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CHANGES OF PERCENT BODY FAT, WAIST CIRCUMFERENCE AND FRUIT AND VEGETABLE INTAKE AMONG DIVISION I COLLEGIATE FEMALE SOFTBALL PLAYERS AFTER NUTRITION CURRICULUM PAIRED WITH TECHNOLOGY

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THESIS

A thesis submitted in partial fulfillment of the
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ABSTRACT OF THESIS

CHANGES OF PERCENT BODY FAT, WAIST CIRCUMFERENCE AND FRUIT AND VEGETABLE INTAKE AMONG DIVISION I COLLEGIATE FEMALE SOFTBALL PLAYERS AFTER NUTRITION CURRICULUM PAIRED WITH TECHNOLOGY

Previous research has found that the quality and intake of collegiate athletes' diets does not meet the recommended standards. Little research has been completed in regards to the diets of collegiate female softball players. The purpose of this research study was to determine if an 11-week nutrition curriculum paired with a technology could increase fruit and vegetable consumption while decreasing percent body fat and waist circumference. The sample included 14 female softball players. Paired t-test were preformed to compare fruit and vegetable intake, body fat percentage, and waist circumference pre- and post-intervention. Linear regression models were used to determine correlations between change in fruit and vegetable consumption and body fat percentage, and change in fruit and vegetable consumption and waist circumference. Results showed that an increase in fruit in vegetable consumption was associated with a significant increase in waist circumference (p=0.0328). Of the participants, 43% were freshmen and may be related to freshman year weight gain. Based on the current findings, more research is needed with stricter protocols.

KEYWORDS: Fruit, Vegetable, Nutrition Curriculum, College Softball Players, Waist Circumference, Body Fat Percentage

Rachel Rusher Thomas

April 19, 2017

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CHAPTER 1: INTRODUCTION

Many young adults have poor eating habits (Laska, 2014). Among the population of young adults is college students; particularly student athletes. Research has found that female collegiate athletes fail to meet their estimated energy and carbohydrate needs, which can negatively impact both training and recovery along with overall nutritional status (Shriver, 2012). Researchers have also found that collegiate athletes need to be targeted for nutrition education as it relates to optimizing performance (Rosenbloom, 2002).

Collegiate female softball players log many hours outside of the classrooms on the fields and weight rooms trying to better their performance. The performance factor for softball players is not focused on endurance, but is focused on strength (Mala, 2015). Other factors, including quality of diet play a role in overall level of performance. There has been a limited amount of work completed to intervene with collegiate female softball players' diet. In 2014, the National Collegiate Athletic Association deregulated meals, allowing for athletes to more appropriately recover and refuel their bodies with whole foods throughout the day (Wilfert, 2014). This deregulation was universal, including both male and female athletes. Little research has been published on female Division I collegiate athletes since the changes (Ludwig, 2015).

The focus of this research is to identify if there were significant changes in fruit and vegetable intake and body composition of female collegiate softball players after an 11-week nutrition curriculum with a technology component was completed during pre-season, after the de-regulation of meals by the NCAA.

PROBLEM STATEMENT

Many studies have been completed to examine the diet quality of female collegiate athletes to determine if they are meeting minimum nutrition guidelines (Ludwig, 2015; Quatromoni, 2008; Rosenbloom, 2002; Shiver, 2012). Studies have also been completed to examine the relationship between attending a nutrition curriculum based intervention and its impact on overall health among college students (Quatromoni, 2008; Richards, 2006; Murphy,2001; Lua, 2012; Kelly, 2013; Plotnikoff, 2015; Kicklighter, 2010). These studies have found that college age students are interested in nutrition curriculum, and intake of fruits and vegetables can be improved (Quatromoni, 2008; Richards, 2006; Murphy,2001; Lua, 2012; Kelly, 2013; Plotnikoff, 2015; Kicklighter, 2010). Little research exists examining the relationship between fruit and vegetable intake and nutrition curriculum based interventions impact on percent body fat and waist circumference among college athletes, specifically collegiate female softball players. This study aims to help fill this gap.

RESEARCH QUESTIONS

1. Does an 11-week nutrition curriculum decrease body fat percentages of female collegiate softball players?
2. Does an 11-week nutrition curriculum increase intake of fruits and vegetables in female collegiate softball players?
3. Does waist -circumference change in collegiate female softball players after an 11-week nutrition curriculum?

4. Is there a correlation between change in fruit and vegetable intake and change in body fat percentage or change in waist-circumference after an 11-week nutrition curriculum for female collegiate softball players?

HYPOTHESES

1. An 11-week nutrition curriculum will decrease the body fat percentages of female collegiate softball players as measured by the Bod Pod®.
2. An 11-week nutrition curriculum will increase the intake of fruits and vegetables in female collegiate softball players as measured by National Cancer Institute (NCI) Fruit and Vegetable Screener.
3. An 11-week nutrition curriculum will result in decrease waist-circumference as measured by manual waist-circumference measurements.
4. There will be a negative correlation between change in fruit and vegetable consumption and change in body fat percentage and change in waist-circumference after an 11-week intervention.

JUSTIFICATION

Research has yet to be completed on the impact of a nutrition curriculum paired with use of technology focusing on female collegiate athletes in improving their overall fruit and vegetable consumption. Evidence has been outlined by the American College of Sports Medicine that indicates that diet quality impacts athletic performance (Thomas, 2016). Limited research has been done with female collegiate athletes, particularly softball players, and the use of technology paired with a nutrition curriculum to improve diet quality, particularly after the deregulation of meals. This deregulation allows athletes access to fruits and vegetables at no additional cost.

CHAPTER 2: LITERATURE REVIEW

When most people think of collegiate athletes, they think of high performing, lean, and nutritionally sound athletes. The average collegiate female softball player does not fit into the lean category, yet resembles the body composition of a typical American of similar age range (Carbuhn, 2010). Because this population wants to perform at their optimal capacity, meeting their individual nutrition needs is important. Multiple studies have looked at the impact of providing a nutrition curriculum and or use of dietary logs to improve and increase consumption of fruits and vegetables among various populations, particularly college students (Lua, 2012; Plotnikoff, 2015; Kicklighter, 2013; Kelly, 2012; Shriver, 2013). Currently the research on collegiate athletes and dietary intake is limited. Research that has been completed on female athlete's dietary intake has focused on if they were meeting the recommended daily intake, but did not focus on increasing intake of fruits and vegetables (Shriver, 2013). Understanding if providing female collegiate softball players with a nutrition curriculum coupled with a technology component, and estimated needs based on body composition recommendations improves their body composition during pre-season is of interest.

DETERMINANTS OF DIET QUAILTY

MEETING RECOMMENDATIONS FRUIT AND VEGETABLE CONSUMPTION OF ATHLETES

The average American does not meet the recommended intake of fruits and vegetables (Shriver, 2013). A recent study conducted by Shriver, L., and colleagues focused on the eating habits of female collegiate athletes, and if they are consuming enough fruits and vegetables to meet the current sports nutrition standards (Shriver, 2013). The main purpose of the study was to assess the energy and macronutrient intakes of female collegiate athletes compared to the minimum sports nutrition recommendations, and to explore the eating habits and dietary patterns in the target population (Shriver, 2013). The researchers recruited participants from three different women's athletic teams between January 2009 and May 2010 (Shriver, 2013). Anthropometric measurements and body composition were taken on each of the participants. The participants also completed a 1-day 24-hour recall that was administered by a trained research assistant (Shriver, 2013). After the 24-hour recall, each of the participants was provided with instructions on how to complete a 3-day food record, and were asked to do so over 2-week days, and 1 –weekend day, and include the type and duration of physical activity they participated in during those days (Shriver, 2013). Something important to note is that during the time of the study all the participants were either in late preseason or early season training, participating in training 6 days per week from 1.5 to 2.5 hours, and were weight stable (Shriver, 2013).

The researchers found that almost all of the athletes they sampled failed to meet their recommended energy intakes for their estimated needs, with most of them failing to meet their carbohydrate needs (Shriver, 2013). A limitation to the present study is that the sample size is relatively small, and the time commitment needed by the participants was too demanding for more to participate. Another limitation is they did not focus on if the athletes were maintaining, gaining, or losing weight. The main finding of this study is that female athletes should be evaluated for their estimated energy needs, and if they are meeting them or not.

