference in nutrition knowledge was found. It was concluded that efforts to increase the nutrition knowledge of college athletes have been ineffective overall. College football programs must amend their nutrition education plans and Training Table provisions to better benefit their players.

In conclusion, studies suggest that increases in body mass in American football players have been accompanied by increases in percent body fat. This has put players at risk for obesity and obesity-related diseases. However, the BMI measurement may misclassify football players as overweight and obese. A more accurate measurement, such as the BOD POD®, should be used to assess the body composition of football players. Nutrition education is needed to teach football players how to increase body mass without increasing body fat.

Chapter 3: Research Purpose

The prevalence of overweight and obesity remain issues in the United States. According to "Prevalence of Overweight and Obesity in Collegiate American Football Players, by Position," "the 'supersizing' of America appears to be occurring in athletes as well as the general population" (Mathews & Wagner, 2008). In 2005, two authors from the Health, Physical Education, and Recreation Department at Utah State University, Logan reported in a letter to the *Journal of the American Medical Association* that 97% of National Football League (NFL) players were overweight and 56% were obese (Mathews & Wagner, 2008).

The research reported by the two authors, like most research on overweight and obesity, is based on body mass index (BMI) measurements. BMI is the ratio of body weight to height squared. Though BMI is commonly used to classify overweight and obesity, the measurement is limited. For instance, BMI does not consider the ratio of fat mass to fat-free mass. It only compares total weight to height- a one-compartment model. Because of this, individuals with larger than average amounts of muscle and bone mass, such as football players, might be misclassified as overweight or obese by BMI measurements.

Discrepancies with the BMI measurement have led to the development of more accurate methods of measuring body mass. In recent years, hydrostatic weighing and air displacement plethysmography using the BOD POD® have become recognized as the most accurate approaches to measuring body composition. Both are two-compartment models estimating fat mass and non-fat mass. Hydrostatic weighing determines body mass by measuring the difference between an individual's weight in water and in air. To conduct the measurement, the individual is submerged in water while exhaling all of the air in their lungs (Biaggi, et al., 1999). The BOD POD® is a two-compartmental analysis instrument that resembles a large egg with a window (Pompei, 2004). Subjects put on spandex clothing and a swim cap and are placed in the instrument for several minutes. The BOD POD® measures body volume and body mass and determines fat mass, fat-free mass, and percent body fat.

This study was conducted upon a change in coaching philosophy after a poor football season. The new philosophy increased the emphasis on training and nutrition. The players' enhanced meal program, Training Table, was improved to provide healthier options. Volunteers were hired to prepare and serve food in the football facility. More fruit, nuts, and bagels were provided before and after practices. Weight gain shakes were encouraged for those who needed to gain weight and limited for those who did not. Nutrition education was also implemented.

The period of time from January to May represented the greatest opportunity to improve body composition. During this time, training consisted mostly of conditioning and weight lifting. Training Table was available during this time. In May, training was optional and no meals were provided to the players. In June, the players were required to be back on campus to begin training again. During June and July, conditioning and weight training continued. The players also had optional skills workouts and watched film. Training Table was not allowed per NCAA regulations. One meal per day was provided to the players at an on-campus dining hall. Football staff could limit what was provided to the players from the dining hall's menu, but they could not enhance the menu as they would at Training Table. While the meal could not be made mandatory, attendance was strongly encouraged. The body compositions of the players included in this study were assessed in January, just prior to these changes, and in May, after months of an increased emphasis on training and nutrition. They were assessed again in August, after having no mandatory training in May, no Training Table in May, June, or July, but having conditioning and weight training and optional skills workouts in June and July.

The specific objectives of this study were to:

1. Assess the effect of an increased emphasis on training and nutrition on the body composition of college football players using BOD POD® data.
2. Assess whether or not the effect of an increased emphasis on training and nutrition is sustained during the summer when there is no mandatory training in May, no Training Table in May, June, or July, but there is conditioning and weight training and optional skills workouts in June and July.
3. Assess the appropriateness of the BMI measurement to evaluate body composition among college football players.

Chapter 4: Methodology

A non-experimental quantitative research design was used to conduct this study. The *ex post facto* research method was specifically used. The study describes an association between something that occurred in the past and subsequent responses to uncover a possible cause-and-effect relationship. The measurements used in this study are a part of a larger data set from research conducted by the Department of Dietetics and Human Nutrition at the University of Kentucky in collaboration with a college athletic department. The collaboration allowed the Department of Dietetics and Human Nutrition to assess the athletes and to get consent to use the data for their research and allowed the athletic department access to the much desired BodPod® measurements.

