EFFECTS OF OFF-SEASON TRAINING ON BODY COMPOSITION AND PERFORMANCE MEASURES IN FEMALE COLLEGIATE SOCCER PLAYERS

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CHAPTER I

INTRODUCTION

Training to reach optimal performance is a common practice among soccer players, as well as within the overall world of athletics. Body composition change in athletes is often a factor studied, particularly as an important outcome of sport-specific training (Clark et al. 2003; Davis and Brewer 1993b; Fogelholm et al. 1995; McCay and Shephard 1988). That change in body composition can serve as an influential factor on performance and/or serve more of an aesthetic purpose (Brewer 1994; Franzoi and Shields 1984). The primary focus in the sport of soccer is performance, and with less emphasis on aesthetics (Caldwell and Peters 2009; Ostojic 2003). However, female athletes have shown inclinations to alter their body composition for aesthetic purposes, not necessarily motivated by improved performance (Franzoi and Shields 1984).

Change in body composition is also influenced by dietary intake. The dietary intake of competitive athletes has been studied to determine the energy and nutrient demands unique to different sports (American Dietetic Association 2009; Burke et al. 2006; Phillips et al. 2011; Tipton and Wolfe 2004; Siahkohian et al. 2008; Davis et al. 1997). Also, energy balance is a popular topic. The alteration of an athlete's body composition by means of a change in dietary intake is something that coaches and athletes look for outside of the gains/losses athletes may experience from training (Garthe et al. 2011; Clark et al. 2003).

As previously stated, optimal performance is an overall goal influenced by diet, training, and body composition. Competitive athletes typically have coaches, trainers, and other staff who structure training regimens for the athletes to improve upon these measures for increased performance. The development of an effective training protocol to achieve this is challenging due to seasonal nature of sports like soccer (Caldwell and Peters 2009; Jones et al. 2010; Murkherjee and Chia 2010). This study looks at a typical off-season training period in a sample of NCAA Division I female soccer players and the resulting effects seen in body composition and performance.

Previous literature on athletes' off-season training is limited and most related studies looking at these variables include well-controlled exercise and/or dietary protocols (Layman et al. 2005; Gammeren et al. 2002). The world of collegiate athletics is subject to variability and this research is meant to provide a look into the efficacy of off-season soccer training in the collegiate setting. The main purpose of this study was to examine the changes in body composition measures of the female collegiate soccer players. With this body composition data, an analysis of body composition measures in relation to soccer-specific performance was completed. A secondary purpose of this study was to analyze the players' energy and macronutrient intake and in comparison to recommended levels of intake for the athletes' training intensities.

Hypotheses

1. There will be a difference in the athletes' lean body mass and fat mass.
2. Athletes' performance measures will change from baseline.
3. Body composition changes will affect athletes' measures of performance.
4. Energy and macronutrient intake of athletes will fall within recommended intake levels for age, gender, and training intensity.
5. Energy and macronutrient intake will not significantly change.

Assumptions

The following assumptions were made for the study:

- All study participants were able to follow instructions given and possessed writing skills appropriate to accurately detail dietary intake.
- Participants gave maximal effort and were sufficiently familiarized with all performance tests.
- Participants performance test efforts were not adversely affected by training or the previous week's testing
- Participants had similar pre-testing levels of dietary intake, hydration, and ergogenic aid use.
- Participants reported dietary intake in their food records as accurately and truthfully as possible.

Definitions of Terms

AMDR – "Acceptable Macronutrient Distribution Range." The recommended ranges of macronutrient consumption in terms of percentage of total energy intake.

Anaerobic Capacity – Participant's mean power measured during Wingate testing divided by weight in kg.

Anaerobic Power – Participant's peak power measured during Wingate testing divided by weight in kg.

DEXA – "Dual absorbance x-ray absorptiometry." Laboratory device that passes x-rays through the body and differentiates the body's composition. Measures of lean body mass and fat mass can be determined

Energy Balance – The concept that differences in energy intake versus energy expenditure will result in body composition change.

Fatigue Index – Participant's peak wattage minus minimum watts divided by the duration of the Wingate testing, 30 seconds.

Food Recall – A form of dietary assessment where the participant details their complete dietary intake in the previous 24 hours.

Food Record – A form of dietary assessment where the participant documents their dietary intake throughout the day over a pre-determined amount of days. Daily dietary intake can then be averaged.

LBM – "Lean body mass." The mass of the body that is not comprised of fat. Includes muscle mass, bone mineral content, and other nonfat tissue.

Macronutrient – Carbohydrate, protein, and fat. Required to support the physiological needs of the body.

Periodization – The alternation of training cycles throughout the year that is meant to prepare an athlete for peak fitness and performance during the competitive season.

RET – "Resistance training." Physical training that uses some form of resistance to build muscle strength, size, and anaerobic endurance.

Seasonal Sport – A sport where the competitive season lasts for a set part of the year. Off-season training occurs throughout the year.

Wingate testing – A performance test, usually performed on a cycle ergometer, where power can be measured in terms of wattage.

Wattage – A unit of power that measures the amount of energy transferred.

VO_{2max} – A measure of the maximum amount of oxygen that the body can uptake when exercising at maximum capacity

CHAPTER II

REVIEW OF LITERATURE

Soccer's Popularity in the US

The popularity of women's soccer in the United States recently got a large boost in part from the USA women's national team. Their recent appearance in 2011's Women's World Cup final netted the highest viewership (13.5 million) of any soccer match in US television history (MLS 2011). The youth soccer movement has a strong following as well, with US Youth Soccer State Associations in each of the 50 states. Approximately 3.2 million players register annually for US Youth Soccer with a national soccer tournament composed of over 10,000 teams nationwide (US Youth Soccer 2009). The sport of soccer has a strong presence and a bright future in the US.

Demands of Soccer

Along with its popularity, the nature of competition in soccer requires a lot from its athletes in terms of physical fitness and ability. The intermittent nature of soccer places a demand on the players' ability to perform at high-intensities with limited periods of recovery (Bradley et al. 2009). In a number of studies, performance testing of anaerobic capacity and endurance aims to give an overview of one's soccer-specific abilities (Moore et al. 2005; Grieco et al. 2012; Siegler et al. 2003). In a typical match, players can cover up to 10-13 km, depending on position. Distance is covered on the field with low-intensity walking and running, up to high-intensity sprinting (Bangsbo et al. 1991; Bangsbo et al. 2006). An estimated 2/3 of a typical soccer match is played at an intensity of 70% of the players' respective VO_{2max}, a measure of maximal oxygen consumption said to be a primary indicator of physical fitness (Brewer 1994, Falls et al. 1966). Competitive soccer demands a high level of physical fitness from its athletes.

Another demanding aspect of competitive soccer is the desire for the athletes to reach an optimal body composition for both performance and aesthetic reasons. The balance between energy intake and energy expenditure for daily activities and exercise has an impact on athletes' body composition. The methods used to achieve the goal of leanness in female athletes can potentially improve or damage performance (Brewer 1994). Also, the dissatisfaction that college aged females often express about their own weight and/or physical appearance can lead to alterations in body composition that are superficial, rather than performance-driven (Franzoi and Shields 1984).

Correlation of Body Composition to Soccer Performance

Currently, average measures of body composition in collegiate and professional female soccer players have been analyzed in several studies. A review by Davis and Brewer found that body fat of female soccer players averages between 19.7% and 22% (1993a). Other studies on collegiate and national-caliber female soccer players have identified body fat averages ranging from approximately 16% to 26% (Clark et al. 2003; Davis and Brewer 1993b; Fogelholm et al. 1995; McCay and Shephard 1988). Currently, data regarding lean body mass of soccer players is limited to studies on male soccer players.

One theoretical association of body composition and soccer-specific performance is that decreasing one's body fat and increasing lean body mass will improve upon an athlete's power and endurance leading to improved soccer ability (Boileau and Lohman 1977). In sports such as soccer that require force to be applied (i.e. change of direction, sprinting), the amount of lean body mass that an athlete carries is said to influence his/her ability to apply force, or use power. The amount of lean body mass carried by an individual may detrimentally affect performance if the mass is too great to efficiently translocate during the match. Likewise, an excess amount of body fat carried by an athlete is disadvantageous to performance in that it cannot assist in applying force and is simply added mass to be translocated during physical activity (Boileau and Lohman 1977). Caldwell and Peters conducted a study on body composition as it related to performance in male semiprofessional soccer players (2009). Off-season sprinting times were shown to increase as body fat increased. This performance effect was attributed to the excess fat that players carried in the off-season (Caldwell and Peters 2009). In a study on 30 elite male professional soccer players, a positive correlation was found between body fat percentage and sprint times from pre-season to early season ($r=1$, $p<0.05$) and also throughout the study's entirety ($r=0.98$, $p<0.05$). This supports a correlation between body fat and athletic performance in this population (Ostojic 2003).

A strict analysis of the association of body composition with endurance and aerobic power measures of female soccer players is not present in current literature. Available studies regarding measures of endurance and power in relation to body composition have involved studies assessing the impact of general resistance and aerobic training on these variables. The analyses completed in these studies do not specifically use body composition as the independent variable. A study by Davis et al. involving two 11-week combination strength and aerobic exercise protocols, non-sport specific, showed increases in muscle endurance and aerobic power measures on average with decreased fat mass and increased lean body mass on average, all as dependent variables (2008). Another study involving a generalized 12-week endurance-resistance exercise protocol found increases in measures of muscular endurance and lean body mass along with decreases in body fat percentage, all as studied dependent variables (Arazi et al. 2011).

Specific effect(s) of body composition on soccer-related performance in college female soccer players is lacking in current literature.