In 2014, the NCAA deregulated the snack ruling, which allowed for athletic departments to provide snacks and meals as part of participation on a sports team (Wilfret, 2014). Ludwig wanted to assess the consumption of fruits and vegetables upon Division I athletes after the deregulation. The purpose of the study was to determine if fruit and vegetable consumption increased, and with the increase of fruits and vegetables that body fat percentage would decrease after the deregulation (Ludwig, 2015). There was a total of 27, male and female collegiate athletes included in the study, with 19 being football players, and eight volleyball players (Ludwig, 2015). The body composition using the Bod Pod® and intake of fruits and vegetables using the Block Dietary Data systems 2005 Food Frequency Questionnaire was completed twice (Ludwig, 2015). The first time was pre-deregulation, and then once after deregulation. It was found that there was no significant change in fruit or vegetable intake for both volleyball and football (Ludwig, 2015). It was found however, that the probability of an increase in vegetables related to a decrease in body fat percentage for the football players was significant ($p=0.0471$)(Ludwig). It was also found that the probability that there was an increase in fruit and vegetable intake related to a decrease in body fat percentage in the football players was significant (p=0.0378) as well (Ludwig, 2015). There was no significant probability for the relation of fruit or vegetable intake and body fat percentage change among the volleyball players. One of the limitations to this study was that it was a small, convenience sample. The researcher also reported that the tight-fitting clothing and swim caps differed among the participants during the Bod Pod® measurements, which could have affected the results (Ludwig, 2015). The study concluded that the increase in fruits and vegetables resulted in a decrease in body fat percentage among collegiate athletes (Ludwig, 2015).

The last study of interest focused on determining the diet and body composition of collegiate athletes. The researcher wanted to determine if there were any dietary excesses and deficiencies found among athletes, if there was a relationship between body fat percentage and diet quality, and if there was a difference in diet quality between male and female athletes (Ireland, 2013). A cross-sectional study was completed over a year and a half period, with 138 collegiate athletes volunteering to participate in the study, 48 being male and 90 females (Ireland, 2013). Body composition was measured through the use of the Bod Pod®, while the Block 2005 Food Frequency Questionnaire was used to assess the participants diets (Ireland, 2013). The diet quality was calculated using the Block 2005 Food Frequency Questionnaire, and the Healthy Eating Index 2005 (Ireland, 2013).

All of the participants had a mean body fat of 17.8; while the male participants had a body fat of 11.1, and the female participants had a body fat of 24.1 (Ireland, 2013). The average diet score was 51, indicating athletes do not have a high quality diet score (Ireland, 2013). The overall average fruit consumption was 1.7 cups; while for males it was 1.8 cups, and for females 1.6 cups (Ireland, 2013). The overall average of vegetables consumed was 2.4 cups; while for males it was 3.1 cups, and 2.0 cups for females (Ireland, 2013). The overall average of dietary fiber was 20.5 grams; while for males it was 27.3 grams and for females 16.8 grams (Ireland, 2013). The overall average of calories from solid fats, alcoholic beverages, and added sugars was 1231.3 calories (Ireland, 2013). For males, the calories from solid fats, alcoholic beverages, and added sugars was1844.6 calories, and 900.6 calories for females (Ireland, 2013). They also found a negative correlation between diet score and percent body fat, and no correlation between BMI and diet score (Ireland, 2013). Limitations of the study were convenience sample and a small sample size. It was also reported that the researcher was not aware if the athletes were in or out of season during the time of assessment. The overall finding from the study was that athletes may not know how to choose appropriate food items to help them achieve their highest athletic ability.

NUTRITION EDUCATION

Providing nutrition educations is an effective way of giving healthy diet and nutrition information to participants (Lua, 2012). A study was conducted to determine the effectiveness of a community-based education program aimed at changing the consumption rate of fruits and vegetables in overweight and obese adults. Participants had to have a BMI of at least $25kg/m^2$ to be included in the study (Wagner MG, 2016). Participants were excluded if they were less than 18 years old, were current smokers, had a BMI lower than 25 kg/m^2, or had a history of bariatric surgery (Wagner MG, 2016). The study initially started with sixty-seven participants, with only fifty-four completing the three phases of the 14-week study (Wagner MG, 2016). The participants were assigned to a control group, an education group, or a fruit and vegetable group that received the intervention.

Participants in the control group received no intervention, but were given the option to receive information about fruits and vegetables at the conclusion of the intervention (Wanger MG, 2016). Participants in both the education and fruits and vegetable groups received information weekly about the antioxidant content of fruits and vegetables, the roles of antioxidants in the inflammatory process, and current recommendations for fruit and vegetable consumption (Wanger MG, 2016). The fruit and vegetable group also received recommendations for incorporating fruits and vegetables into their current meal plans, and offered samples of fresh, frozen, or canned fruits and vegetables at each weekly education session (Wangner MG, 2016).

A pre- and post-test were given to assess demographics and food intake using a three-day food log (Wagner MG, 2016). The intervention consisted of 10, 30-minute sessions that lasted for 10 weeks, for a total of 300 minute, where information on the benefits of fruits and vegetables, how to properly store, clean, and prepare them, and various others factors when incorporating healthy eating into the diet were addressed. At the conclusion of the post-test, 90.7% (Wagner MG, 2016) of the participants in the intervention group increased their intake of fruits and vegetables.

Similar to any study, limitations to this study should be noted. The researchers utilized convenience sampling by focusing on overweight and obese adults. Another limitation noted is that the researchers did not take into account seasonal availability of various fruits and vegetables (Wagner MG 2016), which may have been limited since the study was during the fall and winter months. A typical season lasts 12 weeks, were the study was over a 14-week period, and availability varies by location and climate. Because the participants knew what the study was about, a reporting, and social acceptability bias could have occurred, causing the participants to increase intake of fruits and vegetables with little influence from the intervention. Lastly, because participants dropped out, the sample size for the three groups was not equal (Wagner MG, 2016).

Overall, the researchers found that a nutrition education that either does or does not provide fruits and vegetables to participants to sample can be helpful in increasing fruit and vegetable intake. The researchers also found that even after providing an intervention, most of the participants did not consume the recommended servings of fruits and vegetables, even though their intake did increase (Wagner MG, 2016). This study also suggested that further research should be done on interventions focused on decreasing the intake of high-energy foods.

Knowing the effectiveness of nutrition interventions among the college student age population is important in understanding what type of intervention works best with this age group. Lua and colleagues completed a review in order to provide a summary of studies on the effectiveness of nutrition education interventions used by college students in developed nations (Lua, 2012). A search through relevant databases was conducted for articles published between 1990 and 2011 (Lua, 2012). At baseline, 52 articles were generated with only 14 meeting the inclusion criteria (Lua, 2012). To be included: participants had to be 18-24 years old; study design was cross-sectional, exploratory, longitudinal, or randomized control trials; and available in full-text form (Lua,2012). Studies were excluded if there were published in any other language than English, were reviews, or abstracts (Lua, 2012).

The researchers found the studies used one of three methods of intervention: web-based education, dietary supplements, and educational lectures (Lua, 2012). To determine if dietary changes occurred in the studies reviewed, the researchers found the studies reported the use of: food frequency questionnaires, 3-day dietary record, and 24-hour recall questionnaire (Lua, 2012). It should be noted that of the 1668 participants from all 14 studies, n=1113 of the participants were female, and many of the studies were conducted in the United States (Lua, 2012). After conducting the review of previous research studies, the researchers concluded that significant and beneficial changes in dietary habits among college students after a nutrition intervention; particularly nutrition education combined with providing supplements (sea tangles) is the most effective method (Lua, 2012).

Limitations to the study include selection bias based on only selecting studies in English and from developed nations (Lua, 2012). Overall the study concluded that provided a nutrition education to college students is effective at improving diet quality.

Knowing which methods of delivery for providing a nutrition education to college students is important, but it is also important to clarify the directions for research and practice. Kelly and colleagues conducted a systematic review of dietary interventions with college students. The researchers aim was to facilitate a narrative synthesis of the current literature evaluating nutrition and dietary interventions in college settings, and to determine specific programs and factors associated with healthful dietary changes among the student population in an attempt to provide direction for future research and practice (Kelly, 2013). A total of 936 abstracts were identified from the initial search, with n=14 meeting the inclusion criteria (Kelly, 2013). Of the 14 included studies, n=6 were random control trials, n=1 was quasi experimental, and n=7 were non-experimental (Kelly, 2013). The interventions used in these studies were in-person, online, or environmental/point-of-purchase messages (Kelly, 2013). The researchers found that the most used theoretical approach was the Social Cognitive Theory (Kelly, 2013). The researchers also concluded from their findings that interventions including combination of face-to-face, online, and environmental components could likely be the most effective method of intervention for college students (Kelly, 2013). Limitations to the study included the sample size of studies included. Overall the study suggests that interventions involving self-regulation strategies have the greatest potential of initiating dietary changes among college students (Kelly, 2013).

