FRUIT AND VEGETABLE CONSUMPTION OF DIVISION I COLLEGIATE FOOTBALL AND VOLLEYBALL PLAYERS PRE- AND POST-DEREGULATION OF SNACKS BY THE NCAA

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Dr. Janet S. Kurzynske, Major Professor

Dr. Kelly Webber, Director of Graduate Studies
FRUIT AND VEGETABLE CONSUMPTION OF DIVISION I COLLEGIATE FOOTBALL AND VOLLEYBALL PLAYERS PRE- AND POST-DEREGULATION OF SNACKS BY THE NCAA

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:

Emily Quinn Ludwig, RD, LD

Lexington, Kentucky

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

Lexington, KY

2015

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ABSTRACT OF THESIS

FRUIT AND VEGETABLE CONSUMPTION OF DIVISION I COLLEGIATE FOOTBALL AND VOLLEYBALL PLAYERS PRE- AND POST-DEREGULATION OF SNACKS BY THE NCAA

The deregulation of snacks by the National Collegiate Athletic Association (NCAA) permits institutions to provide enhanced snacks incidental to participation. Athletes may now have the opportunity to improve their diet quality. The purpose of this research was to assess the consumption of fruits and vegetables as well as body composition of Division I collegiate athletes. The sample included 19 American football players and 8 volleyball players. Paired t-tests were performed to compare fruit intake, vegetable intake, and body fat percentage pre- and post-deregulation of snacks. Linear regression models were used to determine correlations between change in fruit intake and change in body fat percentage and change in vegetable intake and change in body fat percentage. There were no significant differences in the paired t-tests; however, there was a significant correlation in increasing fruit intake, vegetable intake, and decreasing body fat percentage among football players. Results suggest that regular contact with a Registered Dietitian may improve diet quality, and providing nutrient-dense foods planned by a Registered Dietitian to college athletes may improve body fat percentage.

KEYWORDS: Fruit, Vegetable, Body Fat Percentage, College Football Players, College Volleyball Players, BodPod®

Emily Quinn Ludwig

November 30, 2015
FRUIT AND VEGETABLE CONSUMPTION OF DIVISION I COLLEGIATE FOOTBALL AND VOLLEYBALL PLAYERS PRE- AND POST-DEREGULATION OF SNACKS BY THE NCAA

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CHAPTER 1: Introduction

There are multiple facets in optimizing performance in athletes. Different sports require different body types, making body composition an important role in athletics. Because Body Mass Index (BMI) is not an appropriate indicator of body type for athletes, body compositions are most commonly used to determine fitness level (Melvin et al., 2014). These measurements often serve as an indicator of goals to be achieved to optimize an individual's performance. Changes in an athlete's diet and training regimen can alter body composition—two changes that a Registered Dietitian, Strength and Conditioning staff, and Sports Medicine staff can work collectively to assist an athlete to improve. While Strength and Conditioning and Sports Medicine are established departments in athletics, nutrition is an emerging aspect of training in multiple levels of athletics, particularly in the collegiate setting. As nutrition continues to become an integral part and public aspect of training, the NCAA bylaws are changing.
Problem Statement

NCAA Division I Athletic Departments first saw change in bylaws regarding food in 1991. Figure 1.1 illustrates a timeline of the changing NCAA bylaws in regards to foods.

Figure 1.1: Timeline of Changing Bylaws by the NCAA

Prior to 2014, under-fueling of the athlete was a concern of professionals in athletics. If an athlete does not consume adequate amounts of protein, carbohydrates, fats, vitamins, minerals, and phytochemicals, it is difficult to optimize full performance potential and recover properly. An athlete’s diet, as well as the average American, is rich in carbohydrates and protein. What is often lacking is the consumption of fruits and vegetables—food sources that provide micronutrients to help muscles recover after intense exercise. As the importance of nutrition in athletics continued to make headline news and Registered Dietitians voiced concerns of current standards, the NCAA deregulated the snack ruling, allowing athletic departments to provide enhanced snacks and meals incidental to participation in team activities beginning August 1st, 2014 (NCAA, 2014). The new ruling not only allows for carbohydrates, but also protein, vitamins, minerals, and phytochemicals to be provided to the athletes. This deregulation has sparked a
surge in the hiring of Registered Dietitians to assist with sports teams and the building of new facilities featuring nutrition centers on campuses nationwide. What was once a simple concept has now progressed to a large aspect of training and recruiting in the collegiate setting. The progressing emphasis on nutrition will only continue to expand what is offered to athletes on a daily basis.

With the persistent emphasis on body composition and the deregulation of snacks, the diet quality of college athletes may be open to change. Traditionally, college athletes have higher intakes of carbohydrates and protein compared to intakes of vitamins and minerals. Since the deregulation has been put into effect, research has not yet been conducted to determine if athletes’ intakes of fruits and vegetables have increased or if there is an effect on body composition. Providing more nutrients through food may spur the question in the effect on body composition. It is these two factors that have formulated the aim of this research.

Purpose:

The purpose of this research was to assess the consumption of fruits and vegetables of Division I collegiate athletes. This study compared fruit and vegetable consumption before and after the deregulation of snacks by the NCAA. Body fat percentage was also be compared pre- and post-deregulation. The objective of this study was to determine if fruit and vegetable intake increases when provided, and if body fat percentage improved with increased consumption of fruits and vegetables among Division I college athletes.

Research Question:

1. Does NCAA deregulation in snacks increase fruit consumption in Division I collegiate athletes?
2. Does NCAA deregulation in snacks increase vegetable consumption in Division I collegiate athletes?
3. Does NCAA deregulation in snacks decrease body fat percentage in Division I collegiate athletes?
Hypotheses:

1. NCAA deregulation in snacks will increase fruit consumption in Division I collegiate athletes as measured by the 2005 Block Food Frequency Questionnaire.