Body Composition Correlates

A number of factors can influence an athlete's overall athletic performance including motor skills, genetics, physical fitness, dietary intake, body composition, psychological factors , sociological factors, and training (Russell and Kingsley 2011; MacArthur and North 2005; Moxnes and Hausken 2008; American Dietetic Association 2009; Moore et al. 2007; Birrer and Morgan 2010; Sabmolec et al. 2007). The overall combination of these factors in an athlete contributes to his/her athletic ability.

Certain performance-related factors are outside of the athlete's locus of control. Genetics for one, according to MacArthur and North (2005), contributes to a "complex fitness phenotype" that is linked to one's athletic performance. The genetically-derived capabilities of an athlete are not something that can be influenced. Similarly, an athlete's body composition is influenced by a number of correlates. In order to improve upon current body composition, athletes can focus on the factors that they can control, training and diet.

Training and Body Composition

Training has shown to be an influential correlate of body composition. The correlation of one's body composition and athletic performance is a key factor that will be further examined in the proposed research study. Body composition has been associated with athletic performance in previous research (Moore et al. 2007; Mikkola et al. 2011). Moore et al. followed healthy, untrained young men throughout a 12-week resistance training program, with lean body mass change as one of the outcomes measured (2007). Results of this study did show a significant increase in amount of lean body mass following the resistance-training protocol (Moore et al. 2007).

Not all training has shown to be impactful on body composition, however. The rigorous in-season training of a NCAA Division I female soccer team was not shown to have a significant impact on the players' overall body mass or body fat percentage in a study with data collected at pre-season and post-season (Clark et al. 2003). Further data is lacking on typical training regimens and their respective outcomes in female soccer players. Outside of soccer, Mikkola et al. looked at body composition changes in recreational endurance runners following 8 weeks of supplemental resistance training (2011). Measures of body fat were taken from a calculation of skinfold measurements. Results in this study showed a decrease in total body mass in all resistance-trained groups. No significant change, however, was found in lean body mass in any of the groups (Mikkola et al. 2011). This inconsistency in findings of body composition measures following sport-specific training warrants further study specifically in female soccer players.

It has also been of interest to study training's effect on the body composition of non-athletes. Research on body composition in the general population usually examines its benefits such as increased strength or improved indicators of health. One such study primarily focused on muscular adaptation to resistance training, with either a single or multiple-set exercise protocol. Subjects were untrained men and women and lean mass changes in specific regions of the body were the measure of interest. This 12-week program did not result in lean body mass changes in either group, although strength and muscle activity was shown to change somewhat. These results were attributed to a proposed neural mechanism that influenced strength (McBride et al. 2003). In another study utilizing a training protocol, improved health outcomes were the primary focus. In this study, type II diabetics underwent a progressive resistance-exercise protocol consisting of two sets, 10 repetitions of exercises for six muscle groups. The study found that several health-related laboratory values, including fasting blood glucose and cholesterol levels, had changed following the 12-week training protocol. Body composition measures largely remained unchanged with no significant differences in lean mass measures. Regional fat stores had been shown to decrease as evidenced by central and peripheral skinfold values, but overall body fat percentage did not change (Misra et al. 2008).

It is evident that training does not always lead to changes in body composition in both non-athletes as well athletes. Also, there is much more to the lifestyle of an athlete that can affect his/her body composition than simply sport-specific training. A large focus of athletes and those who oversee their well-being is the athlete's dietary habits.

Dietary Requirements of Athletes

An athlete's dietary and nutritional habits can significantly impact his or her body composition. The basic theory of energy balance, energy in and energy out, is the basis of diets promoting weight loss, weight maintenance, or weight gain. Adherence or lack of adherence, to a specified dietary intake can affect body composition (Garthe et al. 2011). For example, In a study by Garthe et al., 24 athletes randomly assigned to energy-restricted diets either meant to reduce body weight slowly, via a 0.7% weekly body-weight loss, or rapidly, via a 1.4% weekly body-weight loss (2011). Energy intake was significantly reduced in both experimental groups and a significant decrease in both body weight and fat mass of the groups was found throughout the study (Garthe et al. 2011). In order to meet these energy requirements, specific dietary recommendations are made for people to ensure that they have ample energy to train for and compete in their respective sports.

Current recommendations for macronutrient intake are based upon Dietary Reference Intakes (DRIs) in the U.S. These encompass the recommendations for the general population and do not necessarily address the needs specific to athletes, who generally are more active than the general population and require special considerations (American Dietetic Association 2009). The DRIs include Recommended Dietary Allowance (RDA), Adequate Intake (AI), Tolerable Upper Intake Level (UL), Estimated Average Requirement (EAR), and Acceptable Macronutrient

Distribution Range (AMDR). RDAs are developed in accordance with the nutrient requirements for 97.5 % of the population by age and gender. AIs are recommendations of average daily intakes that are based on determined levels that are considered to be adequate for healthy people. ULs are the highest level of nutrient intake that is not considered to be indicative of adverse health effects. EARs are recommendations for the average daily requirement for 50% of healthy people by age and gender. AMDRs are levels of intake specific to macronutrients that are associated with recommended intakes of essential nutrients and decreased chronic disease risks (National Research Council 2005).

Protein intake is another important factor of dietary intake that can impact performance. Protein and its amino acid monomers can be utilized as an energy substrate via gluconeogenesis when dietary carbohydrate intake is insufficient. Several studies have shown increased levels of leucine oxidation during exercise (Forslund et al. 1998; Lamont et al. 1999). Metabolism of protein and amino acids, however, decreases their ability to synthesize protein in the body. With adequate carbohydrate consumption for energy, dietary protein can be spared and utilized for skeletal muscle protein synthesis (American Dietetic Association 2009). The pairing effect of proper dietary intake and exercise can promote lean mass gain in this regard.

Dietary fat consumption is an important substrate for aerobic metabolism, among the many physiological roles it plays. Current recommendations for athletes follow the guidelines set for the general populations with 20% to 35% of total energy intake from fat as the recommendation according to the Acceptable Macronutrient Distribution Range (AMDR), as detailed below (American Dietetic Association 2009).

Due to the unique energy needs of athletes, the DRIs are not necessarily specific recommendations for this population. Of the DRIs, AMDRs can give a simple indication of overall quality of diet. Use of AMDRs can allow practitioners to analyze the overall composition of one's diet according to proportions of macronutrients. While AMDRs were developed to decrease the risk of chronic diseases, they can give a general outline for proportional intake of macronutrients. AMDRs for carbohydrate, protein, and fat are 45% to 65%, 10% to 35%, and 20% to 35% of overall energy intake, respectively (National Research Council 2005). A majority of energy intake coming from carbohydrate, assuming adequate overall energy intake, can spare dietary and skeletal muscle protein from gluconeogenic metabolism.

The increased workloads that athletes take on require subsequent proportional increases in dietary intake to properly fuel their bodies. Recommendations specific to macronutrient intake have been developed according to the energy needs unique to different sports. Carbohydrate recommendations specific to soccer players, according to Burke et al., during moderate training are 5 to 7 grams • kg^{-1} • day^{-1} (2006). For heavy training and match preparation, this recommendation increases to 7 up to 12 grams • kg^{-1} • day^{-1} (Burke et al. 2006). Protein recommendations for athletes increase in order to maintain the positive nitrogen balance necessary for muscle hypertrophy. For the general population, the RDA recommends 0.8 grams • kg^{-1} • day^{-1} (National Research Council 2005). Recommendations for athletes range generally from 1.2 to 1.8 grams • kg^{-1} • day^{-1} (Phillips and Van Loon 2011, Tipton and Wolfe 2004). According to Phillips and Van Loon, protein consumption up to 2.0 grams • kg^{-1} • day^{-1} can serve to further decrease lean mass losses during energy restriction (2011). Depending on the current training demands of soccer players, these recommendations change in order to meet current demands.

A position paper by the Academy of Nutrition and Dietetics encourages adequate consumption of carbohydrate in order to improve effectiveness of training, prevent the loss of muscle mass, maintenance of blood glucose, and maintain liver and muscle glycogen stores (American Dietetic Association 2009). Studies by Siahkohian et al. (2008) and Davis et al. (1997) examined the impact of carbohydrate consumption on sprint performance and fatigue, respectively. Siahkohian et al. hypothesized that performance would improve with carbohydrate consumption as a result of the prevention of hypoglycemia during physical activity (2008). The study analyzed 30 young and active men and their respective 200 meter dash times at the beginning and end of a 90-minute strenuous running workout. Subjects were divided into two groups, one consuming 1900 mL to 2100 mL of a 5% sucrose polymer solution, and the other consuming 1900 mL to 2100 mL of a placebo solution. Results showed significantly greater blood glucose levels along with significantly lower 200 meter dash times at the end of the 90 minute running workout in the carbohydrate-consuming group compared to the placebo group. The researchers attributed the difference in performance to a higher percentage of glucose oxidation in the glucose-consuming group than the placebo group (Siahkohian et al. 2008).

Davis et al. studied the role of carbohydrate consumption in exercise by measuring the outcomes of carbohydrate ingestion following high-intensity bouts of cycling in physically active men and women (1997). The subjects were given either placebo beverages prior to and at every 20 minutes of exercise, or were given an 18% carbohydrate solution prior to and 6% carbohydrate solution at every 20 minutes of exercise. The group consuming the carbohydrate solution consumed 4 mL • kg body weight^{-1} of each of the solutions. The cycling protocol began with a brief warm-up. The subjects then performed bouts of one minute of cycling at 80 rpm at a resistance based on power output determined via modified Wingate testing. Three minutes of rest followed each one-minute bout and the high-intensity bouts were continued until the subjects could no longer maintain the workload. Blood samples and ratings of perceived exertion (RPE) were taken throughout the experimental protocol. Results showed that subjects consuming the carbohydrate beverages had significantly greater time to exhaustion values compared to the placebo group. Subjects in the carbohydrate beverage-consuming group also had significantly greater plasma glucose and insulin concentrations at fatigue than the placebo group (Davis et al. 1997). As is made evident in the research, adequate carbohydrate consumption is an important factor in athletic performance. A related issue is the amount of carbohydrate needed to promote optimal performance, or at least to prevent decreased performance.