Many studies have found that nutrition education can improve the diet quality of participants, and it is worth the time and cost to implement the intervention. A recent study conducted by Pem and colleagues focused on what factors influence nutrition knowledge, the efficacy of nutrition education, fruit and vegetable intake, energy intake, physical activity, BMI, nutrition knowledge and attitudes of adults before and after a nutrition education intervention (Pem, 2016).

At baseline, the participants completed a food frequency questionnaire (FFQ) that was adapted from the Nutritional Epidemiology group at Leeds University that contained 67 items (Pem, 2016). The nutritional education program was partially designed from adult learning theory and consisted of four steps: assessing learner needs, setting educational objectives, choosing and implementing a wide range of methods, and assessing the learning that occurred (Pem, 2016). The adults in the intervention group attended two, two-hour sessions that focused on lecturing, handouts, and picture collages, with the final session focusing on summarizing the topics discussed (Pem, 2016).

The twelve-week intervention found that at baseline the control and randomized intervention group did not differ in dietary intake patterns. Confounding variables were controlled for in the post-intervention assessment, with results showing that the intervention group significantly increased their intake of fruits and vegetables, and decreased their consumption of high-energy foods compared to the control group (Pem, 2016).

Overall, the nutritional knowledge increased among the intervention group. The researchers found that providing the nutritional education intervention resulted in an overall increase in fruits, nutritional knowledge, attitudes towards healthier eating, and significant decrease in high-energy foods (Pem, 2016). There were several limitations to this study. No significant changes in anthropometrics occurred over a twelve-week period (Pem, 2016). A second limitation was that the cultural influence on food choices was not considered (Pem, 2016). Finally, measuring the food frequency over three days does not fully represent usual intake because it does not show long term dietary habits which can sometimes be influenced to festival changes (Pem, 2016). Educating a population on proper nutrition can improve the overall diet quality and beliefs in a population, as found in this study.

National Cancer Institute (NCI) FRUIT AND VEGETABLE SCREENER

Determining intake of macronutrients at the beginning of an intervention is important in order to determine if the intervention was significant in improving diet quality. Greene and colleagues conducted a study to determine the use of the NCI (National Cancer Institute) Fruit and Vegetable Screener with five ethnically and age diverse adult populations (Greene, 2008). The main focus was to determine the correlation between fruit and vegetable intake estimates from the screener compared the multiple 24-hour recalls and serum carotenoid levels (Greene, 2008).

The screener was administered at various sites across the country to pull from different demographic populations. The screener included nineteen items that asked about the consumption of ten different fruits and vegetables over a twelve-month period.

To determine the validity of the NCI Fruit and Vegetable Screener, the screener was evaluated in the Eating at America's Table Study (EPI,2001). The purpose of the study was to examine the cross-sectional capacity of the fruit and vegetable screener and 1-item measure to estimate the fruit and vegetable servings related to multiple 24-hour recalls at two different time points (Peterson, 2008). The study also focused on the performance of the two screening methods to measure change in fruit and vegetable intake by comparing mean treatment effects with a 24-hour recall at follow-up (Peterson, 2008).

The study of interest concentrated on five of the fifteen locations that were part of The Behavior Change Consortium (Peterson, 2008). A total of 315 participants participated and took a 24-hour recall and fruit and vegetable screener at both baseline and follow-up (Peterson, 2008). The fruit and vegetable screener consisted of 19-items that asking about the frequency of the usual consumption of 10 categories of fruits and vegetables over the past month (Peterson, 2008). The 24-hour recall was conducted over telephone by trained interviewers (Peterson, 2008).

The results of this study indicated that the fruit and vegetable screener overestimated the intake of fruits and vegetables compared to the 24-hour recall (Peterson, 2008). The results after the intervention showed that the correlation of the fruit and vegetable screener to the 24-hour recall improves over time as participants learn how to better estimate their intake of fruits and vegetables (Peterson, 2008). This is significant in proving the validity of a fruit and vegetable screener. The study being reviewed had several limitations. Because there was only 3 days counted in the 24-hour recall, this results in possible error. Another issue is the variation is sample populations in which the different instruments were used on. Overall the study indicated that larger sample size is needed to exam the differences in fruit and vegetable consumption via the use of screeners across various sample populations.

The NCI wanted to know the test-retest reliability of three different dietary assessment-screening tools. Yaroch, and colleagues wanted to evaluate three different short fruit and vegetable screeners, a 2-item serving, a 2-item cup, and a16-item fruit and vegetable screener in adults by using multiple 24-hour recalls as the reference tool (Yaroch, 2012). Another goal of the study was to determine the test-retest reliability of the screening tools over a 2-3 week period (Yaroch, 2012). The sampling population for the study came from adults 18 years and older who were apart of the Synovate's Consumer Opinion Panel in the fall of 2006 (Yaroch, 2012). A stratified random sampling was done of households on the panel, with oversampling taken from African-American households (Yaroch, 2012).

For the validity study of the various screeners, 1,263 participants were initially contacted, with 254 participants returning at least 2 of the 3 screeners (Yaroch, 2012). A separate group was asked to participate in the test-retest to determine the reliability of the screeners. Of the 663 participants invited to participate, only 401 returned the first survey, and 335 returned the second, for the

2-3 week time period of the study (Yaroch, 2012). The study found that short dietary screeners could be useful to determine the estimates and rank individuals on their intake of fruits and vegetables. The current study found that overall; the 16-item screener provided the least amount of bias when determining fruit and vegetable intake, both with and without fried potatoes (Yaroch, 2012). The median fruit and vegetable intake was not significantly different for the 24-hour recall compared to the 16-item screener (Yaroch, 2012).

Limitations from this study should be noted. Because the study was cross-sectional, the researchers were not able to test the screeners' sensitivities to change in fruit and vegetable intake over time, and a convenience sample was used (Yaroch, 2012). The study concluded that even though fruit and vegetable screeners are cost-effective and easy to use, they should not be used when wanting to obtain a precise measurement of fruit and vegetable intake (Yaroch, 2012).

USE OF TECHNOLOGY AND TRACKING INTAKE

Smartphones have dramatically changed the way we communicate with each other, and keep up with our individual behaviors of daily living. Research has been done to show how the use of smartphones can affect health promotion and tracking of dietary intake (Bert, 2013; Rusin, 2013; Carter, 2013; Forster, 2015). The first study of interest was conducted by Bert and colleagues to determine the availability of smartphone applications used to promote health, and the advantages and disadvantages of them. A bibliographic search was conducted through multiple science based research databases, with articles that were selected by title, abstracts, and then full-text (Bert, 2013). The data base searching resulted in 4,669 results were initially found, with only 32 meeting the inclusion criteria and specifically focusing on health promotion (Bert, 2013). The articles were classified into four categories: nutrition, fitness and physical activity, lifestyles, and health in elderly (Bert, 2013).

Limitations to this study were mentioned. The researchers did not conduct an exhaustive search because of the language restriction of only using English and German articles, and the criteria of only including full-text availability of the articles (Bert, 2013). Another limitation mentioned is that the databases used were only scientific literature focused, and the continuous updating of technology and phone applications leads to gaps in the current research (Bert, 2013). Overall, the researchers concluded that the use of smartphones in the promotion of health has many positive aspects that could potentially be further researched. The relative cheapness, small size, and wide availability of smartphones make them a potentially strong tool in improving health promotion (Bert, 2013).

Keeping track on one's diet is key to identifying changes that nutritionally need to be made to improve nutritional health. Rusin and colleagues conducted a study to summarize the existing approaches to self-manage food intake recording and to analyze the functionality of input methods (Rusin, 2013). The researchers used electronic databases to locate publications with systems for recording food intake. They also wanted to know more about the different mobile applications available for food logging that were available free of charge, with a free trial, or on a “freemium” basis (Rusin, 2013). The researchers found that the electronic systems used for recording food intake most commonly use text data input.

A few drawbacks were found to entering food intake into the electronic sources. Some of the databases required the users to calculate the calories and or carbohydrates of the food consumed. Another drawback is obtaining information on the nutritional qualities of foods, particularly meals with differing preparation styles (Rusin, 2013). Also, the users must be able to estimate the portion size they are consuming to accurately record their intake.

Rusin and colleagues also looked at the use of automatic mode of inputting food intake. This is the process where the mobile application allows the user to scan the barcode of the food item, allowing for minimal user input (Rusin, 2013). The main limitation of the study was the lack of evidence about the usefulness of functionalities forms the selection of applications (Rusin, 2013). Overall the study, which looked at research from 1998 to 2012 suggesting that having the database keep track of foods most commonly entered by the user, was something that could be improved (Rusin, 2013). Some of these improvements have been made to mobile applications since the publication of this study.