2. NCAA deregulation in snacks will increase vegetable consumption in Division I collegiate athletes as measured by the 2005 Block Food Frequency Questionnaire.

3. NCAA deregulation in snacks will decrease body fat percentage in Division I collegiate athletes as measured by the Bod Pod®.

Justification:

In a position paper written collaboratively by the American Dietetics Association, Dietitians of Canada, and the American College of Sports Medicine, physical activity, athletic performance, and recovery from exercise are enhanced by optimal nutrition (JCSM, 2009). The recent deregulation of snacks by the NCAA allows for optimal nutrition to be more easily obtained. This research will examine the consumption of fruits and vegetables specifically before and after the deregulation along with the body compositions corresponding to those dietary consumptions.
CHAPTER 2: Literature Review

Introduction

In August 2014, the National Collegiate Athletic Association (NCAA) passed legislation to deregulate the provision of snacks to college athletics (NCAA, 2014). Athletic departments are no longer restricted to certain carbohydrate and protein requirements for food, but can provide fruits, vegetables, protein, carbohydrate, and fat to collegiate athletes. This new regulation spurs interest in the effect of the availability of more food on the athletic performance of collegiate athletes. The following literature review will explore previous research on diet quality of college students and athletes, body composition, and fruit and vegetable intake in order to identify areas for further research.

Diet Quality of College Students

Many college students acquire numerous responsibilities when they attend college that did not fully exist while in high school. One of these responsibilities is making food choices daily. Previous research has shown that college students gain approximately 4 to 9 pounds during their first year at college (Strong, 2008). The objective of this study conducted on a college campus in Virginia was to identify potential targets to improve health behaviors in young adults attending college (Strong, 2008). First- and second-year college students were recruited to participate. Participants were excluded if they majored in nutrition or exercise, or if they experienced symptoms of depression, eating disorders, or major chronic diseases. Forty-three participants completed a series of questionnaires and laboratory-based measurements. Food diaries were analyzed using the Nutrient Data System for Research software. Average calorie consumption for males was 2,236 ± 112 kcal, and for females was 1,711 ± 90 kcal (Strong, 2008). For both males and females, percentage of carbohydrate, fat, and protein was 50%, 35%, and 15% of total energy, respectively. Average daily vegetable consumption was 1.5 ± 0.1 cups, and average daily fruit consumption was 1.0 ± 0.2 cups (Strong, 2008). These
results indicate that college students are not consuming enough fruits and vegetables. Limitations to this study include the small sample size, possible inaccuracies in the food diaries, and vegetables included all varieties of potatoes.

Another study's purpose was to examine associations between various meal routines, practices, and key dietary indicators among college students. The Student Health and Wellness survey was conducted among public four-year university and two-year university college students in the metropolitan area of Minnesota. The online survey took 30-35 minutes to complete. The final sample included 598 two-year and 603 four-year students (Laska et al., 2014). Fruit and vegetable intake were self-reported for 30 days using a validated screener developed by the National Cancer Institute, and then calculated using reported consumption. French fries were excluded from the calculation. Fruit, 100% fruit juice, salad, beans, potatoes, vegetables, tomato sauce, and salsa were included in the calculation (Laska et al., 2014). Results show that the mean fruit and vegetable intake per day was 2.4 cup-equivalents (Laska et al., 2014). This falls short of the recommended daily intake of 4.5-5 cups of fruits and vegetables by the United States Department of Agriculture (“USDA”, 2015). Limitations of this study include a sample from one geographic location limiting generalizability. Self-reported measures of fruit and vegetable intake pose risk for error.

_Diet Quality of College Athletes_

The Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine collaborated to determine nutritional needs for athletes. Energy and macronutrient needs must be met during times of demanding physical activity to maintain body weight, replenish glycogen stores, and provide adequate protein to build and repair tissue. Fat intake should be sufficient to provide essential fatty acids and fat-soluble vitamins. Vitamin and mineral supplementation is not needed if adequate energy to maintain body weight is consumed from a variety of foods. Previously, it was recommended that five or more daily servings of fruits and vegetables provide nutrients and fiber for athletes.
(Rodriguez et al., 2009). Currently, the United States Department of Agriculture makes recommendations for fruit and vegetable intake in cups. For college-aged women, 2.5 cups vegetables and 2 cups fruits are recommended daily. For college-aged men, 3 cups vegetables and 2 cups fruits are the daily recommendations (“USDA”, 2015). These recommendations are for individuals who get less than 30 minutes of exercise per day. Though specific recommendations are not stated for collegiate athletes, their needs are greater due to extensive physical activity performed each day. The following studies evaluate the diet quality of college athletes.

Little is known about the diet quality of collegiate athletes. A study was conducted by Shriver et al. to assess energy and macronutrient intakes of female college athletes compared to the minimum sports nutrition recommendations determined by previous research (5 g/kg body weight [BW] carbohydrate, 1.2 g/kg BW protein, 2 g/kg BW protein for strength athletes or weight loss athletes) (Shriver, Betts, & Wollenberg, 2013). The secondary purpose was to explore dietary patterns and eating habits in NCAA Division 1 female collegiate athletes. Body composition was first taken using a Dual-Energy X-Ray Absorptiometry (DEXA) scan. A trained research assistant obtained a 24-hour dietary recall from each participant. Plastic food models, measuring spoons, cups, and bowls were used to obtain accurate data. Each participant then completed a 3-day (2 weekdays and 1 weekend) food record, and diets were evaluated using the Nutrition Questionnaire addressing questions about meal/snack frequency, dining out, hydration, weight management, and self-evaluation of diet quality. Results indicate the mean proportion of total energy coming from carbohydrates, protein, and fat was 53%, 16%, and 31% respectively. Approximately 91% of participants’ reported energy intake did not meet their specific needs as calculated from the DEXA scan (Shriver, Betts, & Wollenberg, 2013). Carbohydrate and protein recommendations were not met by 74% and 50% of participants, respectively. Regular breakfast was reported by only 27% of participants. The mean frequency of dining out was 5.4 times weekly. Less than half (44%) reported their diet as healthy. Athletes found it difficult to follow a training diet when traveling (22%). The majority of calories
were consumed in the evening. Limitations to this study include accuracy of the food logs and questionnaire; however, using both tools help to eliminate discrepancies. Improving eating habits among female college athletes can optimize nutritional status, ensure proper recovery from training, and maximize performance (Shriver, Betts, & Wollenberg, 2013).