Typical diet composition of female soccer players has been reported in a few studies (Mullinix et al. 2003; Clark et al. 2003). The pre-season portion of a study on 14 female soccer players with an average age of 19.7 ± 0.7 years with average weight of 62.0 ± 4.8 kg assessed the 3-day average intake of the players. Total energy intake averaged 2290 ± 310 kcal consisting of approximately 57% carbohydrate, 13% protein, and 31% fat (Clark et al. 2003). These all fell within the amounts recommended within the AMDRs. By measure of body weight, macronutrient intake was 4.3 g/kg for carbohydrate and 0.96 g/kg for protein, which are both less than the levels recommended for these athletes (Clark et al. 2003).

A study of U-21 female soccer players (n=11) during a training period also assessed 3-day food recall data. Average age and weight of the players was 19.2 ±1.1 years and 59.7 ± 7.1 kg, respectively. Mean energy intake of these players was 2015 ± 19 kcal consisting of approximately 55% carbohydrate, 15% protein, and 30% fat (Mullinix et al. 2003). These levels also fell within the AMDR recommended ranges for macronutrients. The total energy intake of the players in these studies was found to be 34 kcal/kg and 37 kcal/kg; with the recommended intake for performance listed at 37 kcal/kg (Mullinix et al. 2003; Clark et al. 2003). For reference, adult women in the general population are recommended to consume a minimum of 30 kcal/kg (WHO 2004). Recommendations, of course, only take into account a broad spectrum of sport-specific activity. Players' dietary habits to fuel themselves for training and competition may influence their performance and/or their body composition. The goal to influence performance through body composition is correlated to an athlete's training and dietary habits.

Interventions For Body Composition Change

The research that examines changes in body composition as an outcome measure often involves a dietary protocol and/or an exercise protocol conducted within controlled laboratory settings. Thus, diet and exercise are commonly examined as independent variables in the same study. One such study by Layman et al. examined the effect of diets that consisted of either high carbohydrate and low protein content, or low carbohydrate and high protein content (2005). The respective amounts of each were indicated by ratios: high carbohydrate and low protein diet was approximately 3.5 carbohydrate:protein, and the low carbohydrate and high protein diet was approximately 1.24 carbohydrate:protein. As an added measure, the 48 adult, female subjects in the study were grouped according to their level of weekly exercise, measured by daily activity logs and armband accelerometers. The control group exercised an estimated average of less than 100 minutes per week. The exercising group exercised an average of greater than 200 minutes per week, with a minimum of 5 days of walking and 2 days of resistance training per week. Results showed significant decreases in body weight and fat mass in all subjects. With both diet and exercise as separate independent variables, further statistical analysis was required to measure their individual and combined effects. The researchers found significant effects of diet on body weight, fat mass, and trunk fat. A significant effect of exercise was found on fat mass and lean body mass. Furthermore, the group that consumed a high protein diet and exercised more than 200 minutes per week did not show a change in lean body mass, whereas the other groups had significantly reduced amounts of lean body mass (Layman et al. 2005). It must be noted that the methods used in this research did not measure dietary intake over the duration of the training protocol, rather the average intake at baseline and post-training.

Gammeren et al. examined the effects of both dietary and resistance-training interventions on changes in body composition lean body mass (2002). Participants in the study were all male, recreational bodybuilders that were subjected to a four week, increasing intensity resistance-training program that included chest, shoulders, triceps, legs, back, and bicep exercises. Participants also were randomly assigned to consume 10 grams per day of supplemental ribose dissolved in water or no ribose (Gammeren et al. 2002). This study included both exercise and dietary interventions in the methodology. Body composition was measured using DEXA. This study did not measure the combined effect of training and diet, only that of diet since all subjects underwent similar resistance-training protocols. Results did not show a significant change in either ribose or non-ribose groups in any measures of body composition, including body weight and lean body mass. This may have been a result of similar caloric intake between the experimental and control groups. It is also possible that the null findings were a result of the subjects' prior strength training practices (Gammeren et al. 2002).

For sports such as soccer with in-season/off-season variation, sport-specific training is not consistent throughout the year and off-season as may be true in the controlled exercise protocols of the previously mentioned studies. Periodization of training is necessary to promote performance gains that will peak during in-season competition and maintained throughout the off-season.

Seasonal Sport Training

Off-season training is essential for competitive soccer players and other athletes alike to perform at their peak fitness and skill levels during the season. Such training regimens are structured to address the sport-specific needs of the athletes. Length of training regimen varies among sports and specific goals for the athletes.

A look into the typical training regimens of female collegiate athletes was provided by Jones et al. in a study from 2010. Seventy-five NCAA Division III female athletes representing field hockey, and softball were sampled. The athletes all participated in a 12-week strength and conditioning program during their respective off-seasons consisting of four, three-week phases.

The program was organized following linear periodization with a goal of improving sport-related performance. Athletes had structured training three times a week, with two sessions focusing on whole-body lifting and one session focusing on speed and agility. Lifted weights were calculated as a percentage of established 1-rep-max values. Lifts focused on strength of lower-body push/pull exercises, upper-body push/pull exercises, abdominals, lower back, shoulders, and ankles. Lifting volume decreased as phases went on. Speed and agility sessions consisted of dynamic flexibility, agility drills, plyometrics, acceleration drills, sport-specific conditioning drills, and further massaging and stretching. This particular study, however, did not assess body composition and/or dietary intake (Jones et al. 2010).

Analysis of body composition change was included in the study design of Caldwell and Peters' study in 2009 on thirteen semiprofessional soccer players. Year-round training was documented and physiological changes were analyzed throughout this study. The subjects' pre-season training and conditioning regimen lasted for seven weeks, prior to a 38-week competition season. Daily workouts lasted 120-150 minutes, once daily with short warm-up and flexibility exercises prior to each workout. The first four weeks consisted of 60% aerobic-based conditioning, 15% sport-specific anaerobic training, 15% skill-based training, and 10% strength training. Weeks 5-7 workouts were 45% aerobic-based conditioning, 20% sport-specific anaerobic training, 15% skill-based training, and 20% strength training. Seven pre-season games were also played during this period. Body fat measures were analyzed via bioelectrical impedance using Bodystat BS1500 (2009). Measures were completed five times during the study's 12-month period, with one occurring prior to pre-season training and the following after the completion of pre-season training. Results showed significantly decreased body fat measures after pre-season training, 14.9% ± 3.0 in pre-season versus 14.5% ± 3.2 post pre-season (Caldwell and Peters 2009).

The effects of training on body composition were further detailed in a study by Ostojic in 2003. Male professional soccer players aged 23.5 ± 3.1 years in Eastern Europe were studied and body composition and sprint performance from pre-season until the following pre-season were documented. Five test periods were completed starting at the first pre-season period, start of the competitive season, mid-season, end of season, and at the beginning of the next pre-season. Body fat was measured via seven-site skinfold testing; body density and body fat percentage were calculated according to predictive equations from Jackson and Pollock. Duration and training details concerning the pre-season conditioning period were not detailed. Results did not indicate significant changes in total mass, body fat percentage, or fat free mass of players from the first pre-season tests to the beginning of the competitive season. Significant changes in body fat percentage from pre-season did not occur until mid-season and changes in overall body mass did not occur until the end of the season (Ostojic 2003).

An analysis of body composition throughout youth soccer players' training was completed by Murkherjee and Chia in 2010. Twenty male youth professional soccer players aged 17.5 ± 0.3 years, members of the Singapore National Football Academy under-18 team, were studied. The study measured body composition and bone density via DEXA assessment of the subjects throughout 10 months of the soccer season, including pre-season, early season, and mid-season. Player training consisted of 90-120 minutes per day, five days a week during both pre-season and in-season. Pre-season training focused on fitness and strength, whereas in-season training focused on technical and tactical training. Testing was conducted at beginning of pre-season, 12 weeks later during early season, and 13 weeks further at season's end. Results showed a significant increase in subjects' lean body mass (82.5% ± 2.7% to 84.5%±2.3%, $p<0.05$) and a significant decrease in body fat percentage (13.2% ± 2.8% to 11.2% ± 2.2% , $p<0.05$) following the pre-season period.

Body composition measures affected by training have been studied in other female collegiate sports. A study by Petersen et al. in 2006 examined body composition changes among 24 female collegiate swimmers and divers over a period of 16 weeks from October to February, which included pre-season and in-season training (2006). Training consisted of in-water and dryland training. In-water training included nine, 2-hour sessions during six days per week, measuring 6,400 to 10,000 meters per day. Dryland training included 1.5-hour sessions during three days per week of exercises of a resistance, strength and flexibility nature. Body composition measures were taken at preseason and two weeks prior to championship competition using DEXA, Hologic QDR 2000+. Lean mass, in kg, significantly increased between testings from 47.2 ± 2.7 to 47.7 ± 2.4, with a *P*-value of 0.028. Fat mass, in kg, significantly decreased from 15.3 ± 4.9 to 14.0 ± 4.5, with a *P*-value of 0.0002. Body fat percentage significantly decreased from 24.1% ± 5.7% to 22.4% ± 5.6%, with a *P*-value of < 0.0001 (Petersen et al. 2006).

This study by Petersen et al. also included analysis of the athletes' diets at baseline and at the end of the study's 16 week duration (2006). Energy intake and macronutrient intake did not significantly change according to 3-day food records. Average energy intake from pre- to post-season was 2405 ± 864 kcal to 2358 ± 768 kcal (converted from kJ), a non-significant change at p=0.05. No significant change was seen in macronutrient composition of the athlete's diets with pre-season values of 62% carbohydrate, 13% protein, and 24% fat; and late-season values of 65% carbohydrate, 14% protein, and 23% fat (Peterson et al. 2006).