A study conducted by Carter and colleagues, and focused on the difference in adherence to a smartphone application compared to website and paper diary for weight loss in a pilot randomized control trial study in the United Kingdom. The researchers developed a mobile application for the study called My Meal Mate, containing a large United Kingdom-branded food database, and was scaled against the commercially known mobile application MyFitnessPal (Carter, 2013). The aim of this study was to test the acceptability and feasibility before testing in a larger trial. Participants were recruited via advertising, and to be eligible had to have a BMI of ≥ 27kg/m^2, between the ages of 18 to 65 years old, willing to commitment necessary needed time and effort for the study, employed by a large employer in Leed, not pregnant, breastfeeding, or planning to become pregnant, not taking anti-obesity medications or medications/insulin for diabetes, never had surgery for weight loss, not taking the antidepressant sertraline, and able to read and write in English, able to access the internet, and willing to be randomized into one of three groups (Carter, 2013).

The intervention used in the study used a mobile application that allowed the users to set a weight loss goal and self-monitor daily calorie intake to reach their goal (Carter, 2013). The intervention group was assigned to the mobile application, the second group was assigned to a self-monitoring website and the third was assigned a food diary accompanied by a calorie-counting book (Carter, 2013). The study initially had 128 participates who met all eligibility requirement (Carter, 2013) and completed initial assessments. During the 6-week follow-up measurements, only 94 participants returned, and only 79 returned at the end of the 6-month trial period (Carter, 2013). The researchers found that significantly fewer, ($p=0.001$) people dropped out of the mobile application group compared to the diary and website groups. They also found that weight loss in the group assigned the mobile application was comparably to reported weight loss in large multicenter randomized control trial studies of popular commercial diet programs (Carter, 2013).

Limitations to the study were that most of the participants were white, female, and employed in managerial/professional occupations (Carter, 2013). Other limitations were the mobile application suggested for use was a prototype (Carter, 2013). Lastly, 7 participants from the smartphone group, and 7 participants from the diary group reported using a website (Carter, 2013). Of the diary group, there was 4 participants using the smartphone app, and 2 from the website group reporting they have used a smartphone app (Carter, 2013). Lastly, there was one participant originally randomized to the diary group who used a smartphone app for the duration of the trial (Carter, 2013), potentially affecting the overall outcome of the results. The research, as a whole, showed the use of a mobile application could be both acceptable and feasible in a weight loss intervention.

Forster and colleagues conducted a research study to determine the role of new technologies in dietary assessment. The researchers focused on the growing research that implies how providing individuals with specific personalized feedback can be more effective than generic information in improving overall dietary quality (Forster, 2015). The objectives of the research were to examine the current range of new technologies developed for assessing dietary intake, and to assess the utilization and efficacy of these new technologies (Forster, 2015). Because technology is so widespread, there are several methods at which they looked at. These included online website-based dietary assessments, mobile application dietary assessments, and wearable sensor technologies (Forster, 2015). One of the limitations to this study is the main author was financially supported for her research by one of the online food frequency questionnaires (Forster, 2015). Overall the researchers found that more research is needed on the use of personalized feedback and its use in motivating users to reach their weight loss goals (Forster, 2015).

It is well known that technology is widely used among the college-age population. A study conducted by Anderson-Bill and colleagues aimed to examine the social cognitive determinants of nutrition and physical activity among web-health users who were enrolled in an online social cognitive based nutrition, physical activity, and weight gain intervention (Anderson-Bill, 2011). Participants were recruited via web-based email listservs, online and print advertisements, and direct mailings (Anderson-Bill, 2011). The participants (n=1307) were included in the study if they were between the ages 18 to 63 years old, had a high normal to obese BMI, currently not active, and otherwise noted as healthy. All components of the baseline assessment were completed by 731 of the participants (Anderson-Bill, 2011). Background information was taken on the participants via the website, and they were then redirected to NutritionQuest to complete the Block 2005 Food Frequency Questionnaire (Anderson-Bill, 2011). Once the questionnaires and surveys were completed, the researchers mailed the participants a digital bathroom scale and a pedometer for tracking daily steps taken for one week (Anderson-Bill, 2011). The results found that these web users' dietary consumption was higher in fat and lower in fruits, vegetables, and dietary fiber compared to the recommended intake values (Anderson-Bill, 2011). The researchers found that the web-health users showed high levels of self-efficacy for making changes and of expectations that change would have health benefits (Anderson-Bill, 2011). No limitations were identified, but attrition is evident based on the number of participants who dropped out. This study concludes that the self-efficacy contributes to higher levels of physical activity and lower dietary fat intake, but not increased levels of fiber, fruits, and vegetables among internet health users(Anderson-Bill, 2011).

DETERMINATION OF BODY COMPOSITION

WAIST CIRCUMFERENCE (WC)

It is well understood that waist circumference is a strong indicator of morbidity and mortality related to obesity. According to the Center for Disease Control and Prevention (CDC), waist circumference greater than 40 inches for males, and greater than 35 inches for non-pregnant females, are indicators for high risks of developing obesity related health conditions (CDC, 2015). The CDC recommended method of measuring waist circumference while the participant is standing: “place the tape measure around the middle just above the hipbones, measure horizontally around the waist, keep tape measure snug but not compressing, and take the measurement once participant breathes out” (CDC, 2015).

Multiple studies have been conducted to compare recommended methods of measuring waist circumference. A large cohort study with 1,898 participants was conducted to compare waist circumference- iliac crest (WC-IC) and waist circumference-midline (WC-mid) in determining central obesity (Ma, 2012). The WC-IC was measured by using the horizontal plane at the superior border of the right iliac crest (Ma, 2012). WC-mid was measured by using the horizontal plane midway between the lowest rib and the iliac crest (Ma, 2012). To determine reproducibility of the measurement methods, 3 trained nurses measured 10 males and 10 females over 3 consecutive days (Ma, 2012). The measurements of WC-IC values were significantly higher for both males and females then the WC-mid, with the difference being greater in females then in males ($p < 0.001$) (Ma, 2012). The study found that WC-mid is overall a better measurement of central obesity. Limitations to this study are that only two types of waist circumference measurements were compared. Per the studies literature review, there are at least eight different ways to measure waist circumference, but the two methods used are those recommended by the World Health Organization, NCEP, ATP III, and IDF (Ma, 2012). Based on this study, the location of waist circumference measurement has a more significant impact in females compared to males in defining central obesity (Ma, 2012).

A second study reviewed focused on determining the best measurement for waist circumference as it relates to obesity-related morbidity and mortality. A panel of experts in the field of obesity identification and obesity-related epidemiology were gathered to review published scientific literature and the relationships of waist circumference with morbidity from cardiovascular disease (CVD) and diabetes, and with mortality from all causes, and from CVD (Ross, 2008). Over a sixth month period articles were searched for on PubMed, and after manually sifting through, 120 articles with a total of 236 samples (Ross, 2008) met the inclusion criteria. The association of sample size, sex, age, race and ethnicity on the relationship of waist circumference in multivariate models was also examined for the significant or non-significant differences, and the positive or negative associations (Ross, 2008).

The measurement protocols in all of the studies were either based on bony landmarks or external landmarks (Ross, 2008). The data for the studies included: midpoint (35 studies), minimal waist (32 studies), umbilicus (34 studies), iliac crest (5 studies), 1 inch above umbilicus (2 studies), last rib (1 study), and largest abdominal circumference (3 studies) (Ross, 2008). It should be noted that 12 of the studies had participants measuring their own waist circumference, and that except for the minimal waist the protocol for each of the other waist circumference measurements was consistent across all the studies included (Ross, 2008).

Of all the studies examined, 29 focused on waist circumference and all-cause mortality (Ross, 2008). Over half (54%) of the samples in these studies showed a statistically significant association when the WC protocols required: measurement at minimal waist, umbilicus, midpoint, or 1 inch above the umbilicus (Ross, 2008). There was a non-significant association for 44% of the samples when the protocol for WC was: umbilicus, midpoint, or minimal waist (Ross, 2008).

One limitation of the study is that 101 of the 120 studies included in the review, reported waist circumference as being measured at the umbilicus, midpoint, or minimal waist (Ross, 2008), possibly skewing the results. The other limitations to the study involved not being able to conduct a meta-analysis and the method used to calculate the statistical significant association of the studies (Ross, 2008). The study concluded that among the eight protocols the panel identified, the WC measurement protocol used has no substantial influence on the association between WC and morbidity or mortality (Ross, 2008).