Body Composition

Various sports require varying degrees of endurance and muscular power to perform skills necessary for specific sports. Because of this, different body types and compositions perform better in certain sports or positions. While each individual athlete is different, research has been conducted to suggest ideal body compositions for optimal performance.

A study by Mieglo-Ayuso et al. focused on the body composition of volleyball players (2014). Because volleyball requires intermittent spurts of high intensity exercise followed by periods of low intensity activity, various performance movements are required (Mieglo-Ayuso et al., 2014). Different positions also require different movements making it likely that each position has a unique anthropometric and physiological profile desired to optimize performance (Mieglo-Ayuso et al., 2014). In this study, volleyball athletes were characterized by position including middle blockers (n=12), opposite hitters (n=6), outside hitters (n=12), setters (n=8), and liberos (n=4) (Mieglo-Ayuso et al., 2014). Each participated in a battery of physical performance tests and had anthropometric measurements taken. Forty-two Spanish female volleyball players participated with a mean age of 27.2 ± 5.4 years. Height was measured using a SECA® measuring rod, body mass was assessed by a SECA® model scale. Body mass index (BMI) was calculated, and body composition was obtained using the sum of 5 skinfolds taken with a Harpenden® skinfold caliper. Physical performance tests were conducted using battery tests representative of their training and competition load. Significant differences were found in all anthropometric variables and physical performance tests among all groups except relaxed arm corrected girth, the triceps and subscapular skinfolds, and the crunch test (Mieglo-Ayuso et al., 2014). Significant differences were also
found in height among every playing position. Middle blockers were the tallest (186.5 ± 1.4 cm), while liberos were the shortest (166.7 ± 8.1 cm). Opposite hitters were the heaviest (73.6 ± 5.5 kg), and liberos were the lightest (58.2 ± 5.7 kg). Liberos showed significantly lower vertical jumps than setters and opposite hitters. The middle blockers were significantly slower in the speed tests. There was a negative correlation between the tallest and heaviest players of the team and speed. Middle blockers and outside and opposite hitters were the tallest, heaviest, and slowest compared to other positions. Liberos and setters were the smallest, lightest, and fastest participants. Conclusions drawn from this study are that height offers the key performance advantage for middle blockers, whereas lower body mass and fat mass is advantageous for setters and liberos (Mieglo-Ayuso et al., 2014). High musculoskeletal mass with an appropriate fat mass is desired for opposite and outside hitters. Two limitations to this study are the sample size, and the generalizability of the Spanish ethnicity of the athletes in the study.

A study also investigating body composition characteristics focused on male collegiate football athletes. Measuring body composition not only offers baseline differences across positions in terms of referencing injury, weight gains or losses, and declining performance, but it also allows for a better identification of current and future health risks (Melvin et al., 2014). Though the trend of increasing physical size continues in football players, it is important to emphasize body composition so as to decrease the risk of disease (Melvin et al., 2014). The primary purpose of this study therefore was to examine body composition of 69 NCAA Division I football players. Further differences of body composition between player position, race, year, and starter status were also evaluated. Each participant completed one 30-minute testing session after summer training session, but before training camp. Anthropometric measurements were taken and participants completed an exercise and diet questionnaire. Body fat percentage, fat mass, and lean mass were determined by dual-energy x-ray absorptiometry (Melvin et al., 2014). Participants were categorized by player position, race, year classification, and starter status. For fat percentage, there was no difference between the offensive line (22.3 ± 2.3%) and defensive line (24.4 ±2.2%); however, both positions were significantly greater than
wide receivers, linebackers, defensive backs, kickers/punters, and running backs (Melvin et al., 2014). Quarterbacks (18.1 ±2.1%) had significantly less percent fat than offensive linemen but significantly greater than defensive backs (14.0 ±2.2%) (Melvin et al., 2014). Linebackers and tight ends did not have significant differences in fat percentage, but were significantly greater than quarterbacks, wide receivers, linebackers, defensive backs, punters/kickers, and running backs (Melvin et al., 2014). There was no difference in fat percentage between race, year classification, or starter status. Body mass index (BMI) ranges for offensive line (30.4-39.4 kg · m²) and for defensive line (30.0-43.8 kg · m²) categorized participants as obese to severely obese. BMI ranges for defensive backs (24.6-30.4 kg · m²) and running backs (26.8-32.0 kg · m²) categorized them as overweight to obese (Melvin et al., 2014). These results suggest that using BMI as a measurement of health for football athletes is not a reliable measure. Body fat percentage provides a more accurate interpretation for football athletes. Conclusions derived from this study indicate that there are varying body compositions for different positions in football to promote optimal performance. Limitations include limited fasting time before body composition testing.