These studies provide a unique look at off-season training and its effects in competitive athletes. A current gap in research exists in the relation of body composition to performance, specifically in the population of female collegiate soccer athletes. In order to measure this effect, body composition and performance variables in the current study were analyzed pre- and post-off season training.

DEXA Body Composition Analysis

This research utilizes Dual Energy X-Ray Absorptiometry, as it is a valid method of body composition analysis. DEXA sends electromagnetic radiation in the form of x-rays through an object. The x-rays that are attenuated by the object are consistent with the object's thickness, density, and chemical composition. For use in body composition analysis, the differential attenuation by bone, tissue, and fat give an indication of the amounts present of each in the body. Lean mass, fat mass, and further measures of body composition can then be determined. Also, DEXA can be used to determine bone mineral content and bone mineral density through measurement of specific sites in the body. Haarbo et al. determined the CV of DEXA measurements of body fat percentage and lean body mass to be 5.7% and 3.1%, respectively (1991).

Soccer-Specific Performance Measures

Measurement of performance related measures is an effective way of analyzing the efficacy of a particular training regimen. Changes in soccer-related performance measures can be detailed through performance testing. Power, endurance, and cardiovascular fitness are variables that can be measured at baseline and post-regimen in order to assess a particular regimen's efficacy.

Wingate testing using a cycle ergometer is useful in measuring anaerobic power and capacity during exercise (Astorino 2012). Using a standardized protocol, anaerobic peak power (PP), anaerobic power (AP), mean power (MP), anaerobic capacity (AC), anaerobic fatigue (AF), and fatigue index (FI) can be measured using computer software. PP and MP are the highest power generated and mean power generated, respectively, during testing. AP is calculated as the PP divided by the subject's weight in kg. AC is calculated as MP divided by the subject's weight in kg. FI is calculated as peak watts minus minimum watts divided by the test duration, 30 seconds.

VO_{2max} measures the body's maximal oxygen uptake. The intermittent high-intensity nature of soccer requires a high demand of oxygen. The varied anaerobic and aerobic aspects of the sport, including sprinting and acceleration, makes measurement of VO_{2max} a good indicator of the athletes' performance in the sport (Alexander and Mier 2011).

Vertical jump measurement is useful in measuring muscular power, a key component of performance in soccer players (Buckthorpe et al. 2012). Multiple measures of power can be assessed using vertical jump tests, depending on the available equipment. This research primarily makes use of jump height measurements before and after the training regimen.

Summary

Previous research has established that body composition is influenced by training and diet (Caldwell and Peters 2009; Earthman et al. 2004; Fullerton et al. 2007; Garthe et al. 2011). However, little is known about the extent of changes in body composition that occur over the course of a regular off-season training period in female college athletes. The purpose of the proposed study is to assess changes in lean body mass and fat mass relative to training and diet between the beginning and end of a typical 12-week off-season conditioning program and the subsequent effect on performance in a sample of Division I collegiate female soccer players.

CHAPTER III

METHODOLOGY

Study Design, Participants, and Study Procedures

This study was conducted during a soccer off-season between January and April of 2012. Participants for the study were recruited among the members of the women's varsity soccer team at Oklahoma State University. Coaching and training staff were informed about the nature of the study prior to obtaining informed consent from the players. A total of 21 females between the ages of 18 and 22 were assessed prior to and following an off-season, 12-week conditioning program. The inclusion criteria for the study were as follows: 1) current member of the OSU soccer team; 2) 18 years or older; 3) no current injuries or illnesses. Exclusion criteria included the following: 1) younger than 18 years of age; 2) current injury or illness preventing the participant from completing the study measurements; and 3) graduating players as they had completed their final season on the team in the semester prior to this study. All participants were informed of the study purpose, procedures, and inherent risks of the study by the project leader prior to the first day of assessment. Each subject provided written informed consent on day one of data collection. The study procedures were reviewed and approved by the Institutional Review Board at Oklahoma State University prior to any data collection.

Participants underwent body composition testing, performance testing, and dietary analysis at baseline and at the end of the 12-week training protocol. Performance testing was completed at the Health and Human Performance laboratory at Oklahoma State University. Body composition testing and dietary analysis was completed at the Department of Nutritional Sciences at Oklahoma State University.

Body Composition Assessment

Height measurements were taken twice for each participant using a Shorr Board mounted stadiometer (Shorr Productions, Olney, Md) and the average measurement to the nearest .25 inches was used. Conversion to centimeters was calculated by taking inches divided by 2.54. Weight measurements were taken twice for each participant using a digital scale (Seca 664, Hamburg, Germany) and the average measurement to the nearest .1 pound (lb) was used. Conversion to kilograms was calculated by taking pounds divided by 2.2.

Body composition was measured using dual-energy x-ray absorptiometry (DEXA). Due to unanticipated technical difficulties, two DEXA machines were used for analysis, Hologic Discovery A S/N 84671 and Hologic Discovery A S/N 45709. Each subject was assessed at the beginning and end of the off-season using the same DEXA model. The DEXA models were calibrated according to manufacturer QC protocol and step phantom calibration on the morning of each assessment day. Participants were provided medical scrubs and were asked to remove any metal prior to DEXA analysis. Each participant was required to take a standard pregnancy test prior to DEXA analysis as a safety precaution. Measures of lean body mass (grams), total mass (grams), fat mass (grams), and body fat percentage were obtained through the auto whole body scan performed by the fan beam DEXA. The same procedures and tests were used at the end of the 12-week off-season training period.

Dietary Intake Assessment

Prior to the initial assessment at the first day of testing, participants completed a Nutrition Questionnaire (NQ). Self-reported demographics were obtained, including birthdate, height, and weight. The NQ included questions regarding meal and snacking habits, food allergies, hydration habits in regards to exercise, history of muscle cramping menstrual history, adulthood height and weight history, perception of self body image, dieting history, ease of weight maintenance, prescription and over the counter supplementation, training volume, dietary quality before/during/after competition, diet quality during phases of training, iron status testing, and further nutritional concerns. A trained nutrition graduate assistant followed up with the participants to assist the participants in completing these forms.

At the initial assessment, each participant completed a 24-recall with a trained nutrition graduate student. Participants were asked to list the foods and their respective amounts of the foods that they consumed in the previous 24 hours. Beverages and supplements consumed were also included in the recalls. Times of food consumption were documented. Food models, spoons and cups of different sizes, and other containers were used as visual examples of serving sizes of various foods in order to help the participants determine the amount of food that they consumed. In addition the participants were asked to document the duration and type of the physical activity and training that they had done in the previous 24-hours. The completion of the initial 24-hour recall with the trained graduate assistant was used to familiarize the participants with food records to increase the accuracy of the 3-day food records that they were asked to complete.

The participants were each given a 3-day food record to complete on their own. Participants were asked to document consecutive days with two weekdays and one weekend. Time, amount, and description of foods, beverages, and supplements were documented. Participants were also asked to document the duration and intensity of each day’s workout. Upon completion of the 3-day food records, they were given to the team's athletic trainer, who delivered them in a sealed envelope directly to a trained nutrition graduate assistant for dietary analysis. Dietary analysis of the 3-day food records was conducted using the Food Processor software (version 8.3 for Windows, ESHA, Salem, Oregon). The 3-day averages of energy intake (kcal), carbohydrates (grams), fat (grams), and protein (grams) were determined from the input of the 3-day records into Food Processor. Macronutrient to body weight ratios (grams/kilogram) were calculated for comparison to recommended levels of intake for age, gender, and training intensity of "moderate" to "heavy" training.

Performance Testing

Performance testing was completed at the beginning of the 12-week training and conditioning regimen and at its completion. Subjects were assigned to one of two groups and completed the testing on one of two days. All testing was completed at the Health and Human Performance lab at Oklahoma State University and the tests included measures of power and endurance.

Prior to power testing by Wingate, subjects gave verbal acknowledgement of readiness. Subjects warmed up on a Monark 828E ergometer (Vansbro, Sweden) for 5 minutes at 50 RPM and 1 kg resistance. Subject then performed an additional 20-second warm-up at computer-controlled 100 watts with a 10-second cadence acceleration phase. Resistance-weight load was then applied to the flywheel at 7.5% of body weight and subjects were instructed to pedal "all-out" for 30 seconds. Power measures consisting of peak watts, mean watts, anaerobic capacity (watts/kg), and fatigue index (watts/sec) were recorded using Wingate Software Version 1. Power was also measured using peak vertical jump height. The vertical jump was measured with the use of wall tape. Subjects performed three jumps with hands-at-hips. The peak jump height of the three jumps was measured (in cm).

A graded VO_{2max} test was administered a week following the Wingate test administration. Subjects warmed up on a Monark 828E ergometer (Vansbro, Sweden) for 5 minutes at a cadence $\geq$ 50 RPM, with 1 kg of resistance. Subjects then completed 2-minute stages of increasing speed and grade on a treadmill (See Table 4). Time to exhaustion at VO_{2max} was measured. VO2, heart rate (HR), rated perceived exertion (RPE), and respiratory exchange ration (RER) were determined throughout the test's duration using Parvomedics TrueOne Metabolic System – OUSW 4.3.

Off-Season Training Protocol

Participants performed a 12-week, standardized resistance training and conditioning regimen in the off-season from their competition under the direction of the team's strength and conditioning staff. Structured training occurred five times a week, lasting 75-90 minutes per day. The training was organized into three, four-week cycles. The first 4-week cycle included exercises that emphasized basic aerobic fitness, introductory speed and acceleration, landing and deceleration technique, full body strength, the building of work capacity, and flexibility. Weekly workouts during this cycle included: 3 resistance training workouts, 3 conditioning workouts, and 2 injury prevention workouts. Some form of movement, resistance, and conditioning was performed each of the 5 weekly training days. The second 4-week cycle included exercises emphasizing advanced speed and acceleration, advanced deceleration and reactive agility technique, advanced plyometrics, full body strength, fitness maintenance, transitioning toward anaerobic fitness, and flexibility. The third 4-week cycle included exercises emphasizing advanced speed and acceleration, advanced deceleration and reactive agility technique, full body strength, anaerobic fitness, and flexibility.