Even though WC measurement has been validated as a strong predictor for obesity related diseases, little has been done to look into errors of measurement. Multiple studies have found that less variability occurs in WC measurements when they are performed by a trained health professional rather than a physician (Verweij, 2012). Because of the variability in measurements, a few potential issues arise for the validity of waist circumference studies. These issues include: only a few of the studies are actually reliable, many studies report reliability but not an absolute measurement of error, and it is not clear what is known as clinically significant change in WC (Verweij, 2012).

Verweij and colleagues reviewed current literature to explain differences in reliability and measurement error of WC. They also wanted to document why it is important to determine errors in WC. The aims of their literature review were to: discuss what is already known about measurement errors and the contributing factors; discuss what is known about clinical relevant changes in WC; discuss how knowledge about clinically relevant changes may help explain the importance and impact of measurement error; and provide recommendations for future research (Veweij, 2012). The researchers reported the importance of measurement error, is that it provides an advantage over reliability for clinical interpretation as it is displayed on the actual measurement scale and not as a dimensionless value between 0 and 1 (Veweij, 2012). The literature review was conducted using PubMed, searching for studies between the years of 1975 and February 2011, with the search resulting in 559 studies, and only 9 of them reporting intra- or inter-observer measurement error (Veweij, 2012). The study overall reported intra-observer measurement error was 0.7 to 9.2 cm, and 1.4 to 15cm for inter-observer error (Verweij, 2012). The researchers reported that a reduction of waist circumference of >5% could be considered a clinically relevant change in some patients for the short term, and a maintained waist circumference reduction of >3% for the long term for some patients (Verweij, 2012). The researchers also found that smaller intra- and inter-observer error was found in studies with larger sample sizes.

The researchers found that because of the small number of studies, a conclusion cannot be made on the effects of measurement errors, resulting in a significant limitation. Based on the findings of what was notable from the literature review, the researchers concluded that training research assistants, repeated WC measurements with average taken, and adopting a standard protocol (Verwij, 2012), are all ways to reduce measurement errors.

BOD POD®

Body composition is a valuable measure in determining the overall health of a patient or client. The Bod Pod® is an egg shaped chamber that derives body composition information, particularly pounds of lean body mass and pound of fat mass by air-displacement plethysmography (Tseh, 2010).

Knowing the validity of lab measurements is important in achieving proper measurements of body composition in research. Wagner, D., and Heyward, V., tested the validity and reliability of various lab and field techniques for measuring body composition. The laboratory methods examined in the study were hydrodensitometry, air displacement plethysmography (Bod Pod®), isotope dilution, and dual-energy x-ray absorptiometry (Wagner, 1999). The field measurements assessed were bioelectrical impedance analysis, near-infrared interactance, skinfold measurements, and anthropometry (Wagner, 1999). Each of the laboratory and field methods was assessed for its strengths and limitations. A brief description of the methods, and background information on how the validation of each method was developed was provided in detail.

The study of the various methods was reviewed and compared. Body density was compared from the measurements taken by the Bod Pod® and hydrostatic weighing. The researcher found that body density measured by the two methods was highly correlated with a mean difference in percent body fat of 0.3% (Wagner, 1999). The researchers found the laboratory methods to be more precise than the field methods (Wagner, 1999). No limitations for this study were provided. The study provides evidence that the Bod Pod® is a more precise measure of body composition when compared to field methods.

In a study conducted by, M. Malavolti, and colleagues, they tested the accuracy and validity of a wearable energy expenditure monitor compared to a metabolic cart Sensor Medics Vmax with ventilated canopy (SM-29N), and assessed body composition, percentage fat mass, and percentage fat free mass using skinfold thickness measurements, bio-electrical analysis, and air displacement plethysmography (Bod Pod®), and compared the results in normal weight, healthy adults (Malavolti, 2007). The study was almost evenly split between male and female participants who were 30 +/- 14 years, and had a BMI 23 +/- 3 kg/m^2 (Malavolti, 2007). To more accurately assess the REE of the participants, a study screening and protocol procedure was put in place. The participants were asked to be examined by a physician to rule out any medical conditions or illnesses that may affect the results, and to follow their normal diet the week before they were asked to come in for the study. The measurements for each of the participants were taken in the morning after an overnight fast, and after the participant had voided (Malavolti, 2007).

Resting energy expenditure was measured using the wearable energy expenditure monitor and SM-29N, by following recommended factory standards for both measurement devices. The same researcher using procedures as stated in the Anthropometric Standardization Reference Manual measured the anthropometrics of all participants (Malavolti, 2007). Bioimpedance analysis was conducted using an eight-polar-electrode impedance-meter (Malavolti, 2007). Lastly, body density was tested by air displacement plethysmography using the Bod Pod®. The Bod Pod® measurements were taken per machine accuracy recommendations, with participants being instructed to wear a swim cap to minimize effect of hair volume, remove all jewelry, and wear a tight-fitting swimsuit (Malavolti, 2007).

Because there were no statistical differences in age or gender, the results were clustered into one sample. The results found that the measurements of fat free mass taken by the Bod Pod® were more closely correlated with resting energy expenditure measured by wearable energy expenditure monitor then resting energy expenditure by SM-29N. The findings of the study concluded that measurements taken by the Bod Pod® were reliable and a valid technique that can quickly and safely be done on a diverse population of participants.

SUMMARY

College students, particularly college athletes, have poor dietary intakes. Dietary intake is critical for performance and for optimal body composition. There is a need for interventions to improve dietary intake and body composition in this population. The use of technology to improve dietary intake is promising. One of the most accurate ways to assess body composition is by using the Bod Pod®. One of the quickest and easiest ways to assess dietary intake is the NCI Fruit and Vegetable Screener. This study seeks to determine the effectiveness of a technology enhanced 11 week nutrition curriculum in changing fruit and vegetable intake, assessed by the NCI Fruit and Vegetable Screener, and body composition, assessed by the Bod Pod®, in collegiate female athletes.

CHAPTER 3: METHODS

STUDY DESIGN

This study was pre-experimental, using a one group before and after design. Data for this study was collected as part of a larger research project conducted in collaboration with researchers from the Department of Dietetics and Human Nutrition at the University of Kentucky (UK). The study was approved by the

University of Kentucky Non-medical Institutional Review Board (IRB). The larger data collection consisted of determining body composition using the Bod Pod®, collection of anthropometrics including weight, height, and waist measurement, and one standardized survey: the National Cancer Institute (NCI) Fruit and Vegetable Screener of several NCAA sports teams.

PARTICIPANTS

The population of interest for this particular study consisted of a convenience sample of female collegiate athletes on the softball team who participated in an 11-week nutrition curriculum that was independent from this research and had consented to participate in the larger research project with measurements taken pre/post to the nutrition curriculum. The total sample size consisted of 25 participants ages 18-21. All participants at baseline were included in the data analysis, but if a participant was missing pre- or post- data, they were excluded from the particular analysis test. For the pre-intervention assessment there were 21 participants and 18 participants of them were included in the post-intervention assessment. For the correlation test there were 14 participants for change in fruit and vegetable consumption vs. change in body fat percentage, and 13 participants included in changes in fruit and vegetable consumption vs. changes in waist circumference. Participants were excluded if they did not have both pre- and post-intervention data. Participants were also excluded if they were an outlier based on the fruit and vegetable screener. Athletes under the age of 18 were not permitted to participate in this study.

MEASUREMENTS

All measurements and surveys used for this study were completed in the Nutrition Assessment Laboratory at the University of Kentucky Department of Dietetics and Human Nutrition. The measurements included data on body composition collected from the Bod Pod®, including weight; and height and waist measurements that were collected manually.

The main data-collecting instrument used was the Bod Pod®. The Bod Pod® is manufactured by COSMED, Inc., and is only used for research purposes by researchers from the Department of Dietetics and Human Nutrition. The machine is serviced annually, following manufacturer protocol, and is properly calibrated per manufacturer instructions before each testing session.

Measurement of height and weight is completed through the use of the calibrated scale which is part of the Bod Pod® system and properly mounted wall-measuring stadiometer. All participants wore swimwear or tight athletic clothing and no shoes for all measurements. The measurement of waist was completed manually with the average of three measurements taken.

The NCI Fruit and Vegetable Screener is a standardized and validated survey. Providing this type of questionnaire is standard procedure used by dietitians to assess the nutritional status of participants. The screener was evaluated for performance in the Eating at America's Table Study, which was designed to validate the Diet History Questionnaire (DHQ) (NIH,). To score the NCI Fruit and Vegetable Screener, a scoring guide is provided with values for each of the questions. The frequency of daily intake is measured on an average, and is given a score of 0-5.0, depending on the response of never to 5 or more times per day of fruits and vegetables consumed in the past month. Participants were asked to report both raw and cooked fruits and vegetables.