Athletes gave their informed consent and were measured by a researcher in the Department of Dietetics and Human Nutrition's Nutrition Assessment Laboratory using the BOD POD®. The athletes wore tight-fitting exercise shorts and a swim cap. Prior to the BOD POD® measurement the researcher measured the athlete's height using a standard floor stadiometer and entered it into the BOD POD®. They were then weighed using the BOD POD® scale which is accurate to one gram. Calibration occurred prior to each measurement. The athletes then entered the BOD POD® chamber and were measured for two 50-second intervals. The BOD POD® was opened between each interval. A third measurement was taken if the first two were not statistically the same. Body mass was recorded by the BOD POD®. The athletes were measured in January, just prior to these changes and in May, after months of an increased emphasis on training and nutrition. They were assessed again in August, after having no mandatory training in May, no Training Table in May, June, or July, but having conditioning and weight training and optional skills workouts in June and July.

Sample

The population of interest is college football players. This is recognized as a limitation because it cannot be assumed that the sample of participating football players were representative of all college football players.

Statistical Analysis

Data were entered into IBM SPSS Statistics version 22. Paired t-tests were performed to compare BMI and percent fat between January and May, May and August, and January and August. A p-value of 0.05 or less was considered statistically significant.

Chapter 5: Results

Demographics

Table 5.1: Demographic characteristics of football players in January. (N=68)

	Minimum	Maximum	Mean	Standard Deviation
Height (inches)	67.5	83.0	73.6	2.8
Weight (pounds)	158.3	344.2	236.4	48.8
Age (years)	18.3	23.4	20.4	1.2

Table 5.2: Demographic characteristics of football players in May. (N=68)

	Minimum	Maximum	Mean	Standard Deviation
Height (inches)	67.5	83.0	73.6	2.8
Weight (pounds)	160.8	345.0	232.9	44.6
Age (years)	18.5	23.6	20.6	1.2

Table 5.3: Demographic characteristics of football players in August. (N=68)

	Minimum	Maximum	Mean	Standard Deviation
Height (inches)	67.5	83.0	73.7	2.8
Weight (pounds)	162.9	351.2	234.6	46.7
Age (years)	18.8	23.9	20.9	1.2

The sample included 68 football players. All participants were male. The mean height of the players in January was 73.6 inches +/- 2.8 inches. The minimum height of the players in January was 67.5 inches and the maximum height was 83.0 inches.

The mean weight of the players in January was 236.4 pounds +/- 48.8 pounds. The minimum weight of the players in January was 158.3 pounds and the maximum weight was 344.2 pounds. The mean age of the players in January was 20.4 years +/- 1.2 years. The minimum age of the players in January was 18.3 years and the maximum age was 23.4 years. In May, the mean height of the players was 73.6 inches +/- 2.8 in. The minimum height of the players in May was 67.5 inches and the maximum height was 83.0 inches. The mean weight of the players in May was 232.9 pounds +/- 44.6 pounds. The minimum weight of the players in May was 160. 8 pounds and the maximum weight was 345.0 pounds. The mean age of the players in May was 20.6 years +/- 1.2 years. The minimum age of the players in May was 18.5 years and the maximum age was 23.6 years. In August, the mean height of the players was 73.7 inches +/- 2.8 inches. The minimum height of the players in August was 67.5 inches and the maximum height was 83.0 inches. The mean weight of the players in August was 234.6 pounds +/- 46.7 pounds. The minimum weight of the players in August was 162.9 pounds and the maximum weight was 351.2 pounds. The mean age of the players in August was 20.9 years +/- 1.2 years. The minimum age of the players in August was 18.8 years and the maximum age was 23.9 years.

Percent Fat and BMI Paired T-Tests

Table 5.4: Statistics of paired t-test analysis of BMI and percent fat.

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Percent Fat January	18.387	68	7.8686	.9542
	Percent Fat May	16.269	68	7.1382	.8656
Pair 2	Percent Fat May	16.269	68	7.1382	.8656
	Percent Fat August	16.497	68	7.4166	.8994
Pair 3	Percent Fat January	18.387	68	7.8686	.9542
	Percent Fat August	16.497	68	7.4166	.8994
Pair 4	BMI January	30.511	68	4.8648	.5899
	BMI May	30.050	68	4.2947	.5208
Pair 5	BMI May	30.050	68	4.2947	.5208
	BMI August	30.196	68	4.4974	.5454
Pair 6	BMI January	30.511	68	4.8648	.5899
	BMI August	30.196	68	4.4974	.5454

Table 5.5: Results of paired t-test analysis of BMI and percent fat.