Statistical Analyses

Descriptive statistics, including means, standard deviations and frequencies were utilized to describe the sample. Paired T-tests were used to determine the differences from baseline to completion of off-season training for each subject's total mass, lean body mass, fat mass, average energy consumption, average macronutrient consumption per kg of body weight, and performance measures (vertical jump, VO_{2max}, and Wingate power measures). Multiple regression analyses were utilized to identify the effect of body composition (LBM, fat mass, and body fat) on performance measures at baseline and post-test. Overall means of energy intake and macronutrient intake were compared with current dietary recommendations for the studied population. Differences were considered statistically significant at the $p < 0.05$ levels. All statistical analyses were completed using SPSS (version 20.0, Windows, Chicago, IL).

CHAPTER IV

RESULTS

Physical Characteristics

A total of 21 subjects provided complete data during the study. The anthropometric characteristics of the subjects are presented in Table 1. Mean weights and heights of the subjects did not significantly change from pre- to post-training. Mean fat mass of the subjects significantly decreased from pre- to post-training, with respective values of 16.05 ± 3.05 kg and 14.73 ± 2.90 kg. Mean lean mass, consisting of lean body mass and bone mineral content, significantly increased from pre- to post-training, with respective values of 47.44 ± 4.74 kg and 49.20 ± 4.55 kg. Mean body fat percentage of the subjects significantly decreased from pre- to post-training, with respective values of 25.2 ± 3.5% and 22.9 ± 3.0%. Mean BMI values for the subjects did not significantly differ from pre- to post-training. Of the 21 subjects with complete data, 19 subjects gained lean mass (90.5%) and 16 (71.4%) lost fat mass.

Table 1. Subjects' anthropometric characteristics at pre- and post-training (n=21)

Variable	Pre	Post	p-value
Weight (kg)	63.3 ± 6.4	63.7 ± 6.2	0.400
Height (cm)	166.6 ± 5.0	166.6 ± 4.8	0.740
Fat Mass (kg)	16.05 ± 3.05	14.73 ± 2.90**	0.005**
Lean + BMC (kg)	47.44 ± 4.74	49.20 ± 4.55***	0.000***
Body Fat %	25.2 ± 3.5	22.9 ± 3.0***	0.000***
BMI	22.8 ± 2.1	23.0 ± 2.0	0.415

Note. Values expressed as mean ± standard deviation. *$p < 0.05$; **$p<0.01$; ***$p<0.001$.

Energy and Macronutrient Intake

Complete dietary data from subjects' 3-day food records were available for 16 out of the original 21 subjects (Table 2). The remaining subjects' data was unavailable due to player absence or players were no longer active members of the team at the time of food record collection. The only significant change from pre- to post-training was found in average total percentage of kcal coming from protein, with respective values of 16.0 ± 2.1% and 18.0 ± 3.9%. The energy intake during both data collection points was similar (Table 2). Mean energy and macronutrient intakes in terms of total, amount per kg body weight, and percentage of total kcal are detailed in **Table 2**.

Table 2. Subjects' (n=16) dietary intakes of energy and macronutrients

Variable	Pre	Post	p-value
Energy			
Total Kcal[a]	1888 ± 443	1818 ± 500	0.580
Kcal/kg[b]	30.3 ± 7.8	29.1 ± 9.3	0.545
Carbohydrate			
Total g[c]	246.8 ± 57.4	241.6 ± 71.0	0.751
g/kg	4.0 ± 1.1	3.8 ± 1.3	0.544
% total kcal	52.7 ± 6.7	51.9 ± 4.7	0.68
Protein			
Total g	76.5 ± 23.1	84.1 ± 30.5	0.301
g/kg	1.2 ± 0.4	1.4 ± 0.6	0.256
% total kcal	16.0 ± 2.1	18.0 ± 3.9*	0.011*
Fat			
Total g	67.6 ± 24.5	61.5 ± 19.6	0.309
g/kg	1.1 ± 0.4	1.0 ± 0.3	0.379
% total kcal	31.4 ± 7.1	29.8 ± 4.9	0.309

Note. Values expressed as mean ± standard deviation. [a]Kcal-kilocalories; [b]kg-kilograms; [c]g-grams. *Significantly different from pre-training level ($p < 0.05$).

Table 3. Comparison of subjects' dietary intakes to recommended levels

	Recommended	**# Under**	**# Over**	**# Met**
Kcal/kg I*	≥ 37	17 (85%)		3 (15%)
Kcal/kg II**	≥ 37	13 (76%)		4 (24%)
CHO/kg I	5.0 - 7.0	17 (85%)		3 (15%)
CHO/kg II	5.0 - 7.0	13 (76%)		4 (24%)
CHO % I	45 - 65%	2 (10%)	1 (5%)	17 (85%)
CHO % II	45 - 65%	2 (12%)		15 (88%)
PRO/kg I	1.2 - 2.0	10 (50%)	1 (5%)	9 (45%)
PRO/kg II	1.2 - 2.0	10 (59%)	2 (12%)	6 (35%)
PRO % I	10 - 35%			20 (100%)
PRO % II	10 - 35%			17 (100%)
FAT % I	20 - 35%	2 (10%)	7 (35%)	11 (55%)
FAT % II	20 - 35%		1 (6%)	16 (94%)

***Testing I: n= 20**
****Testing II: n = 17**

Performance Measures

Results from performance testing of the subjects were available for 19 of the 21 subjects in most cases (Table 3). VO_{2max} data was available for 16 of the 21 subjects. The remaining subjects' data was unavailable due to players no longer being active members of the team at the time of post-training data collection. VO_{2max} increased significantly from pre- to post-training. Wingate measures of peak wattage, mean wattage, and anaerobic capacity increased significantly. Also, fatigue index calculated from Wingate testing showed a significant decrease from pre- to post-training.

Table 4. Subjects' performance measures at pre- and post-training (n=19)

Variable	Pre-testing	Post-testing	p-value
VO_{2max} [a]	46.6 ± 5.7	49.3 ± 4.5*	0.041*
Peak Wattage	754.5 ± 111.9	748.6 ± 85.3	0.687
Mean Wattage	492.0 ± 57.5	517.9 ± 44.8*	0.006**
Anaerobic Capacity	7.8 ± 0.7	8.2 ± 0.6*	0.004**
Anaerobic Power	11.9 ± 0.8	11.8 ± 0.5	0.541
Fatigue Index	14.7 ± 3.9	13.3 ± 2.6*	0.039*
Vertical Jump- Peak Height (cm)	16.0 ± 1.8	15.6 ± 1.6	0.198

Note. Values expressed as mean ± standard deviation. *$p < 0.05$; **$p<0.01$; ***$p<0.001$. [a] n=16 for VO_{2max} data

Correlation of Body Composition to Performance

Stepwise linear regression analyses were conducted to determine if there were any significant relationships between changes in body composition measures and the changes in performance measures. Body composition variables analyzed as the independent variables were fat mass, lean mass, and body fat percentage. Fat mass and body fat percentage analysis was included to provide data on subjects' individual fat mass' and their fat mass relative to total body mass. All performance measures were included in the analyses as dependent variables.

Significant relationships were found only with fat mass as the independent variable. Lean body mass and body fat percentage as independent variables were not shown to be correlated to any of the performance measures. Findings from the regression analyses indicated that 33.8% of variation in the performance measure, VO_{2max} was accounted for by the change in body composition measure, fat mass ($p = 0.018$). Thirty-two percent of variation in the performance measure, peak watts, was accounted for by the change in body composition measure, fat mass ($p = 0.012$). Also, 26.8% of the variation in the performance measure, fatigue index, can be accounted for by change in the body composition measure, fat mass ($p = 0.023$). All other body composition and performance measure variable relationships were excluded from analyses due to non-significance of results.

CHAPTER V

DISCUSSION

This study's purpose was to determine the effect of a typical structured off-season training on female collegiate soccer players' body compositions, performance measures, and to their dietary intakes. A correlation analyses between body composition and performance measures was also conducted. Results from this study indicated significant changes in fat mass, lean body mass, and several measures of performance from pre- to post-training testing. Changes in fat mass were shown to have an effect on the variance in several measures of performance. Dietary intake values largely remained unchanged, with the only exception being percentage of calories derived from protein.

This study adds valuable detail and analysis of typical off-season training in the population of female collegiate soccer players. Further detail of the training specific to this study can be found in **Table 1** of the appendices, involved periodization of multiple resistance and conditioning training exercises to increase performance throughout the duration of training. With regard to previous research on the changes in body composition and performance measures during individual training periods among collegiate athletes, limited research is available and has primarily focused on male soccer players. Previous studies have examined male soccer players' body composition changes resulting from pre-season and in-season training and have had mixed results. In relation to measured body composition, studies of male soccer players have found lean mass increases and body fat decreases, only body fat decreases, or no changes in body composition (Caldwell and Peters 2009; Ostojic 2003; Murkherjee and Chia 2010).

In previous studies, collegiate and national-caliber female soccer players have been shown to have body fat ranging between 16% and 26% (Clark et al. 2003; Davis and Brewer 1993b; Fogelholm et al. 1995; McCay and Shephard 1988). The mean body fat percentages in this study fell within that range, with respective pre- and post-training values of ~25% and ~23%. Lean body mass and fat mass measures in this study did significantly change, indicating the accrual of lean mass and a loss of fat mass. This gives credence to the varied resistance and conditioning training that the players participated in. In Clarke's et al's 2003 examination of female collegiate soccer players throughout a typical season, no change in body fat was found. This is surprising as one may expect a significant loss of body fat during high-intense and demanding period of the competitive soccer season (Ostojic 2003). Given the scarcity of studies in this area, further studies are warranted to closely measure and monitor the yearlong variation in the players' body composition along with training and competition.