In scoring the screener, the fruits and vegetables are divided up into categories, and given scores based on the category classification, and the number of portion sizes based on cup equivalents, see Figure 1. The categories from the screener that were analyzed for this study are: 100% fruit juice, fruit, lettuce salad, other vegetables, French fries, other white potatoes, and tomato sauce. The category not analyzed include cooked dried beans. The scoring of the screener was completed by using Statistical Analysis Software (SAS) Program 9.4. The NCI has previously developed programming codes for data analysis to score the screener.

Food	MyPyramid Cup Equivalents for each Portion Size Category			
	1	2	3	4
Juice	.5	1.0	1.625	2.5
Fruit (units)	.25	.5	1.0	1.5
Fruit (cups)	.25	.5	1.0	1.5
Lettuce salad	.25	.5	1.0	1.5
French fries	.2	.5	.75	1.3
Other white potatoes	.25	.75	1.2	2.0
Dried beans	.25	.75	1.25	2.0
Other vegetables	.25	.75	1.5	2.25
Tomato sauce	.25	.5	1.0	1.5
Vegetable soups	.3	1.0	1.6	2.25

Figure 3.1. Fruit and Vegetable Screening tool scoring for cup equivalent for each category.

PROCEDURES

Prior to testing of body composition, the athletes were instructed to follow guidelines outlined by the Bod Pod® manufacturer to allow for accurate data collection. Participants were asked to refrain from exercise, eating and drinking for two hours prior, and to use to the restroom immediately before testing to allow for more accurate data collection. The participants were required to wear a tightly fitting swimsuit or exercise shorts and sports bra top, and a swim cap. All jewelry and eyeglasses were removed immediately prior to data collection.

The procedures for operating the Bod Pod®, were followed as outlined in the manufacturer's manual. At the beginning of each test, ID of the participant along with height was manually entered into the Bod Pod® by the researcher. Lung volume was predicted for each participant. Prior to each group being tested, the Bod Pod® required a two-point calibration test. The first calibration was completed with the chamber empty. The second calibration test was completed so the instrument could measure an object of a known value. The object of known value was a manufacturer provided hollow cylinder of approximately 49.974 liters. Immediately following the two-point calibration the total body mass of each participant was measured and automatically recorded. The total body mass measurement of the participant was taken twice during two 50-second intervals, with the machine being opened between each measurement. The participant was asked to relax, breathe normally, remain quiet, and to sit still during the measurement periods.

The waist was measured three times at the participant's natural waist. The natural waist was determined by finding where the participant bends, and taking the measurement from there with a tape measure. The average of the three measurements was taken.

Upon entering the Nutrition Assessment Laboratory, the participant was asked to complete the 10-question NCI Fruit and Vegetable Screener.

Prior to the final testing of body composition, an 11-week nutrition curriculum was provided to the softball team by the sports team dietitian. Once a week the team would meet as a group with the dietitian for about 20 minutes each session. A discussion over the previous week would take place followed by a short lesson and an assignment for the coming week. The curriculum and assignments are outlined in Table 1. The athletes were asked to track their food intake during the 11-week period electronically by either the use of their phone or computer, through an App, such as MyFitnessPal®. At the conclusion of the 11-week nutrition intervention, body composition, waist, and height measurements were reassessed using the same methods as previously identified pre-curriculum. The NCI Fruit and Vegetable screener was also completed again during the follow-up measurements.

Table 3.1. Outline of 11-week nutrition curriculum provided to female collegiate softball team.

	Lesson	Assignment
Week 1	Watch *That Sugar Movie*	Each athlete will be assigned a calorie amount to try and attain for the week based on body composition measurements; 10% of calories from added sugar; write down commonly eaten foods, and find substitutes to stay within sugar allotment.
Week 2	What foods are carbohydrates and what is a serving size?	Each athlete assigned a ratio of macronutrients based on body composition goals. Will continue to try and meet sugar recommendation; no athlete will be allowed to follow a diet that is less than 40% carbohydrate.
Week 3	What is fiber and what are different types of fiber?	Continue staying within carbohydrate requirements assigned in week 2; track daily fiber intake with goal of reaching 25g/day.
Week 4	Cooking class: cooking with whole grains	Cook a dinner using whole grains.
Week 5	Anti-oxidant and phyto-nutrients: how to get vitamins and mineral through food	Each athlete's carbohydrate goals are divided into three groups to try and stay within: sugar/starch, fruits, vegetables.
Week 6	Fats: How much fat we need, the different types, and how we get them in our diet.	Goal for fat intake is broken down into MUFA/PUFA and SFA; athlete will try to stay within goal amount.
Week 7	Field Trip: Olive Oil Store; taste testing	---
Week 8	Grocery Store Tour: Scavenger Hunt on Label Reading	----
Week 9	Cooking Class: Healthy Party Foods-Introduction to Mindful Eating; video on mindfulness	Eat one meal a day with no distractions-no phone, television, or other people. Write one paragraph about experience and evaluate hunger pre and post meal.
Week 10	---	Continue mindful eating. Eat one meal with non-dominate hand and put fork down between bites; write about experience and evaluate hunger pre and post meal.
Week 11	---	Make one meal special; Make special in whatever way athlete deems. Post one picture per day on Twitter, tweeted at RD, or emailed to RD about how they made the day better.

ANALYSIS

The statistical analysis program used was SAS 9.4. The data was analyzed for differences between pre-intervention and post-intervention. Descriptive information such as mean, standard deviation, minimum value, and maximum value were determined. A paired t-test was completed to determine the significance of change in body composition of the female athletes between pre- and post-intervention. Correlation tests were run to determine the relationship of the change in intake of fruits and vegetables vs. change in waist, and change in intake of fruits and vegetables vs. change in percent body fat.

CHAPTER 4: RESULTS

DEMOGRAPHICS

During the pre-intervention data collection, 21 participants were included. For post intervention data, participants were excluded if they did not complete pre-intervention assessment. There were 18 participants included in the post-intervention data assessment. All participants during both sets of data collections were female. Table 4.1, 4.2, 4.3, and 4.4 display the characteristics of the participants at each data collection for both body composition and intake of fruits and vegetables.

Table 4.1: Characteristics of Body Composition of Softball players in August 2015.

	n	Minimum	Maximum	Mean	Standard Deviation
Waist (cm)	21	62.33	97.07	74.13	8.23
Height (cm)	21	160.0	176.5	168.04	4.21
Age (years)	21	18.24	21.48	19.89	1.17
Percent Body Fat (%)	21	16.5	38.0	25.59	5.78
Body Mass (kg)	21	59.33	102.66	74.06	11.01

The sample included 21 softball players at baseline. As shown in table 4.1, the mean waist was 74.13±8.23cm, the mean height was 168.04±4.21cm, mean age was 19.89±1.17 years, the mean percent body fat was 25.59±5.78%, and the mean body mass was 74.06±11.01kg.

Table 4.2: Characteristics of Fruit and Vegetable intake in August 2015.

	n	Minimum	Maximum	Mean	Standard Deviation
Fruit and Vegetable intake (cups)	20	0.76	6.18	2.66	1.49
Sum of Fruits (cups)	20	0.22	3.21	1.25	0.80
Juice Intake (cups)	20	0.0	1.63	0.35	0.37
Fruit Intake (cups)	20	0.11	3.00	0.90	0.75
Sum of Vegetables (cups)	20	0.28	3.68	1.40	0.90
Lettuce Salad Intake (cups)	20	0.03	1.00	0.31	0.26
Other Vegetable Intake (cups)	19	0	2.25	0.54	0.59
Tomato Sauce Intake (cups)	20	0.02	1.00	0.17	0.22
Vegetable Soup Intake (cups)	20	0	0.5	0.13	0.17
French Fries (cups)	18	0	0.25	0.07	0.07
White Potatoes (cups)	20	0.02	0.94	0.22	0.26

The sample included 20 softball players who completed the fruit and vegetable screener. The mean for combined intake of fruits and vegetables was 2.66±1.49cups. For each component reported on the mean intake for juice was 0.35±0.37cups, the mean intake for fruit was 0.91±0.75cups, the mean intake for lettuce salad was 0.31±0.26 cups, the mean intake for other vegetables was 0.54±0.59 cups, the mean intake for tomato sauce was 0.17±0.22cups, the mean intake for vegetable soup was 0.13±0.17cups, the mean intake for French fries was 0.07±0.07cups, and the mean intake of white potatoes was 0.22±0.26cups. The individual questions pertaining to fruits were summed for a fruit intake total. The participants consumed a mean intake of 1.25±0.80 cups of fruits. The individual questions pertaining to vegetables were also combined to determine a sum of vegetable intake. The mean intake of vegetables was 1.40±0.90 cups

Table 4.3: Characteristics of body composition of softball players in November 2015.

	n	Minimum	Maximum	Mean	Standard Deviation
Waist (cm)	17	61.93	94.23	72.40	7.96
Height (cm)	18	161.3	175.3	168.13	3.55
Age (years)	18	18.47	21.71	20.13	1.26
Percent Body Fat (%)	18	14.0	32.6	23.07	4.81
Body Mass (kg)	18	59.71	100.04	72.59	10.27

The final sample included a total of 18 female softball players, but only 17 participants for waist at follow up. As shown in Table 4.3, mean waist was 72.40±7.96 cm, the mean height was 168.15±3.55cm, mean age was 20.13±1.25

years, the mean percent body fat was 23.07±4.81%, and the mean body mass was 72.59±10.27kg.