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper	t	df	Sig. (2-tailed)
Pair 1	Percent Fat January – Percent Fat May	2.1176	1.9132	.2320	1.6546	2.5807	9.127	67	.000
Pair 2	Percent Fat May – Percent Fat August	-.2279	2.0331	.2465	-.7200	.2642	-.925	67	.359
Pair 3	Percent Fat January – Percent Fat August	1.8897	2.3767	.2882	1.3144	2.4650	6.557	67	.000
Pair 4	BMI January – BMI May	.4608	.9718	.1178	.2256	.6960	3.910	67	.000
Pair 5	BMI May – BMI August	-.1453	.9561	.1159	-.3768	.0861	-1.253	67	.214
Pair 6	BMI January – BMI August	.3155	1.1095	.1345	.0469	.5840	2.345	67	.022

The paired t-test analysis of BMI and percent fat between January and May, May and August, and January and August resulted in significant differences in percent fat between January (PercentFat1) and May (PercentFat2), percent fat between January (PercentFat1) and August (PercentFat3), BMI between January (BMI1) and May (BMI2), and BMI between January (BMI1) and August (BMI3). The differences between percent fat in May (PercentFat2) and percent fat in August (PercentFat3) and BMI in May (BMI2) and BMI in August (BMI3) were not significant.

Correlations Between Percent Fat and BMI

Figure 5.1: Scatterplot between BMI in January and percent fat in January.

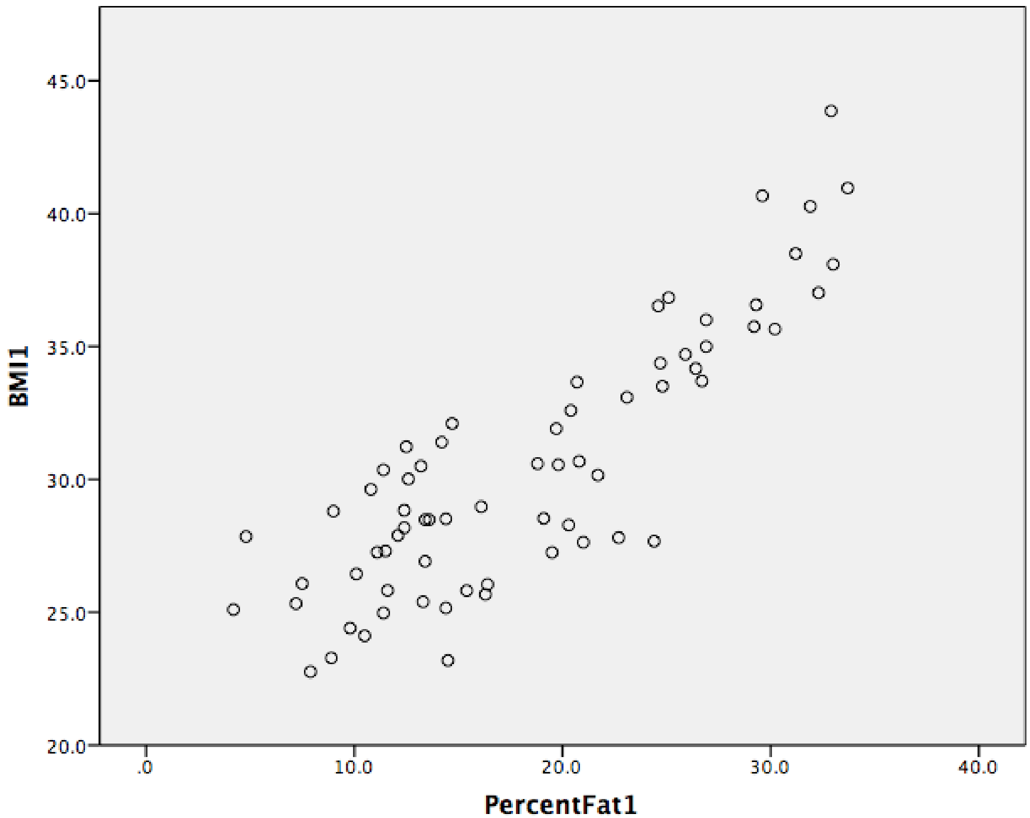

Table 5.6: Linear regression analysis of BMI in January and percent fat in January.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	20.781	.786		26.435	.000
Percent Fat January	.529	.039	.856	13.448	.000

Dependent Variable: BMI January

Figure 5.2: Scatterplot between BMI in May and percent fat in May.