Natalie Digate Muth, a Registered Dietitian, established body fat percentage guidelines for male and female athletes (2009). For female athletes, the recommended body fat percentage is between 14 and 20%. Male athletes are recommended to obtain a body fat percentage between 6 and 13% (Muth, 2009). While these values are not sport specific, they provide a point of reference when measuring collegiate athletes body composition.
Micronutrient Intake through Fruits and Vegetables and Performance

Most research regarding diet quality of athletes focuses on macronutrients; however, some studies have begun to investigate the importance of micronutrients in an athlete’s diet, specifically pertaining to recovery.

The intention of Lamprecht’s research review is to build a bridge between the science behind fruit and vegetable supplementation in exercise and the practical relevance of its application on the other. Increased metabolism due to exercise training results in increased demands for energy, protein, carbohydrate, water, essential fatty acids, and micronutrients (Lamprecht, 2013). A deficit of micronutrients with antioxidant functions can result in oxidative stress and molecular cell and tissue damage. An increase in oxidative stress can increase inflammatory processes, decrease immunity, and increase the susceptibility to injury and prolonged recovery in athletes (Lamprecht, 2013). To combat these risks, fruit and vegetable consumption is imperative for athletes. In a research article looking at trained and untrained individuals, daily consumption of commercially available fruit and vegetable concentrate increased serum concentrations of antioxidant vitamins. Numerous articles have reported reduced concentrations of oxidative stress and inflammatory markers. Another pilot study reviewed in this article revealed that a 3-week supplementation with a fruit and vegetable concentrate reduced concentrations of carbonyl proteins- a marker of oxidative stress before and after mountain biking (Lambrecht, 2013). The mixed fruit and vegetable concentrate was given with the last meal before exercise and the first meal post-exercise. Another research study found that fruit and vegetable capsule supplementation reduced frequency of the common cold, sore throat, and fever. While supplementation is not the ideal answer for gaps in a diet, this review does highlight the positive effects of the antioxidants found in fruits and vegetables.

Another study examined the effects of a flavonoid-rich fresh fruit and vegetable juice on chronic resting and post-exercise inflammation, oxidative stress, immune function, and metabolic profiles in elite sprint and middle-distance swimmers. Nine elite male sprint and middle-distance swimmers were recruited and were compared to a control group of 7 non-athletic participants. The swimmers
were randomized into juice or non-juice and drank 8 fl oz. of juice pre- and post-training for 10 consecutive days. The juice consisted of the following: Red Delicious apple (including peel), orange (including peel), red bell pepper, carrot, broccoli, parsley, tomato, cucumber (including peel), blueberries, strawberries, blackberries, and pineapple (Knab et al., 2013). There was a 3-week washout period between juice and non-juice trials. The athletes maintained the same training throughout the trial, whereas the control group maintained normal eating and physical activity patterns. All participants completed a baseline fitness test and were instructed on keeping a 3-day food log. Body composition was measured using the BodPod®. Blood samples were taken to determine values for seven inflammatory cytokines. The mean body fat percentage of swimmers was 11.7 +/- 0.8% compared to controls at 19.6 +/- 1.6%. Swimmers consumed an average of 4,105 kcal/day consisting of 49% carbohydrate, 18% protein, and 33% fat (Knab et al., 2013). No effect of the juice for 10 days was found on exercise-induced measures of inflammation, oxidative stress, or immune function; however, due to low post-exercise inflammation, oxidative stress, and immune function, there was not much room for the fruit and vegetable juice to have an effect. This was a major limitation in the study. The small sample size also is a limitation to the results.
Conclusion

Current research supports the need for adequate nutrition in college students, specifically college athletes. Proper nutrition is necessary to maximize athletic performance and optimize fitness. While much research focuses on macronutrients, there is a gap in the literature concentrating on micronutrients. There is also a lack of published research showing the relationship between diet quality and body fat percentage.

New NCAA regulations regarding food and nutrition that can be made available to college athletes began in August 2014. Because of this new deregulation of food, athletes can be exposed to wider varieties outside the traditional fruits, nuts, and bagels. This study is believed to be the first to examine the impact of the new NCAA regulations on diet quality, specifically fruit and vegetable intake, and body fat percentage.
CHAPTER 3: Methodology

National Collegiate Athletic Association (NCAA)

The NCAA is a membership-driven organization that is dedicated to
upholding the well being of collegiate student-athletes pertaining to the classroom,
playing field, and life outside of college (NCAA, 2015). The NCAA is committed to
enforcing rules and creating fair competition (NCAA, 2015). One of these rules
includes providing food for athletes. The first rule regarding food came into effect
on August 1, 1996. This rule stated: “An institution may provide only one training
meal per day to a student-athlete during the academic year on those days
when regular institutional dining facilities are open.” (CPSDA, 2015). This ruling
did not include non-scholarship athletes; however, they were allowed to purchase a
training meal with their own money. Three years later the NCAA authorized
schools to provide fruits, nuts, and bagels to student-athletes throughout the day. In
August 2012, the NCAA began allowing institutions to provide spreads (i.e. jelly,
peanut butter, cream cheese) for the bagels. Finally in August 2014, the NCAA
deregulated all snacking for institutions. This deregulation allowed for an
institution to provide meals and snacks to all student-athletes (scholarship and non-
scholarship) at its discretion as a benefit incidental to participation in intercollegiate
athletics (NCAA, 2015).

Study Design

This research was a non-randomized, quantitative, pre-post design. The
measurements analyzed for this study were a portion of a larger data set from a
research project conducted by the Department of Dietetics and Human Nutrition at
the University of Kentucky. The University of Kentucky Institutional Review Board
(IRB) originally approved the study in August 2010 with continuation approval in
subsequent years. The full research project composed of data collected via the Bod
Pod®, anthropometric measurements of height and waist circumference, the EDI-3
Eating Disorder Inventory Referral Form, and the Block Dietary Data Systems 2005
Food Frequency Questionnaire. The only data used in this study were body fat percentage measured via the Bod Pod®, and daily servings of fruits and fruit juices and daily servings of vegetables via the Block Dietary Data Systems 2005 Food Frequency Questionnaire.