The performance measures completed by this study provided a look at the sample's respective levels of power and endurance before and after a typical resistance and conditioning training. The power components of testing, peak wattage, anaerobic power, and vertical jump did not change significantly from pre- to post-training. A possible explanation for this was that the training might have been more suited for endurance improvement and the ability to perform at a high intensity longer. This was illustrated by the endurance measures of VO_{2max}, mean wattage, anaerobic capacity, and fatigue index, which all changed significantly from pre- to post-training. A similar finding in regards to VO_{2max} change was evident in a study conducted over the span of a women's collegiate soccer teams' season. VO_{2max} was shown to significantly increase following the team's in-season training and competition (Clark et al. 2003). This study adds further evidence that while soccer off-season training did not increase power, it lead to significant increases in the players' aerobic endurance (VO_{2max}), which is a crucial component of overall performance in soccer.

The results from this study indicated that decreased fat mass had a significant correlation with several measures of performance; the VO_{2max} and fatigue index measures were indicative of endurance capacity and peak watts as an indicator of the athletes' power. This supports the theory that body fatness can inhibit one's performance because fat mass represents excess mass that an athlete must translocate during play (Boileau and Lohman 1977). Similar results have been found in studies conducted on the sprint times of male professional and semiprofessional soccer players. Increases in body fat in these studies was significantly correlated with increases in sprint times (Caldwell and Peters 2009; Ostojic 2003). Although expected, lean mass was not shown to have a significant effect on any of the performance measures tested. The lack in effect on peak wattage and vertical jump height was surprising in this study. The lack of statistical effect may be attributed to insufficient familiarization with the performance testing methods, the measures' misrepresentation of the athletes' soccer-specific performance capabilities, or simply the body composition changes were not large enough to affect power.

Dietary intakes of the subjects in this study were evidenced by self-reported 3-day food records. Mean daily energy intake of approximately 1800 kcal in this study was similar to the intake of female soccer players found in Clark et al.'s study in 2003. Energy intake in relation to body weight fell well below recommended intake of > 37 g/kg to meet energy requirements for "active" to "very active" females (Clark et al. 2003; Trumbo et al. 2002). Actual energy intake more closely corresponded to the minimum recommended by the World Health Organization (2004) for females in the general population, 30 kcal/kg. Inadequate energy intake may have been a factor related to the extent of performance gains, or lack thereof, in this population. With the small number of players that actually met the recommended caloric intake, an analysis of energy intake's relation to performance would not prove to be valid in this study. A more extensive study including a larger sample of soccer players either meeting or not meeting recommended levels of energy intake is advisable to better detail the effect of energy intake on performance in this population.

Carbohydrate intake (~4 g/kg) fell below the recommended intake level of 5 g/kg recommended for this population in "moderate training" as well as the 7-12 g/kg recommended for athletes in "heavy training" (Burke et al. 2006). Overall, mean macronutrient intakes did fall within recommended AMDR ranges for the general population (National Research Council 2005). Low carbohydrate intake may be attributed to the general under-consumption of overall energy intake, since carbohydrate and other macronutrients intake did fall within the 45-65% of total energy intake AMDR. The influence of carbohydrate consumption has been shown to effect glycogen storage in the body, lean mass maintenance, as well as optimal performance gains (American Dietetic Association 2009). In studies examining the effect of a glucose beverage on sprint performance and cycling time to exhaustion, the consumption of a carbohydrate containing beverage significantly improved performance (Siahkohian et al. 2008; and Davis et al. 1997). Although it was daily carbohydrate intake examined in this study, inadequate carbohydrate consumption very well may have inhibited optimal performance gains in the sample.

Mean protein intake of the sample fell within the levels recommended for athletes, 1.2 up to 2.0 g/kg body weight. Meeting these levels in athletes is meant to help maintain lean mass or further increase lean mass with training (Phillips and Van Loon 2011; Tipton and Wolfe 2004). When paired with the low overall energy intakes of the players, protein and its component amino acids can be used for energy. Lean mass gains may have been limited by the extent of protein metabolized in the body versus the amount available for skeletal protein synthesis (American Dietetic Association 2009) The only change found during analysis of the players' dietary intakes was the amount of consumed calories derived from protein, although total protein and protein grams per kilogram of body weight did not significantly change and protein remained in the

AMDR range recommended during both pre- and post-training analysis. With the lack of dietary intervention in this study, no change in composition of dietary intake had been anticipated from pre- to post-training analysis.

Limitations

The current study has several limitations that should be noted. First, the study utilized a sample of collegiate female soccer players consisting of the players eligible during the spring semester of the academic year. Of the 21 players available at the time of the study, complete data from pre- and post-season was available for 15 subjects. Data from the testing(s) was unavailable for certain subjects due to player absence or the players no longer being on the team's active roster. This negatively influenced the power of statistical analyses completed on the measured variables.

Second, the use of 3-day food records following the completion of an example 24-hour recall conducted with a trained graduate student was meant to give an accurate depiction of the players' average dietary intake. Overall accuracy of the players' food records was limited by their self reported intake, as well as their knowledge of portion sizing of foods listed in their 3-day food records. Inaccurate reporting of dietary intake has been shown to occur by individuals with a desire to change their body composition (Johansson et al. 1998; Burke 2001). Prolonged response time to researcher's follow-up questions on portion sizes and other record details may have been an issue in the accuracy of reported intake.

Third, with the unique seasonal nature of collegiate women's soccer, the effects of the training on the team's actual soccer performance could not be captured in the current study. The training took place in the spring semester, whereas the actual competitive season takes place throughout the fall. The team's spring exhibition matches may best show the performance gains from the athletes' training. However, the gains from the off-season training need to be maintained throughout the summer in order to potentially have a beneficial impact on the players' competitive fall season.

Conclusion

The results of this study indicated that the soccer players' body composition measures significantly changed from pre- to post-training; lean body mass increased and fat mass decreased. Dietary intakes of the players did not change from pre- to post-training, except for the percentage of calories derived from protein. This was expected because players did not participate in any nutrition education program or workshops during the study. Average kcal and carbohydrate intake per kilogram of body weight did not meet recommendations for this population of female soccer athletes in training. Protein intake per kilogram of body weight did meet recommended levels of intake for this population. Performance measures of VO_{2max}, mean watts, anaerobic capacity, and fatigue index significantly increased from pre- to post-training testings. Furthermore, analyses of the relationship between body composition and performance demonstrated an effect of the change in fat mass on the variance in change of VO_{2max}, peak watts, and fatigue index measures. The results shown here support the effect of off-season training on body composition of collegiate female soccer players and an effect of body composition change on the variation in change of soccer-related performance measures.

Practical Implications and Future Research

Currently, limited information is available for this population in the off-season period of collegiate soccer. This study provides useful descriptive data of female collegiate soccer players' body composition, performance measures, and average dietary intakes in the off-season. Details of the changes of these measures resulting from sport-specific training can provide useful information for the potential validation of such training regimens. The very detailed and structured nature of the team’s strength and conditioning protocol can be examined to determine where changes can be made to maximize its efficacy.

Due to the limited number of soccer players examined in this study, further research should include a larger sample of players spanning multiple collegiate soccer programs and should include year-long data on performance and body composition changes. The nature of the off-season and in-season periods of women’s collegiate soccer combined with NCAA practice time regulations can be limiting to the goals of the coaching staff and the strength and conditioning staff. Periodization of yearly training in other sports has previously been analyzed, and can help maximize performance gains in the sports’ respective competitive seasons (Koutedakis 1995; Steward & Hopkins 2000). Year-long data for this population may influence NCAA regulations with regard to allowed practice time. Although athletes are not required to participate, the effect(s) of voluntary workouts that players may participate in throughout the year would be of importance to coaches and athletes alike.

The inclusion of a dietary intervention in this population paired with a control sample could illustrate the effect(s) of dietary intake on body composition change. A study design that includes multiple day food records during training would give a better representation of dietary intake. An assessment of energy expenditure using the MET Compendium of physical activities (Ainsworth et al. 2011) or another assessment tool would be useful to utilize along with food records to more accurately determine energy requirements of athletes. Furthermore, dietary carbohydrates’ role has been examined in studies on other populations of athletes with regards to body composition (Soric et al. 2008) and performance (Moncada-Jiménez et al. 2009). Analysis of dietary carbohydrate intake during training in this population in comparison to performance and/or body composition changes would further strengthen the study and add evidence to the relationships between dietary intakes, body composition, and performance measures explored in this study.

REFERENCES

Alexander RP, Mier CM. Intermittent vs continuous graded exercise test for vo2max in college soccer athletes. *International Journal of Exercise Science*. 2011;4(3):185-191.

Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR, Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS. 2011 compendium of physical activites: a second update of codes and met values. *Medicine & Science in Sports & Exercise*. 2011:43(8);1575-1581.

Astorino TA, Cottrell T. Reliability and validity of the velotron racermate cycle ergometer to measure anaerobic power. *International Journal of Sports Medicine*. 2012:33:205-210.

American Dietetic Association. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *Journal of the American Dietetic Association*. 2009;109(3):509-527.

Arazi H, Faraji H, Moghadam MG, Samadi A. Effects of concurrent exercise protocols on strength, aerobic power, flexibility and body composition. *Kinesiology*. 2011;43(2):155-162.

Ball S, Swan PD, Altena TS. Skinfold Assessment: Accuracy and Application. *Measurement in physical education and exercise science*. 2006;10(4):255-264.