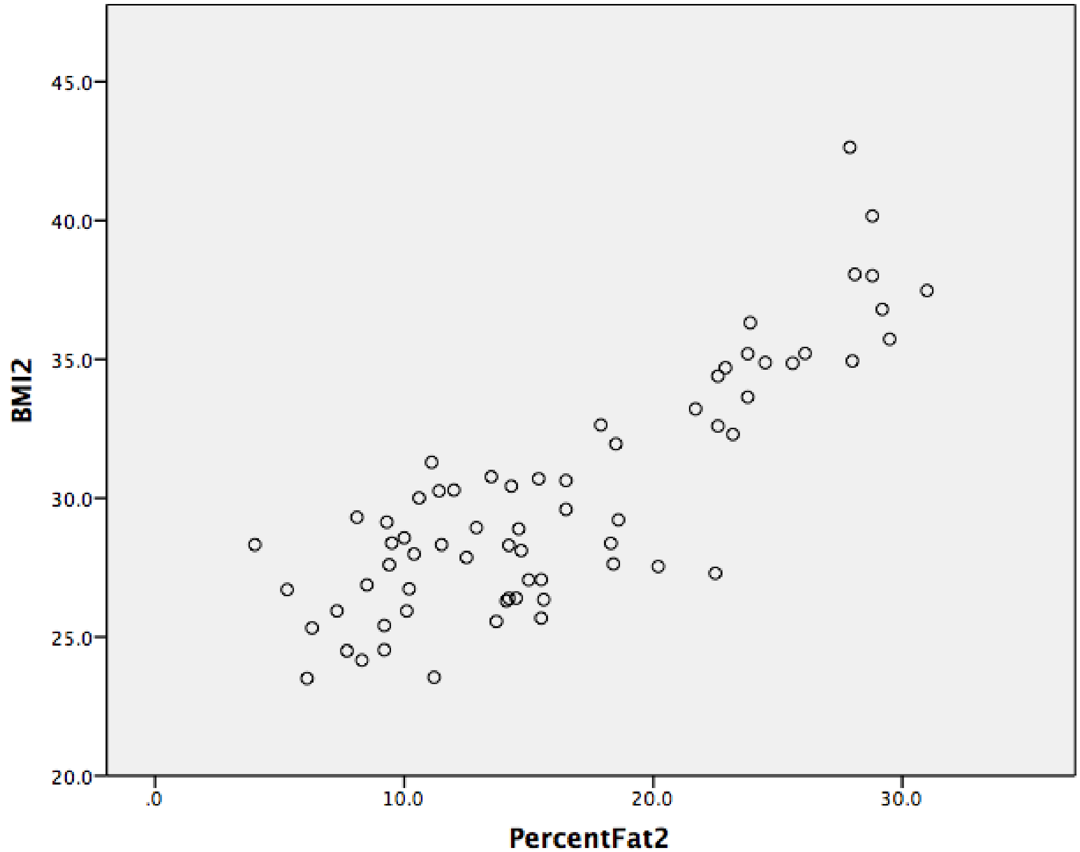

Table 5.7: Linear regression analysis of BMI in May and percent fat in May.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	21.819	.711		30.682	.000
Percent Fat May	.506	.040	.841	12.625	.000

Dependent Variable: BMI May

Figure 5.3: Scatterplot between BMI in August and percent fat in August.