Subjects

Twenty-seven NCAA Division I male and female collegiate athletes between the ages of 18 and 25 participated in this study. Nineteen American football players and eight volleyball players were included in this study. Body composition and fruit and vegetable intake were determined pre-deregulation of snacks in April of 2014 and post-deregulation of snacks by the NCAA in March 2015 for football players. For volleyball players, body composition and fruit and vegetable intake were collected pre-deregulation of snacks in August 2014 and post-deregulation in August 2015. Participants were included if a Bod Pod® measurement and Food Frequency Questionnaire pre-deregulation of snacks and post-deregulation of snacks existed. This was a convenience sample because these two teams had data available prior to the deregulation of snacks by the NCAA. Each participant signed a consent form prior to the assessment informing of the procedures for the fruit and vegetable survey and anthropometric measurements, as well as an explanation of the research.

Instruments

All survey measurements used for this study were completed in the Nutrition Assessment Laboratory at the University of Kentucky. The measurements used for this study included body fat percentage assessment via the Bod Pod®, and fruit and vegetable consumption estimated by the 2005 Block Dietary Data Systems Food Frequency Questionnaire.
Bod Pod®

The Bod Pod® is a computerized, egg-shaped, two-compartment air displacement plethysmograph machine that determines body composition in adults and children accommodating a wide range of populations. The Bod Pod® is serviced by a manufacturer representative annually per protocol. Prior to each testing session, the Bod Pod® is calibrated in compliance with manufacturer instructions. In a study comparing air displacement plethysmograph and dual energy x-ray absorptiometry (DEXA) for measuring body composition, height, and weight, the Bod Pod® was shown as a validated instrument to obtain such data (Ballard, Fafara, & Vukovich, 2004). Participants were asked to not consume food or beverages, or participate in any physical activity four hours prior to testing. Males wore only spandex shorts and a swim cap, while females wore spandex shorts with a sports bra or a tight-fitting swimsuit and a swim cap. All jewelry and eyeglasses were removed. Trained personnel conducted the Bod Pod® data collection and extraction of data from the software.

Food Frequency Questionnaire

The 2005 Block Food Frequency Questionnaire was designed to estimate usual and habitual intake of a wide span of nutrients and food groups. The food list was developed from NHANES 1999-2002 dietary recall data, and the nutrient database was developed from the USDA Food and Nutrient Database for Dietary Studies. The questionnaire was validated through a study comparing multiple diet records and the self-administered diet history questionnaire (Block, 1990). Pictures of portion sizes were provided to enhance accuracy of quantification. Approximately 110 food items are referenced in the paper questionnaire. Two categories that were analyzed to determine fruit and vegetable intake were daily cups of fruit and fruit juices and daily cups of vegetables.
Procedures

Participants completed the self-administered food frequency questionnaire and submitted them at their individually scheduled BodPod® measurement. Football athletes’ data were conducted in April 2014 and March 2015 prior to deregulation and after deregulation, and volleyball athletes’ data were collected in August 2014 and August 2015 before deregulation and after deregulation. After the initial data collection, the intervention group, football athletes, received constant interaction with a Registered Dietitian, which involved group presentations, individual educations, and enhanced snack and meal management. Volleyball athletes, received group presentations and individual educations once each month; however, a Registered Dietitian did not influence or order the snacks and meals provided. Football players completed the self-administered food frequency questionnaire and had body composition measurements by the BodPod® in August 2015, one year after the pre-deregulation data collection. Football athletes had the same data collected in March 2015; one year after the pre-regulation data was obtained. Body compositions were paired pre- and post-intervention, as well as fruit and vegetable consumption paired pre- and post-intervention.

Statistical Analysis

The software used for statistical analysis was JMP®10.0. A standard paired t-test was used to compare fruit intake, vegetable intake, and body composition pre-deregulation and post-deregulation. Changes over time within groups were determined using paired t-tests. Additionally, linear regression models were explored to determine a correlation between change in body fat percentage and change in vegetable intake, and change in body fat percentage and change in fruit intake among football players and volleyball players.
CHAPTER 4: RESULTS

Demographics of Subjects

The 19 American football players who participated in this study were all male. The 8 volleyball players included in the research were all female. Tables 4.1, 4.2, 4.3, and 4.4 display the characteristics of the football players and volleyball players at data collection times.

Table 4.1: Characteristics of American football players in April 2014. (N= 19)

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (inches)</td>
<td>68.8</td>
<td>79</td>
<td>74.21</td>
<td>2.9</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>176.85</td>
<td>338.32</td>
<td>249.23</td>
<td>51.62</td>
</tr>
<tr>
<td>Body Fat Percentage</td>
<td>9.4</td>
<td>30.6</td>
<td>19.26</td>
<td>6.91</td>
</tr>
<tr>
<td>Vegetable Intake (cups)</td>
<td>0.641</td>
<td>2.88</td>
<td>1.68</td>
<td>0.74</td>
</tr>
<tr>
<td>Fruit Intake (cups)</td>
<td>0.50</td>
<td>3.34</td>
<td>1.63</td>
<td>0.83</td>
</tr>
</tbody>
</table>

The sample included 19 American football athletes. Five of nineteen (26.32%) of football players were African American. As shown in Table 4.1, in April 2014 for football players, the mean height was 74.21 ± 2.9 inches, the mean weight was 249.23 ± 51.62 pounds, and the mean body fat percentage was 19.26 ± 6.91.