Table 4.4: Characteristics of Fruit and Vegetable consumption in November 2015.

	n	Minimum	Maximum	Mean	Standard Deviation
Fruit and Vegetable Intake (cups)	16	0.77	5.45	3.11	1.30
Sum of Fruit (cups)	16	0.17	3.35	1.61	0.89
Juice Intake (cups)	16	0	2.00	0.31	0.54
Fruit Intake (cups)	16	0.11	3.000	1.29	0.83
Sum of Vegetables (cups)	16	0.59	3.52	1.50	0.83
Lettuce Salad Intake (cups)	16	0	0.79	0.28	0.21
Other Vegetable Intake (cups)	16	0.16	3.0	0.81	0.81
Tomato Sauce Intake (cups)	16	0	0.32	0.12	0.08
Vegetable Soup Intake (cups)	16	0	0.21	0.08	0.07
French Fries (cups)	16	0	0.16	0.05	0.04
White Potatoes (cups)	15	0.05	0.38	0.15	0.11

The characteristics of fruit and vegetable intake in November 2015 are summarized in Table 4.4. There were 16 participants who completed the fruit and vegetable screener. The mean intake for fruits and vegetables was 3.11±1.30 cups. For juice the mean intake was 0.31±0.54 cups, for fruit the mean intake was 1.29±0.83 cups, for lettuce salad the mean intake was 0.28±0.21 cups, for other vegetables the mean intake was 0.81±0.81cups, for tomato sauce the mean intake was 0.12±0.08 cups, for vegetable soup the mean intake was 0.13±0.17 cup, for French fries the mean intake was 0.05±0.04 cups, and for white potatoes the mean intake was 0.15±0.11cups. The total of fruits was combined again, and the participants consumed a mean intake of 1.61±0.89 cups of fruit. The total of vegetables was combined as well, and the participants consumed 1.50±0.83 cups of vegetables.

BODY COMPOSITION

Table 4.5: Difference in waist circumference and body fat percent among female college softball players following an 11-week nutrition education curriculum.

Paired t-test	n	Mean Difference	Standard Deviation	Pr >|t|
Waist November 2015	17	-1.7318	2.18	0.0048
Waist August 2015				
Percent Body Fat November 2015	18	-1.9056	2.3232	0.0029
Percent Body Fat August 2015				

The paired t-test for both waist circumference and percent body fat of softball players between August 2015 and November 2015 revealed statistical significance ($p<0.05$). On average waist circumference decreased by 1.73 cm and percent body fat decreased by 1.91%. These results indicate there was a change in body composition among softball players after an 11-week nutrition curriculum coupled with a technology component.

TOTAL OF FRUIT AND VEGETABLE INTAKE

Table 4.6: Difference in sum of fruit and vegetable intake among female college softball players following an 11-week nutrition education curriculum.

Paired t-test	n	Mean Difference	Standard Deviation	Pr>|t|
Fruit and Vegetable Intake November 2015 Fruit and Vegetable Intake August 2015	16	0.3708	1.5059	0.3403

There was no significant difference in fruit and vegetable intake (in cups) for softball players between August 2015 and November 2015 after a paired t-test was performed. On average all the participating softball players increased combined fruit and vegetable intake by 0.45 cups. These results indicate that although there was an increase in fruit and vegetable intake, the increase was not significant after an 11-week nutrition curriculum coupled with a technology component.

FRUIT INTAKE

Table 4.7: Difference of fruit juice intake, fruit intake (whole or cut up), and sum of classifications of fruit group intake among female college softball players following an 11-week nutrition education curriculum.

Paired t-test	n	Mean Difference	Standard Deviation	Pr>|t|
Sum of Fruit November 2015 Sum of Fruit August 2015	16	0.2514	0.9354	0.2994
Juice Intake November 2015 Juice Intake August 2015	16	-0.0478	0.3356	0.5776
Fruit Intake November 2015 Fruit Intake August 2015	16	0.2991	0.8707	0.1896

There was no significant difference in fruit intake based on classification type or sum of both juices and fruit among softball players between August 2015 and November 2015 after a paired t-test was performed. For all the participants, the mean intake of fruit juice decreased by 0.05 cups, mean intake of fruit increased by 0.38cups, and the mean intake of the sum of fruit juice and fruit increased by 0.45 cups. These results indicate there was not a significant increase in fruit consumption after a 11-week nutrition curriculum coupled with a technology component.

VEGETABLE INTAKE

Table 4.8: Statistics of paired t-test analysis of vegetable intake based on sum, and classification of vegetable types among female college softball players following an 11-week nutrition education curriculum.

Paired t-test	n	Mean Difference	Standard Deviation	Pr>|t|
Sum Vegetable Intake November 2015 Sum Vegetable Intake August2015	16	0.1195	1.0373	0.6517
Lettuce Salad Intake November2015 Lettuce Salad Intake August 2015	16	-0.0303	0.2975	0.6900
Other Vegetable Intake November 2015 Other Vegetable Intake August 2015	16	0.2603	0.8966	0.2637
Tomato Sauce Intake November 2015 Tomato Sauce Intake August 2015	16	-0.0515	0.2111	0.3540
Vegetable Soup Intake November 2015 Vegetable Soup Intake August 2015	16	-0.0324	0.1767	0.4747
French Fry Intake November 2015 French Fry Intake August 2015	14	-0.0136	0.0654	0.4509
White Potato Intake November 2015 White Potato Intake August 2015	15	-0.0198	0.1708	0.6600

There was no significant change in vegetable intake of softball players between August 2015 and November 2015 following the 11-week nutrition education curriculum. On average, all the softball players' consumption of vegetables included in the study increased by 0.12 cups, intake of lettuce salad decreased by 0.03 cups, intake of other vegetables increased by 0.26 cups, intake of tomato sauce decrease by 0.05 cups, intake of vegetable soup decreased by 0.03 cups, intake of French fries decreased by 0.01 cups, and intake of white potatoes decreased by 0.02 cups. These results indicate that vegetable intake among the softball players did not significantly increase after an 11-week nutrition curriculum coupled with a technology component.

CORRELATION TEST BETWEEN FRUIT AND VEGETABLE INTAKE AND BODY FAT PERCENTAGE

Figure 4.1: Scatterplot of change in fruit and vegetable intake versus change in body fat percentage among female college softball players following an 11-week nutrition education curriculum.

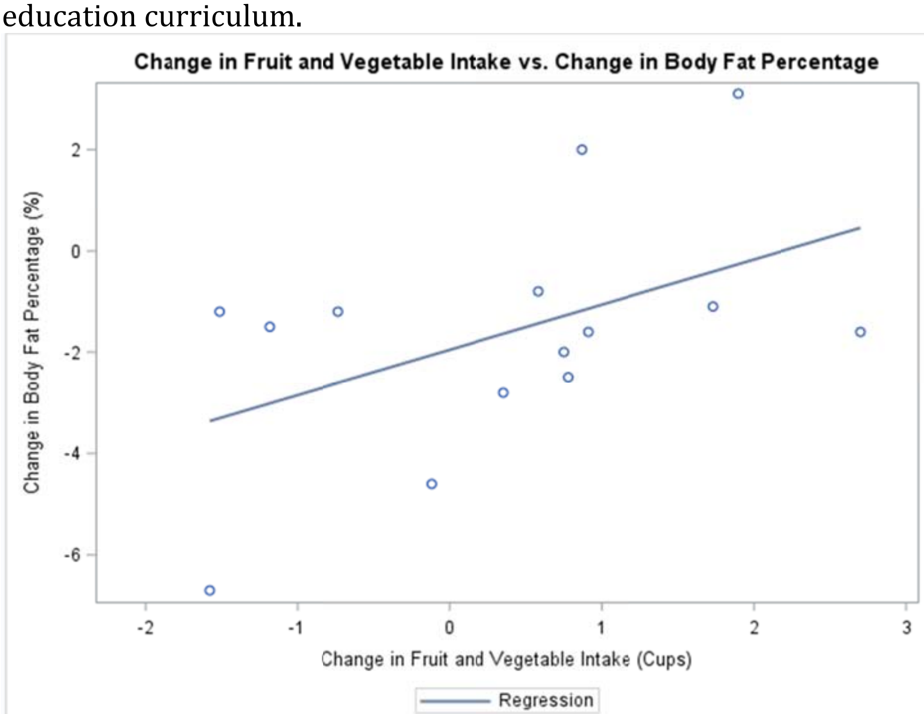

Table 4.9: Linear regression analysis of change in fruit and vegetable intake versus change in body fat percentage among female college softball players following an 11-week nutrition education curriculum.