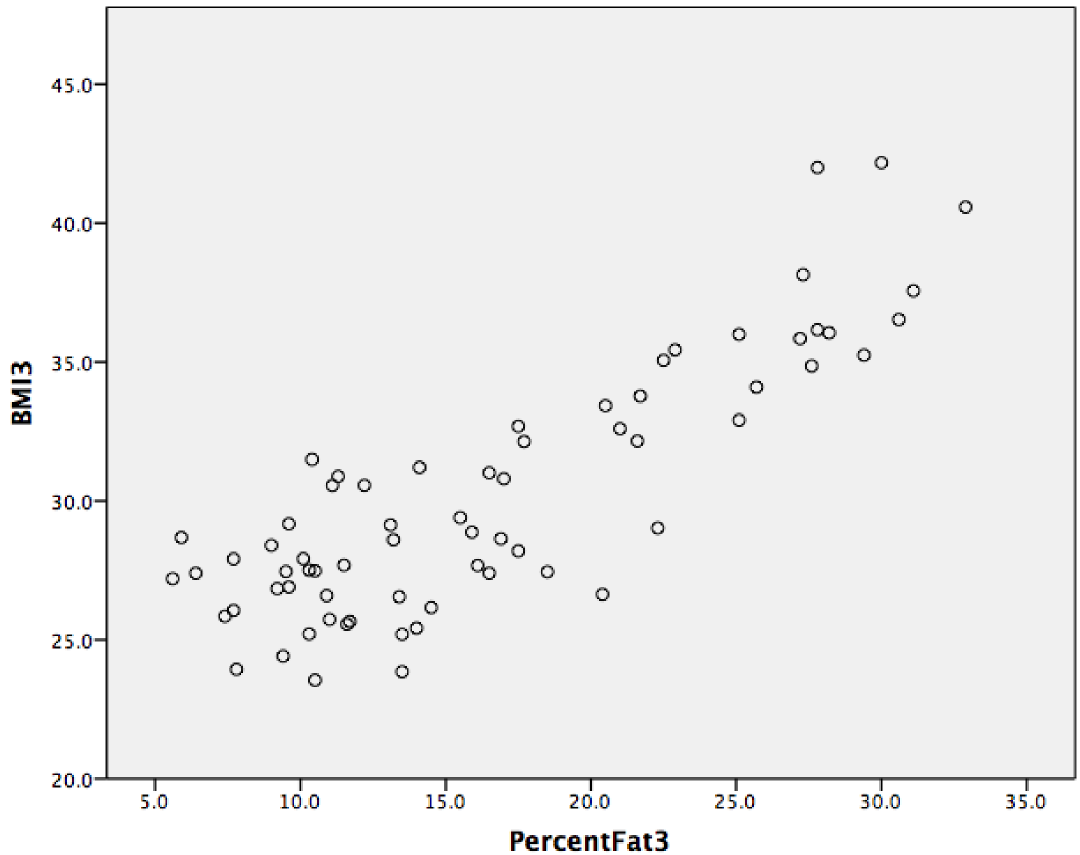

Table 5.8: Linear regression analysis of BMI in August and percent fat in August.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	21.704	.713		30.453	.000
Percent Fat August	.515	.039	.849	13.049	.000

Dependent Variable: BMI August

Presenting the correlations between BMI1 and PercentFat1, BMI2 and PercentFat2, and BMI3 and PercentFat3 in scatterplots revealed linear relationships. The scatterplots are presented above as Figure 5.1, Figure 5.2, and Figure 5.3. Linear regression analysis revealed the regression equations. Table 5.6 displays the slope of the relationship between BMI1 and PercentFat1 as 0.529 and the intercept as 20.781. Therefore, the equation of the relationship between BMI1 and PercentFat1 is as follows: BMI = 0.529*percent fat + 20.721. Table 5.7 displays the slope of the relationship between BMI2 and PercentFat2 as 0.506 and the intercept as 21.819. The equation of the relationship between BMI2 and PercentFat2 is as follows: BMI = 0.506*percent fat + 21.819. Table 5.9 displays the slope of the relationship between BMI and PercentFat3 as 0.515 and the intercept as 21.704. The equation of the relationship between BMI3 and PercentFat3 is as follows: BMI = 0.515*percent fat + 21.704.

Chapter 6: Discussion

The purpose of this study was to evaluate the effect of an increased emphasis on training and nutrition on the body composition of college football players. The body compositions of the players included in this study were assessed in January, just prior to these changes and in May, after months of an increased emphasis on training and nutrition. They were assessed again in August, after having no mandatory training in May, no Training Table in May, June, or July, but having conditioning and weight training and optional skills workouts in June and July. The BMI and percent fat of the players were compared between January and May, May and August, and January and August.