The average fruit intake in cups was 1.63 ± 0.83, and the average vegetable intake in cups was 1.68 ± 0.74. These intakes fall short of the USDA minimum daily recommendations for males of 2 cups of fruit and 3 cups of vegetables each day (USDA, 2015).
Table 4.2: Characteristics of American football players in March 2015. (N=19)

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (inches)</td>
<td>68.8</td>
<td>79</td>
<td>74.19</td>
<td>2.94</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>176.49</td>
<td>342.72</td>
<td>250.56</td>
<td>54.97</td>
</tr>
<tr>
<td>Body Fat Percentage</td>
<td>4.8</td>
<td>29.9</td>
<td>19.37</td>
<td>7.41</td>
</tr>
<tr>
<td>Vegetable Intake (cups)</td>
<td>0.283</td>
<td>3.46</td>
<td>1.82</td>
<td>0.78</td>
</tr>
<tr>
<td>Fruit Intake (cups)</td>
<td>0.283</td>
<td>2.92</td>
<td>1.62</td>
<td>0.81</td>
</tr>
</tbody>
</table>

In March 2015, the mean height was 74.19 ± 2.94 inches, the mean weight was 250.56 ± 54.97 pounds, and the mean body fat percentage was 19.37 ± 7.41. The average fruit intake in cups was 1.62 ± 0.81, and average vegetable intake in cups was 1.82 ± 0.78. These intakes also do not meet the USDA minimum intake recommendations for males.
Table 4.3: Characteristics of volleyball players in August 2014. (N=8)

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (inches)</td>
<td>66.6</td>
<td>75</td>
<td>71.46</td>
<td>2.59</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>128.28</td>
<td>196.17</td>
<td>166.59</td>
<td>21.78</td>
</tr>
<tr>
<td>Body Fat Percentage</td>
<td>15.8</td>
<td>22.4</td>
<td>18.86</td>
<td>2.17</td>
</tr>
<tr>
<td>Vegetable Intake (cups)</td>
<td>0.106</td>
<td>1.72</td>
<td>1.29</td>
<td>1.20</td>
</tr>
<tr>
<td>Fruit Intake (cups)</td>
<td>0.274</td>
<td>2.87</td>
<td>0.94</td>
<td>0.84</td>
</tr>
</tbody>
</table>

The sample included 8 volleyball athletes. Three of eight (37.5%) volleyball players classified themselves as African American. Table 4.3 displays the anthropometric measurements for volleyball players in August 2014. The mean height was 71.46 ± 2.59 inches, the mean weight was 166.59 ± 21.78 pounds, and the mean body fat percentage was 18.86 ± 2.17. The average fruit intake in cups was 0.94 ± 0.84, and the mean vegetable intake was 1.29 ± 1.20. These intakes do not meet the USDA minimum daily recommendations of 2 cups fruit and 2.5 cups of vegetables for females (USDA, 2015).
Table 4.4: Characteristics of volleyball players in August 2015. (N=8)

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (inches)</td>
<td>66.6</td>
<td>75</td>
<td>71.46</td>
<td>2.59</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>146.93</td>
<td>196.79</td>
<td>169.15</td>
<td>17.33</td>
</tr>
<tr>
<td>Body Fat Percentage</td>
<td>18.1</td>
<td>22.5</td>
<td>19.75</td>
<td>1.75</td>
</tr>
<tr>
<td>Vegetable Intake (cups)</td>
<td>0.597</td>
<td>2.07</td>
<td>1.76</td>
<td>1.53</td>
</tr>
<tr>
<td>Fruit Intake (cups)</td>
<td>0.118</td>
<td>6.64</td>
<td>1.58</td>
<td>2.12</td>
</tr>
</tbody>
</table>

For August 2015, the mean height was 71.46 ± 2.59, the mean weight was 169.15 ± 17.33 pounds, and the mean body fat percentage was 19.75 ± 1.75 for volleyball players. Mean fruit intake was 1.58 ± 2.12, and mean vegetable intake was 1.76 ± 1.53, again falling short of the minimum recommendations.
Body Fat Percentage

Table 4.5: Statistics of paired t-test analysis of percent fat for football and volleyball players.

<table>
<thead>
<tr>
<th></th>
<th>Paired Differences</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Difference</td>
<td>Std. Error Mean</td>
<td>95% Confidence Interval of the Differences</td>
<td>t</td>
<td>df</td>
<td>Sig. (prob &lt; t)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 1</td>
<td>Percent Fat</td>
<td>-1.2368</td>
<td>1.45785</td>
<td>-4.2997</td>
<td>1.82599</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Football April</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent Fat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Football March</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 2</td>
<td>Percent Fat</td>
<td>0.8875</td>
<td>0.42571</td>
<td>-0.1191</td>
<td>1.89414</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volleyball August</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent Fat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volleyball August</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The paired t-test analysis of body fat percentage for football players between April 2014 and March 2015 and volleyball players between August 2014 and August 2015 revealed no significance; however, on average, football players decreased body fat percentage by 1.2%, and volleyball players increased body fat percentage by 0.88%. These results indicate that there was not a decrease in body fat percentage among football and volleyball players post-deregulation of snacks.
**Vegetable Intake**

Table 4.6: Statistics of paired t-test analysis of vegetable consumption (cups) for football and volleyball players

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean Difference</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Differences</th>
<th>t</th>
<th>df</th>
<th>Sig. (prob &gt;</th>
<th>t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td></td>
<td></td>
<td>Upper</td>
<td></td>
</tr>
<tr>
<td>Pair 3</td>
<td>Vegetable Intake Football April 2014</td>
<td>0.13395</td>
<td>0.15917</td>
<td>-0.2004</td>
<td>0.46834</td>
<td>0.84156</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Vegetable Intake Football March 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 4</td>
<td>Vegetable Intake Volleyball August 2014</td>
<td>0.46738</td>
<td>0.7275</td>
<td>-1.2529</td>
<td>2.18765</td>
<td>0.64244</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Vegetable Intake Volleyball August 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There was no significant difference in vegetable intake (in cups) for football players between April 2014 and March 2015, or volleyball players between August 2014 and August 2015 after a paired t-test was conducted. On average, football players increased vegetable consumption by 0.13 cups, and volleyball players increased by 0.47 cups. These results indicate that there was not an increase in vegetable consumption post-deregulation of snacks for football or volleyball players.
**Fruit Intake**