Bangsbo J, Nørregaard L, Thorsø F. Activity profile of competition soccer. *Canadian Journal of Sport Sciences*. 1991;16(2):110-116

Bangsbo J, Mohr M, Krustrup P. Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sport Sciences*. 2006;24(7):665-674)

Birrer D, Morgan G. Review: Psychological skills training as a way to enhance an athlete's performance in high-intensity sports. *Scandanavian Journal of Medicine & Science in Sports*. 2009;20(2):78-87.

Bradley PS, Sheldon W, Wooster B, Olsen P, Boanas P, Krustrup P. High-intensity running in english FA premier league soccer matches. *Journal of Sports Sciences*. 2009;27(2):159-168.

Buckthorpe M, Morris J, Folland JP. Validity of vertical jump measurements. *Journal of Sports Sciences*. 2012;30(1):63-69.

Burke LM. Energy needs of athletes. *Canadian Journal of Applied Physiology*. 2001;26(S1):S202-S219.

Burke LM, Loucks AB, Broad N. Energy and carbohydrate for training and recovery. *Journal of Sports Sciences*. 2006;24(7):675-685.

Caldwell BP, Peters DM. Seasonal variation in physiological fitness of a semiprofessional soccer team. *Journal of Strength and Conditioning Research*. 2009;23(5):1370-1377.

Clark M, Reed DB, Crouse SF, Armstrong RB. Pre- and post-season dietary intake, body composition, and performance indices of NCAA division I soccer players. *International Journal of Sport Nutrition and Exercise Metabolism*. 2003;13:303-319.

Davis JA, Brewer J. Applied physiology of female soccer players. *Sports Medicine*. 1993;16(3):180-189.

Davis JA, Brewer J. Physiological characteristics of an international female soccer squad. *Journal of Sports Sciences*. 1993;10:142-143.

Davis JM, Jackson DA, Broadwell MS, Queary JL, Lambert CL. Carbohydrate drinks delay fatigue during intermittent, high-intensity cycling in active men and women. *International Journal of Sports Nutrition*. 1997;7:261-273.

Davis WJ, Wood DT, Andrews RG, Elkind LM, Davis WB. Concurrent training enhances athletes' strength, muscle endurance, and other measures. *Journal of Strength and Conditioning Research*. 2008;22(5):1487-1502.

Drummond MJ, Dreyer HC, Pennings B, Fry CS, Dhanani S, Dillon EL, Sheffield-Moore M, Volpi E, Rasmussen BB. Skeletal muscle protein anabolic response to resistance exercise and essential amino acids is delayed with aging. *Journal of Applied Physiology*. 2008;104:1452-1461.

Drummond MJ, Fry CS, Glynn EL, Timmerman KL, Dickinson JM, Walker DK, Gundermann DM, Volpi E, Rasmussen BB. Skeletal muscle amino acid transporter expression is increased in yound and older adults following resistance exercise. *Journal of Applied Physiology*. 2011;111:135-142.

Earthman CP, Goldman LP, Gwazdauskas FC, Nickols-Richardson SM, Puglisi MJ, Rankin JW. Effect of post-exercise supplement consumption on adaptations to resistance training. *Journal of the American College of Nutrition*. 2004;23(4):322-330.

Forslund AH, Hambraeus L, Olsson RM, El-Khoury AE, Yu YM, Young, VR. The 24-h whole body leucine and urea kinetics at normal and high protein intakes with exercise in healthy adults. *American Journal of Physiology – Endocrinology and Metabolism*. 1998;275(2):E310-E320.

Franzoi SL, Shields SA. The body esteem scale: multidimensional structure and sex differences in a college population. *Journal of Personality Assessment*. 1984;48(2):173-178.

Fogelholm GM, Kukkonen-Harjula TK, Taipale SA, Sievanen HT, Oja P, Vuori M. Resting metabolic rate and energy intake in female gymnasts, figure skaters, and soccer players. *International Journal of Sports Medicine*. 1995;16(8):551-556.

Fullerton AV, Hartman JW, Lawrence RL, Phillips SM, Tang JE, Tarnopolsky MA, Wilkinson SB. Consumption of fat-free fluid milk after resistance exercise promotes greater lean mass accretion than does consumption of soy or carbohydrate in young, novice, male weightlifters. *The American Journal of Clinical Nutrition*. 2007;86:373-381.

Gammeren DV, Falk D, Antonio J. The effects of four weeks of ribose supplementation on body composition and exercise performance in healthy, young male recreational bodybuilders: A double-blind, placebo-controlled trial. *Current Therapeutic Research*. 2002;63(8):486-495.

Garthe I, Raastad T, Refsnes PE, Koivisto A, Sundgot-Boren J. Effect of two different weight-loss rates on body composition and strength and power-related performance in elite athletes. *International Journal of Sport Nutrition and Exercise Metabolism*. 2011;21(2):97-104.

Garthe I, Raastad T, Sundgot-Borgen J. Long-term effect of nutritional counseling on desired gain in lean body mass in elite athletes. *Applied Physiology, Nutrition, and Metabolism*. 2011;36(4):547-554.

Grieco CR, Cortes N, Greska EK, Lucci S, Onate JA. Effects of a combined resistance-plyometric training program on muscular strength, running economy, and vo2peak in division I female soccer players. 2012:26(9);2570-2576.

Haarbo J, Gotfredsen A, Hassager C, Christiansen C. Validation of body compostion by dual energy x-ray absorptiometry (DEXA). *Clinical Physiology*. 1991;11(4):331-341.

Jackson AS, Pollock ML. Generalized equations for predicting body density of man. *The British Journal of Nutrition*. 1978;40:497-504.

Johansson L, Solvoll K, Bjørneboe GE, Drevon CA. Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. *American Journal of Clinical Nutrition.* 1998;68(2):266-274.

Jones MT, Matthews TD, Murray M, Van Raalte J, Jensen BE. Psychological correlates of performance in female athletes during a 12-week off-season strength and conditioning program. *Journal of Strength and Conditioning Research.* 2010;23(3):619-628.

Koutedakis Y. Seasonal variation in fitness parameters in competitive athletes. *Sports Medicine*. 1995;19(6):373-392.

Lamont LS, McCullough AJ, Kalhan SC. Comparison of leucine kinetics in endurance-trained and sedentary humans. *Journal of Applied Physiology*. 1999;86(1):320-325.

Layman DK, Evans E, Baum JI, Seyler J, Erickson DJ, Boileau RA. Dietary protein and exercise have additive effects on body composition during weight loss in adult women. *The Journal of Nutrition*. 2005;135(8):1903-1910.

MacArthur DG, North KN. Genes and human elite athletic performance. *Hum Genet*. 2005;116:331-339.

McBride JM, Blaak JB, Triplett-McBride T. Effect of resistance exercise volume and complexity on EMG, strength, and regional body composition. *European Journal of Applied Physiology*. 2003;90:626-632.

McCay L, Shephard RJ. Standardized tests for Canadian soccer players. Ottawa, ON: Canadian Soccer Association, 1988.

Mikkola J, Vesterinen V, Taipale R, Capostagno B, Häkkinen K, Nummela A. Effect of resistance training regimens on treadmill running and neuromuscular performance in recreational endurance runners. *Journal of Sports Sciences*. 2011;29(13):1359-1371.

Misra A, Alappan AK, Vikram NK, Goel K, Gupta N, Mittal K, Bhatt S, Luthra K. Effect of supervised progressive resistance-exercise training protocol on insulin sensitivity, glycemia, lipids, and body composition in Asian Indians with type 2 diabetes. *Diabetes Care*. 2008:31(7):1282-1287.

MLS. Women's world cup final sets new US television record. MLS Soccer. http://www.mlssoccer.com/news/article/2011/07/18/womens-world-cup-final-sets-new-us-television-record. Published July 18, 2011. Accessed January 24, 2013.

Moncada-Jiménez J, Plaisance EP, Mestek ML, Ratcliff L, Araya-Ramírez F, Taylor JK, Grandjean PW, Aragón Vargas LF. Duathlon performance unaltered by short-term changes in dietary fat and carbohydrates. *International Journal of Sport Nutrition and Exercise Metabolism*. 2009;19(1):47-60.

Moore DR, Del Bel NC, Nizi KI, Hartman JW, Tang JE, Armstrong D, Phillips SM. Resistance training reduces fasted- and fed-state leucine turnover and increases dietary nitrogen retention in previously untrained young men. *The Journal of Nutrition*. 2007;137:985-991.

Moore EWG, Hickey MS, Reiser RF. Comparison of two twelve week off-season combined training programs on entry level collegiate soccer players' performance. *Journal of Strength and Conditioning Research*. 2005:19(4):791-798.

Moxnes JF, Hausken K. The dynamics of athletic performance, fitness and fatigue. *Mathematical and Computer Modelling of Dynamical Systems*. 2008;14(6):515-533.

Mukherjee S, Chia M. Within-season variation in the body composition of Asian youth professional soccer players. *Sport Science*. 2010; 2:15-22.

Must A, Anderson SE. Body mass index in children and adolescents: considerations for population-based applications. *International Journal of Obesity*. 2006;30:590-594.

National Research Council. 13 Applications of Dietary Reference Intakes for Macronutrients. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients)*. Washington, DC: The National Academies Press; 2005. 1. Print.

Ostojic SM. Seasonal alterations in body composition and sprint performance of elite soccer players. *Journal of Exercise Physiology online*. 2003;6(3):24-27.

Petersen HL, Petersen CT, Reddy MB, Hanson KB, Swain JH, Sharp RL, Alekel DL. Body composition , dietary intake, and iron status of female collegiate swimmers and divers. *International Journal of Sport Nutrition and Exercise Metabolism*. 2006;16:281-295.

Phillips SM, Van Loon LJC. Dietary protein for athletes: From requirements to optimum adaptation. *Journal of Sports Sciences*. 2011;29:S29-S38.