A paired t-test analysis showed a significant difference between percent fat in January and percent fat in May, percent fat in January and percent fat in August, BMI in January and BMI in May, and BMI in January and BMI in August. The differences between percent fat in May and percent fat in August and BMI in May and BMI in August were non-significant. The means of the percent fat measurements, as shown in Table 5.4, were 18.4% in January, 16.3% in May, and 16.5% in August. This indicates that there was a significant decrease in percent fat from January to May, a non-significant increase in percent fat from May to August, and a significant decrease in percent fat between January and August. The means of the BMI measurements, also shown in Table 5.4, were 30.5 in January, 30.1 in May, and 30.2 in August. This indicates that there was a significant decrease in BMI from January to May, a non-significant increase in BMI from May to August, and a significant decrease in BMI between January and August.

These results suggest that the increased emphasis on training and nutrition in January lead to improvements in body composition in May. From May to August, there was a non-significant trend for the players to increase percent fat and BMI. In May, training was optional. In June and July, conditioning and weight training resumed. The players also had optional skills workouts and watched film. Training Table was not available during June and July. This may indicate that some, but not all, of the changes made to the training and eating behaviors of the players were maintained during the summer, preventing a significant increase in percent fat from May to August. The results also indicate that though there were slight increases in percent fat and BMI from May to August, there was still an overall significant decrease in percent fat and BMI between January and August. This suggests that the increased emphasis on training and nutrition significantly improved the body composition of the players.

This study also questioned the appropriateness of the BMI measurement to assess body composition in this population. As mentioned before, the American Council on Exercise considers a BMI of less than 18.5 to be underweight, a BMI of 18.5-24.9 to be normal weight, a BMI of 25.0-29.9 to be overweight, a BMI of 30.0-34.9 to be grade I obesity, a BMI of 35.0-39.9 to be grade II obesity, and a BMI of greater than 40.0 to be grade III obesity (ACE, 2015). For percent body fat in men, they consider greater than 25% to indicate obesity, 18-24% to be acceptable, 14-17% to be ideal for fitness, and 6-13% to be ideal for athletes (ACE, 2015). To test the validity of the BMI measurement for assessing the body composition of the players, BMIs of 18.5 (normal), 25 (overweight), and 30 (obese) were plugged in to the equations of the relationships between BMI1 and PercentFat1, BMI2 and PercentFat2, and BMI3 and PercentFat3. When 18.5, 25, and 30 are plugged into the equation for the relationship between BMI1 and PercentFat1, BMI = 0.529*percent fat + 20.721, the percent fat equals -4.2, 8.1, and 17.5, respectively. When 18.5, 25, and 30 are plugged into the equation for the relationship between BMI2 and PercentFat2, BMI = 0.506*percent fat + 21.819, the percent fat equals -6.6, 6.3, and 16.2, respectively. When 18.5, 25, and 30 are plugged into the equation for the relationship between BMI3 and PercentFat3, BMI = 0.515*percent fat + 21.704, the percent fat equals -6.2, 6.4, and 16.1, respectively. This implies that in order for a player to have a BMI of 18.5 (low normal body composition), his percent body fat would have to be approximately -4% to -6%. It also suggests that a player with a percent body fat of approximately 16% to 17%, which the American Council on Exercise considers ideal for fitness, would be obese. While figures 5.1, 5.2, and 5.3 show linear relationships between percent body fat and BMI, they also show that the BMI measurement grossly overestimates percent body fat in this population. These results indicate that the BMI measurement is not appropriate for measuring body composition among college football players.

Limitations

All of the players included in this study were from the same university. It cannot be assumed that these players are representative of all college football players. Also, the differences among the tight-fitting clothing and swim caps provided to the players during BOD POD® testing may have had an effect on the results. Also, all factors that could have impacted body fat percent, such as hydration, the time of day for both height and weight, and the manual assessment and recording of height could have influenced the outcomes.

Chapter 7: Conclusion

This study suggests that increasing the emphasis on training and nutrition among college football players leads to the improvement of the body composition of the players. This improvement in body composition can help prevent the known health implications associated with overweight and obesity among this population. This study also suggests that the BMI measurement is not an appropriate measure of body composition among college football players. Other measures of body composition, such as the BOD POD®, should be used for this population.

References

American Council on Exercise (2015). Healthy Living: BMI Reference Chart. *www.acefitness.org*.

American Council on Exercise (2015). Healthy Living: Percent Body Fat Norms for Men and Women. *www.acefitness.org.*

Anzell, Anthony R., Potteiger, Jeffrey A., Kraemer, William J., and Otieno, Sango (2013). Changes in Height, Body Weight, and Body Composition in American Football Players From 1942 to 2011. *Journal of Strength and Conditioning Research*, 27(2), 277-284.