Table 4.7: Statistics of paired t-test analysis of fruit consumption (cups) for football and volleyball players

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean Difference</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Differences</th>
<th>t</th>
<th>df</th>
<th>Sig. (prob &gt; t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit Intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Football</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 2014</td>
<td>-0.0127</td>
<td>0.21586</td>
<td>-0.4662</td>
<td>0.44082</td>
<td>7</td>
<td>0.1208</td>
</tr>
<tr>
<td>March 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volleyball</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2014</td>
<td>0.64013</td>
<td>0.50045</td>
<td>-0.5432</td>
<td>1.8235</td>
<td>7</td>
<td>0.1208</td>
</tr>
<tr>
<td>August 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On average, football players decreased fruit consumption by 0.01 cups, and volleyball players increased by 0.64 cups. Statistically, there was no significant difference in fruit intake (in cups) for football players between April 2014 and March 2015, or volleyball players between August 2014 and August 2015 after a paired t-test was conducted. These results indicate that there was not an increase in fruit consumption post-deregulation of snacks for football or volleyball players.
Correlations between Body Fat Percentage and Vegetable Intake

Figure 4.1: Scatterplot between percent fat and vegetable intake among football players

![Scatterplot between percent fat and vegetable intake among football players](image)

Table 4.8: Linear regression analysis of change in body fat percentage and change in vegetable intake in cups for football players from 2014 to 2015

| R-Square | Change in VCUP Intake (Slope) | Y-Intercept | F Ratio | Prob > F | t Ratio | Prob > |t| |
|---|---|---|---|---|---|---|---|
| 0.212 | -4.22 | -0.67 | 4.5822 | 0.0471* | -2.14 | 0.0471* |

Displaying the correlations between body fat percentage and vegetable intake among football players and volleyball players using scatterplots revealed some relationship between the variables. In football players, though the R-Square value was moderately strong (0.212), the probability that there was an increase in vegetable intake (in cups) related to a decrease in body fat percentage was significant (p=0.0471). These results indicate that increasing intake of vegetables may decrease body fat percentage with regular contact with a Registered Dietitian who plans snacks available.
Figure 4.2: Scatterplot between percent fat and vegetable intake among volleyball players

![Figure 4.2: Scatterplot between percent fat and vegetable intake among volleyball players](image)

Table 4.9: Linear regression analysis of change in body fat percentage and change in vegetable intake in cups for volleyball players from 2014 to 2015

| R-Square | Change in VCUP Intake (Slope) | Y-Intercept | F Ratio | Prob > F | t Ratio | Prob > |t|l|
|----------|-------------------------------|-------------|---------|---------|---------|--------|
| 0.003    | -0.03                         | 0.90        | 0.02    | 0.90    | -0.13   | 0.90   |

In volleyball players, the R-Square value was also weak (0.002), and there was no significance in the probability of an increase in vegetable intake (in cups) related to a decrease in body fat percentage (p=0.9029).
**Correlations Between Body Fat Percentage and Fruit Intake**

Figure 4.3: Scatterplot between percent fat and fruit intake among football players

![Scatterplot between percent fat and fruit intake among football players](image)

Table 4.10: Linear regression analysis of change in body fat percentage and change in fruit intake in cups for football players from 2014 to 2015

| R-Square | Change in VCUP Intake (Slope) | Y-Intercept | F Ratio | Prob > F | t Ratio | Prob > |t| |
|----------|------------------------------|-------------|----------|----------|----------|--------|-----|
| 0.23     | -3.19                       | -1.39       | 5.07     | 0.04*    | -2.25   | 0.04*  |

Presenting the correlations between body fat percentage and fruit intake among football players and volleyball players using scatterplots revealed some relationship between the variables. In football players, though the R-Square value was moderately strong (0.2298), the probability that there was an increase in fruit intake (in cups) related to a decrease in body fat percentage was significant (p=0.0378) indicating that increasing fruit intake may decrease body fat percentage with regular interaction with a Registered Dietitian who plans snacks.
Figure 4.4: Scatterplot between percent fat and fruit intake among volleyball players

![Scatterplot](image)

Table 4.11: Linear regression analysis of change in body fat percentage and change in fruit intake in cups for volleyball players from 2014 to 2015

| R-Square | Change in VCUP Intake (Slope) | Y-Intercept | F Ratio | Prob > F | t Ratio | Prob > |t|  |
|----------|-----------------|-------------|---------|---------|---------|--------|-----|
| 0.01     | -0.12           | 0.93        | 0.04    | 0.85    | -0.20   | 0.85   |

In volleyball players, the R-Square value was very weak (0.006), but there was no significance in the probability of an increase in fruit intake (in cups) related to a decrease in body fat percentage (p=0.8517).
CHAPTER 5: Discussion

The purpose of this research was to examine the consumption of fruits and vegetables of Division I collegiate athletes. This study compared fruit and vegetable consumption before and after the deregulation of snacks by the NCAA in Division I college football and volleyball athletes. Body fat percentage was also compared pre- and post-deregulation. The objective of this study was to determine if fruit and vegetable intake increases when provided, and if body fat percentage improves with increased consumption of fruits and vegetables among Division I college athletes.