R-Square	n	Correlation	Change in Fruit and Vegetable Intake (slope)	Y-Intercept	Prob > |t|
0.23	14	0.484	0.26	0.81	0.0794

Participants who did not have pre- and post- data for the fruit and vegetable screener and body fat percentage were excluded from the correlation test. The correlation of body fat percentage and fruit and vegetable intake of softball players' presented in a scatterplot (Figure 4.1) revealed a positive correlation between the variables (0.484).

However, the correlation between fruit and vegetable intake and percent body fat was not significant (p=0.0794).

CORRELATION TEST BETWEEN FRUIT AND VEGETABLE INTAKE AND WAIST CIRCUMFERENCE

Figure 4.2: Scatterplot between fruit and vegetable intake and waist circumference change among female college softball players following an 11-week nutrition education curriculum.

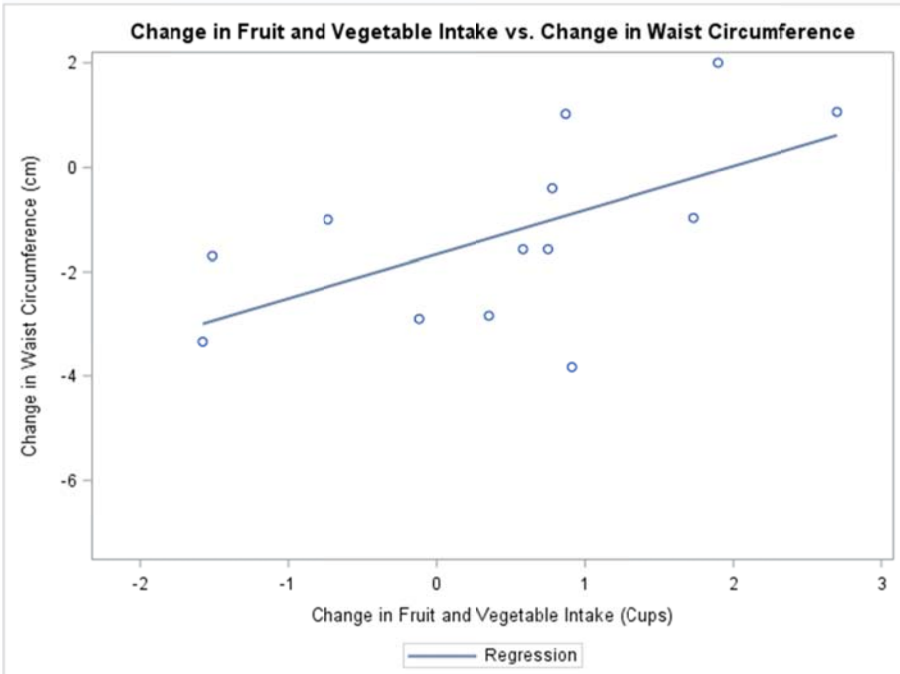

Table 4.10: Linear regression analysis of change in waist circumference and change in fruit and vegetable intake in cups for softball players from August 2015 to November 2015.

R-Square	n	Correlation	Change in Fruit and Vegetable Intake (slope)	Y-Intercept	Prob > |t|
0.35	13	0.59	0.42	1.02	0.0328

Among the softball players, there was a positive correlation (0.59279), between the change in fruit and vegetable intake and change in waist circumference. The R-Square value was moderately strong (0.351403), and the probability that an increase in intake of fruits and vegetables related to an increase in waist circumference was significant (p=0.0328).

Due to this being a convenience sample, access was unable to be provided to review the change in dietary intake that was tracked electronically. Therefore, these results cannot be reported.

CHAPTER 5: DISCUSSION

The purpose of this study was to determine if offering an 11-week nutrition curriculum coupled with a technology component increased the consumption of fruits and vegetables while decreasing waist circumference and body fat percentage among collegiate softball players. This study compared fruit and vegetable intake of softball players to waist circumference, and fruit and vegetable consumption to body fat percentage both before and after the offering of an 11-week nutrition curriculum coupled with a technology component. The objective of this study was to determine if there was an impact of a nutrition curriculum based intervention on fruit and vegetable intake on percent body fat and waist circumference in college athletes, specifically collegiate female softball players.

The hypotheses of this research are offering an 11-week nutrition curriculum will decrease body fat percent, increase the intake of fruits and vegetables, decrease waist-circumference, and result in a negative correlation for changes in body fat percentage and waist-circumference compared to fruit and vegetable intake. Based on the paired t-test, both waist circumference and body fat percentage had a statistically significant decrease. Most research will demonstrate that an increase in fruit and vegetable consumption will result in a lower body fat percentage and waist-circumference due to replacing high caloric foods with fruits and vegetables that are lower calorie. However, in this research, statistically there was no significant change in fruit and vegetable intake. In the fall, softball players are in training. The decrease in both waist-circumference and percent body fat may be more reflective of the training level than fruit and vegetable consumption.

Over the 11-week period, the participants on average increased their intake of whole fruit by 0.38 cups, and decreased their fruit juice intake by 0.05 cups. This reduction of juice and increase of whole fruit may be related to the lesson taught during the third week on increasing the intake of fiber.

Over the 11-week period, the sum of fruit and vegetable consumption increased by 0.45 cups. Although not statistically significant, is still encouraging particularly when coupled with the change in seasons. The first set of data was collected in August, which is still a peak fruit and vegetable season. The second set of data was collected in November when fresh fruits and vegetables are not as readily available. Unfortunately, both fruit and vegetable consumption continued to remain below USDA recommendations for this age range of females. Fruit intake was 1.61 cups, while the USDA recommendation is 2 cups (USDA, 2016). Vegetable intake was 1.50 cups while the USDA recommendation is 2.5 cups for females ages 19-30 (USDA, 2016).

Linear regression models were also used to determine the correlation between a change in body fat percentage and fruit and vegetable intake, and a change in waist circumference and fruit and vegetable intake in softball players. There was a positive trend for both body fat percentage and fruit and vegetable intake, and waist circumference and fruit and vegetable intake. However, statistically only the relationship between waist circumference and fruit and vegetable intake was significant. As fruit and vegetable intake increased, waist circumference increased. Of the participants included, 43% were freshman, and the duration of the study was from August to November. Studies show freshman year of college is associated with the greatest gains in weight and body fat due to newly found food independence, social comparison with peers, and the influence of friends and family (Smith-Jackson, 2012, Gropper, 2012). It can be assumed that for many of the participants, this was their first time away from home and a controlled food environment. This may have impacted the results.

LIMITATIONS

The study had several limitations that could have affected the results found. Participant limitations include that this was a convenience sample, only 14 participants met inclusion criteria and 43 percent were true freshmen. It cannot be assumed that these collegiate softball players represent all collegiate softball players.

Other limitations included that data was not available for participant attendance nor the food records during the 11-week intervention. The Fruit and Vegetable Screener was administered in two distinct food seasons. Anthropometric measurements were taken in two dissimilar performance seasons.

For these limitations, the results of this study cannot be generalized to a larger population. For future research, having access to how many nutrition lessons each participant attended, food logs, and exercise logs could aid in knowing if attendance to nutrition lessons is correlated to changes in body fat percentage, waist circumference, and fruit and vegetable intake.

CHAPTER 6: CONCLUSION

This study suggests there may be a positive trend between fruit and vegetable intake and waist circumference, and fruit and vegetable intake and percentage of body fat among these female softball players after an 11-week nutrition curriculum with a technology component. As fruit and vegetable consumption increased, there was a significant increase in waist circumference. Further research is needed to determine why there was an increase in body fat percentage and waist circumference as fruit and vegetable intake increased. Ideally, a decrease in waist circumference, body fat percentage, and increase in fruit and vegetable intake can play a role in optimizing athletic performance among collegiate athletes. Since this study did not control for the number of sessions the athletes attended, or if they attended any at all, further research is needed to determine the effects of attending nutrition sessions with a technology component on fruit and vegetable intake, waist circumference and body fat percentage among female collegiate softball players.

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