Biaggi, Robert R., Vollman, Michael W., Nies, Mary A., Brener, Craig E., Flakoll, Paul J., Levenhagen, Deanna K., Sun, Ming, Karabulut, Zafer, & Chen, Kong Y. (1999). Comparison of air-displacement plethysmography with hydrostatic weighing and bioelectrical impedance analysis for the assessment of body composition in healthy adults. *American Journal of Clinical Nutrition*, 69, 898-903.

Cole, Constance R., Salvaterra, George F., Davis Jr, Joseph E., Borja, Marianne E., Powell, Loreen M., Dubbs, Elizabeth C., & Bordi, Peter L. (2005). Evaluation of Dietary Practices of National Collegiate Athletic Association Division I Football Players. *Journal of Strength and Conditioning Research*, 19(3), 490-494.

Collins, Mitchell A., Millard-Stafford, Melinda L., Sparling, Phillip B., Snow, Teresa K., Rosskopf, Linda B., Webb, Stephanie A., and Omer, Jay (1999). Evaluation of the BOD POD® for assessing body fat in collegiate football players. *Medicine & Science in Sports & Exercise*, 31(9), 1350-1356.

Harp, J.B. & Hecht, L. Obesity in the National Football League. *JAMA,* 293(9), 1058-1062.

Jacobson, Bert H., Sobonya, Chris, & Ransone, Jack (2001). Nutrition Practices and Knowledge of College Varsity Athletes: A Follow-Up. *Journal of Strength and Conditioning Research,* 15(1), 63-68.

Kirwan, Rochelle D., Kordick, Lindsay K., McFarland, Shane, Lancaster, Denver, Clark, Kristine, & Miles, Mary P. (2012). Dietary, Anthropometric, Blood-Lipid, and Performance Patterns of American College Football Players During 8 Weeks of Training. *International Journal of Sport Nutrition and Exercise Metabolism*, 22, 444-451.

Kraemer, W.J., Torine, J.C., Silvestre, R., French, D.N., Ratamess, N.A., Spiering, B.A., Hatfield, D.L., Vingren, J.L., & Volek, J.S. (2005). Body size and composition of National Football League players. *Journal of Strength and Conditioning Research*, 19(3), 485-489.

Lambert, Brad S., Oliver, Jonathan M., Katts, Gilbert R., Green, John S., Martin, Steven E., & Crouse, Stephen F. (2012). DEXA or BMI: Clinical Considerations for Evaluating Obesity in Collegiate Division I-A American Football Athletes. *Clinical Journal of Sports Medicine,* 22(5), 436-438.

Long, Doug, Perry, Christina, Unruh, Scott A., Lewis, Nancy, and Stanek-Krogstrand, Kaye (2011). Personal Food Systems of Male Collegiate Football Players: A Grounded Theory Investigation. *Journal of Athletic Training*, 46(6), 688-695.

Mathews, Emily Millard & Wagner, Dale R. (2008). Prevalence of Overweight and Obesity in Collegiate American Football Players, by Position. *Journal of American College Health,* 57(1), 33-37.

Noel, M.B., VanHeest, J.L., Zaneteas, P., & Rodgers, C.D. (2003). Body composition in Division I football players. *Journal of Strength and Conditioning Research*, 17(2), 228-237.

Ode, Joshua J., Pivarnik, James M., Reeves, Mathew J., & Knous, Jeremy L. (2007). Body Mass Index as a Predictor of Percent Fat in College Athletes and Nonathletes. *Medicine & Science in Sports & Exercise*, 39(3), 403-409.

Peeters, Maarten W. & Claessens, Albrecht L. (2011). Effect of different swim caps on the assessment of body volume and percentage body fat by air displacement plethysmography. *Journal of Sports Sciences*, 29(2), 191-196.

Tucker A.M., Vogel R.A., Lincoln A.E., Dunn, R.E., Ahrensfield, D.C., Allen, T.W., Castle, L.W., Heyer, R.A., Pellman, E.J., Strollo, P.J. Jr, Wilson, P.W., & Yates, A.P. (2009). Prevalence of cardiovascular disease risk factors among National Football League players. *JAMA*, 301(20), 2111-2119.

VITA

Lindsey Goderwis is from Florence, Kentucky. She was awarded a Bachelor of Science in Dietetics from the University of Kentucky in 2013. She has held the professional positions of Dietetic Intern and Teaching Assistant at the University of Kentucky.