Vegetable consumption and fruit consumption were collected using the 2005 Block Dietary Data Systems Food Frequency Questionnaire. Body fat percentage was collected using the Bod Pod®. Fruit and vegetable consumption were analyzed separately due to the fact that fruit in some form was available previously for athletes, whereas vegetables were not. A wider variety and larger quantity of fruits were available after deregulation. For football athletes, data were first collected in April 2014, pre-deregulation of snacks by the NCAA. Regular contact with the Registered Dietitian was consistent prior to deregulation and during the intervention. Football athletes also were provided enhanced snacks planned by a Registered Dietitian. Prior to deregulation, snacks were limited to fruits, nuts, and bagels planned by a Registered Dietitian. After deregulation, snack availability increased to include protein options, as well as foods rich in vitamins and minerals, like vegetables and a larger selection of fruit. Various carbohydrate food sources were still available. Body fat percentage and fruit and vegetable intake were then collected for football athletes 1 year later in March 2015. For volleyball athletes, initial data was collected in August 2014. Pre- and post-deregulation, volleyball players had limited contact with a Registered Dietitian, and a Registered Dietitian did not plan available snacks. Snacks provided generally consisted of fruits, nuts, bars, and bagels not planned by a dietitian. Data were then collected 1 year later in August 2015.
The hypotheses of this research were that there would be an increase in fruit consumption and vegetable consumption, and a decrease in body fat percentage. Paired t-tests were conducted resulting in no significant difference in body fat percentage, vegetable intake, or fruit intake for football players or volleyball players between pre-deregulation of snacks and post-deregulation of snacks. These results suggest that there was not a significant decrease in body fat percentage, or a significant increase in fruit and vegetable consumption among football players or volleyball players, despite an increase in food availability for football players; however, volleyball players on average increased their combined fruit and vegetable intake by approximately 1 cup, which is a significant increase despite the statistical results. Exposure to a dietitian did not change pre-deregulation and post-deregulation in the respective groups, but remained high for football and low volleyball. Volleyball players did not meet the USDA recommendations for average females of 2.5 cups of vegetables and 2 cups of fruits pre- or post-deregulation. Football players also did not meet the USDA recommendations for average males of 3 cups of vegetables and 2 cups of fruits pre- and post-deregulation. These shortfalls show that athletes are not meeting the minimum fruit and vegetable consumption for the average human being, much less the increased needs of athletes.

Linear regression models were also used to determine a correlation between a change in body fat percentage and vegetable intake and a change in body fat percentage and fruit intake for football and volleyball players. There was statistical significance in the correlation of vegetable intake and body fat percentage in football athletes showing a negative relationship. As vegetable intake increased, body fat percentage decreased. There was also significance in increasing fruit consumption and decreasing body fat percentage among football players. These results show that consumption of fruits and vegetables decrease fat mass. Also, substituting nutrient-dense foods with fewer calories (vegetables and fruits) for foods not as nutritious and higher in calories are correlated with a lower body fat percentage as expected. Figure 4.1 and 4.3 show three possible outliers in the linear regression model.
These data points were not removed from the data set. One observation was still included because both fruit and vegetable intake decreased and body fat percentage increased. Fruits and vegetables consumed prior to deregulation were likely replaced with foods higher in calories and not as nutrient-dense as fruits and vegetables, resulting in an increase in body fat percentage. Another possible outlier increased fruit and vegetable consumption by 1.57 and 1.62 cups respectively, and decreased body fat percentage by 18.8%. It is likely that this football player substituted fruits and vegetables for high calorie options that are not as nutrient-dense. The other possible outlier increased fruit intake by 1.01 cups, but decreased his vegetable intake by 0.1 cups. The body fat percentage decreased by 14.3%. These results are justified by the theory that the football athletes substituted fruit for higher calorie foods. For volleyball athletes, there was no correlation between a change in fruit or vegetable intake and a change in body fat percentage. These results may signify that regular contact with a Registered Dietitian can improve diet quality, specifically fruit and vegetable consumption among athletes promoting improvements in body composition.
Limitations

There are several limitations in this study that may affect the results found. All of the athletes included in this study were from the same university. The sample size is also a limitation. Because the study included pre-existing data, the sample size was only 19 football players, and 8 volleyball players. For these two reasons, it cannot be assumed that these athletes are a representation of all collegiate athletes and indicates the need for replication with a larger sample size in other settings. Also, a larger sample size may have found significance in the change in body fat percentage, vegetable intake, or fruit intake. Differences among the tight-fitting clothing and swim caps provided to the players during BodPod® testing may have impacted body fat percentage results. Also, all factors that may have affected body fat percentage, like hydration, time of day for height and weight, and the manual evaluation and recording of height could have influenced test results. The length of the 2005 Block Food Frequency Questionnaire may have provided some inaccuracies; however, the change in fruit and vegetable consumption is assumed to be unaffected.
CHAPTER 6: Conclusion

This study suggests there is a negative relationship between fruit intake and body fat percentage, and vegetable intake and body fat percentage among football athletes with regular interaction with a Registered Dietitian who plans snacks available. As fruit or vegetable intake increase, body fat percentage decreased. Due to the deregulation of snacks by the NCAA, increasing vitamins and minerals through fruits and vegetables available for athletes can have a positive impact on diet and body fat percentage. Both can play roles in optimizing athletic performance among athletes. Despite the increased availability, athletes are still falling short of the recommendations for fruit and vegetable intake. Continuing to provide education, nutrient-dense snacks, variety of fruits and vegetables, and constant interaction with a Registered Dietitian may close this gap.
References


VITA

Emily Ludwig is from Southgate, Kentucky. She was awarded a Bachelor of Science in Dietetics from the University of Kentucky in 2014. She has held the professional positions of Dietetic Intern and Graduate Assistant at the University of Kentucky.