Powers PS, Johnson C. Small victories: Prevention of eating disorders among athletes. *Eating Disorders: The Journal of Treatment and Prevention*. 1996;4(4):364-377.

Russell M, Kingsley M. Inflluence of Exercise on Skill Proficiency in Soccer. *Sports Medicine*. 2011;41(7):523-539.

Sambolec EJ, Kerr NL, Messé LA. The Role of Competitiveness at Social Tasks: Can Indirect Cues Enhance Performance? *Journal of Applied Sport Psychology*. 2007;19:160-172.

Siahkohian M, Farhadi H, Baghi AN, Valizadeh A. Effect of carbohydrate ingestion on sprint performance following continuous exercise. *Journal of Applied Sciences*. 2008;8(4):723-726.

Siegler J, Gaskill S, Ruby B. Changes evaluated in soccer-specific power endurance either with or without a 10-week, in-season, intermittent, high-intensity training protocol. *Journal of Strength and Conditioning Research*. 2003;17(2):379-387.

Soric M, Misigoj-Durakovic M, Pedisic Z. Dietary intake and body composition of prepubescent female aesthetic athletes. *International Journal of Sport Nutrition and Exercise Metabolism*. 2008;18(3):343-354.

Stewart AM, Hopkins WG. Seasonal training and performance of competitive swimmers. *Journal of Sport Sciences*. 2000;18(11):873-884.

Tipton KD, Wolfe RR. Protein and amino acids for athletes. *Journal of Sport Sciences*. 2004;22(1):65-79.

Trumbo P, Schlicker S, Yates AA, Poos M. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. *Journal of the American Dietetic Association*. 2002;102(11):1621-1630.

US Youth Soccer. Largest youth sports organization celebrates 35th anniversary. US Youth Soccer. http://www.usyouthsoccer.org/aboutus/History/. Published 2009. Accessed January 24, 2013.

Human Energy Requirements: Report of a Joint FAO/WHO/UNU Expert Consultation. Rome; World Health Organization; 2004.

APPPENDICES

Table 1. Training Overview, Cycle 1

	Cycle 1 (Jan-Feb)
Overview	Basic Aerobic Fitness, Intro to Speed and Acceleration, Landing and Deceleration Technique, Full Body Strength, Build Work Capacity, Flexibility
Monday	Speed Mechanics, Acceleration/Short Sprints, Landing Progression, Full Body Lift (kettlebell swings, push-ups, db reverse lunges, lat pulldowns, lunge isometric hold)
Tuesday	Injury Prevention of Knee, Tempo Run (aerobic system) of 50 and 75 yard intervals, endurance abdominal work
Wednesday	Full Body Lift: Box Jumps, Front Squat, DB Military, Back Extensions/Reverse Hypers, Horizontal Pull-ups, Lunge isometric holds
Thursday	Injury Prevention of Knee, Footwork Drills and Deceleration Technique, Anaerobic Conditioning (200 and 300 yard shuttles or aerobic shuttle runs of 100%+ effort)
Friday	Work Capacity through slideboards, burpees, battling ropes, tire flips, core

Table 2. Training Overview, Cycle 2

	Cycle 2 (Feb-Mar)
Overview	Advanced Speed and Acceleration, Advanced Deceleration and Reactive Agility Technique, Advanced Plyos, Full Body Strength, Maintain Fitness and Transition toward Anaerobic Emphasis, On-field practice, Flexibility
Monday	Speed Mechanics, Short Sprints with intro to flying 20s and 50s and 30s yard sprints and linear jumps, Full Body Lift (front squat, db deadlift, chin-ups, kb swings, lateral step-ups)
Tuesday	Practice
Wednesday	Deceleration and landing technique, Full Body Lift (db push jerk, tire flips, db rear foot elevated split squat, horizontal pull-ups, glut ham raise), extra fitness if needed after practice
Thursday	Practice
Friday	Lateral jumps and hops, Full Body Lift (pin pulls off rack, weighted push-ups, db rdl, 1 leg box squat, 3 point row) and Work Capacity Metabolic Challenge (i.e. Crossfit, etc.)

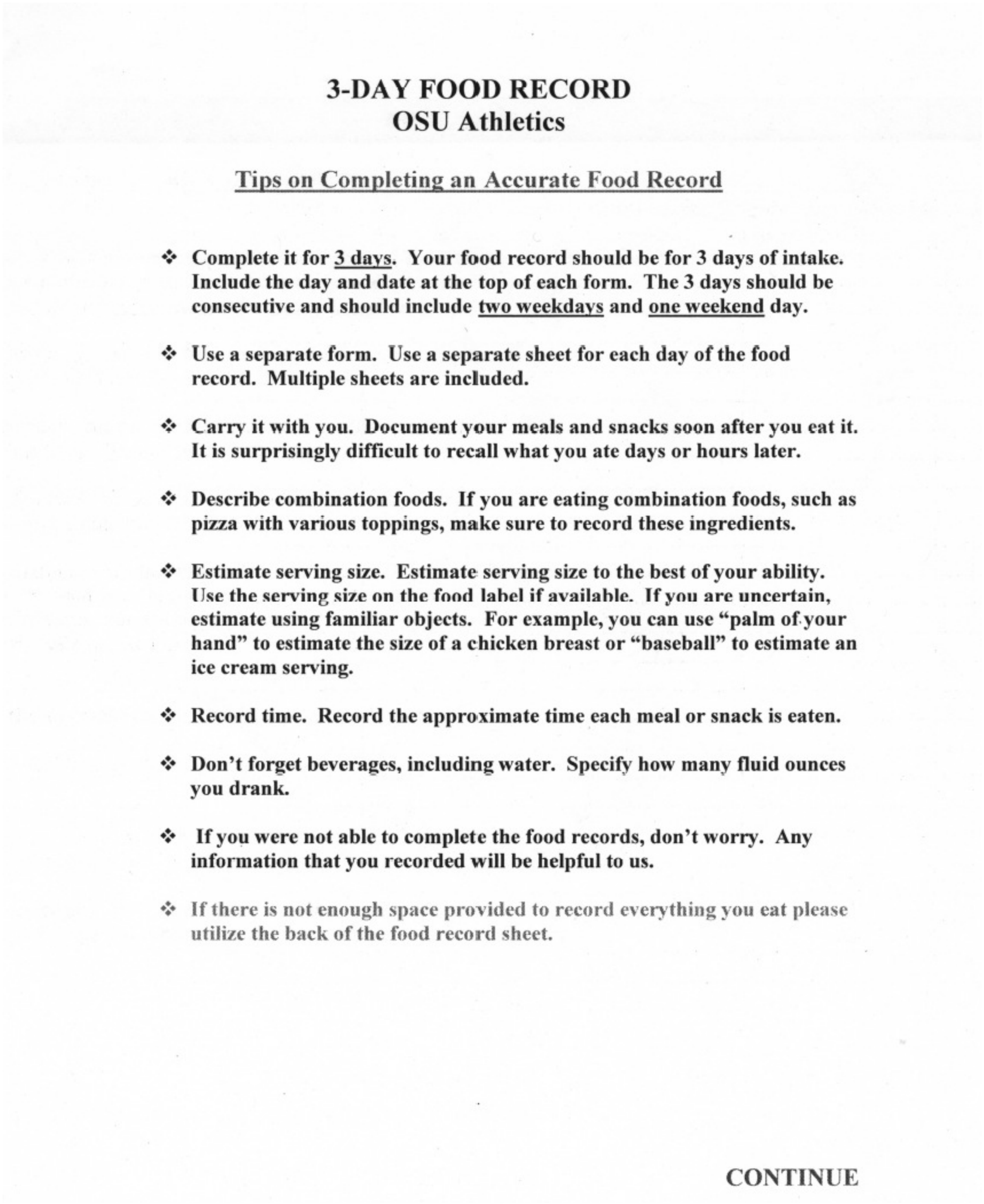
Table 3. Training Overview, Cycle 3

	Cycle 3 (Mar-Apr)
Overview	Advanced Speed and Acceleration, Advanced Deceleration and Reactive Agility Technique, Full Body Strength, Anaerobic fitness, Flexibility, On-field practice
Monday	Speed Mechanics, Full Body Lift (clean deadlift, db rfe split squat, weighted push-ups, bb high pull, glute ham raise)
Tuesday	Practice
Wednesday	Deceleration, Change of Direction technique, Full Body Lift (front squat, bb push press, db sl rdl, sandbag lateral lunge, chin-ups)
Thursday	Anaerobic Training
Friday	Training at coach’s discretion

Table 4. VO_{2max} Test Protocol

Stage	**Minutes**	**Speed (mph)**	**Grade**
1	0 1	2.5	0%
2	2 3	5.0	0%
3	4 5	6.0	0%
4	6 7	7.0	0%
5	8 9	7.5	0%
6	10 11	7.5	2%
7	12 13	7.5	4%
8	14 15	7.5	6%
9	16 17	7.5	8%
10	18 19 20	7.5	10%

Appendix A



3-DAY FOOD RECORD
OSU Athletics

Tips on Completing an Accurate Food Record

- **Complete it for 3 days. Your food record should be for 3 days of intake. Include the day and date at the top of each form. The 3 days should be consecutive and should include two weekdays and one weekend day.**

- **Use a separate form. Use a separate sheet for each day of the food record. Multiple sheets are included.**

- **Carry it with you. Document your meals and snacks soon after you eat it. It is surprisingly difficult to recall what you ate days or hours later.**

- **Describe combination foods. If you are eating combination foods, such as pizza with various toppings, make sure to record these ingredients.**

- **Estimate serving size. Estimate serving size to the best of your ability. Use the serving size on the food label if available. If you are uncertain, estimate using familiar objects. For example, you can use "palm of your hand" to estimate the size of a chicken breast or "baseball" to estimate an ice cream serving.**

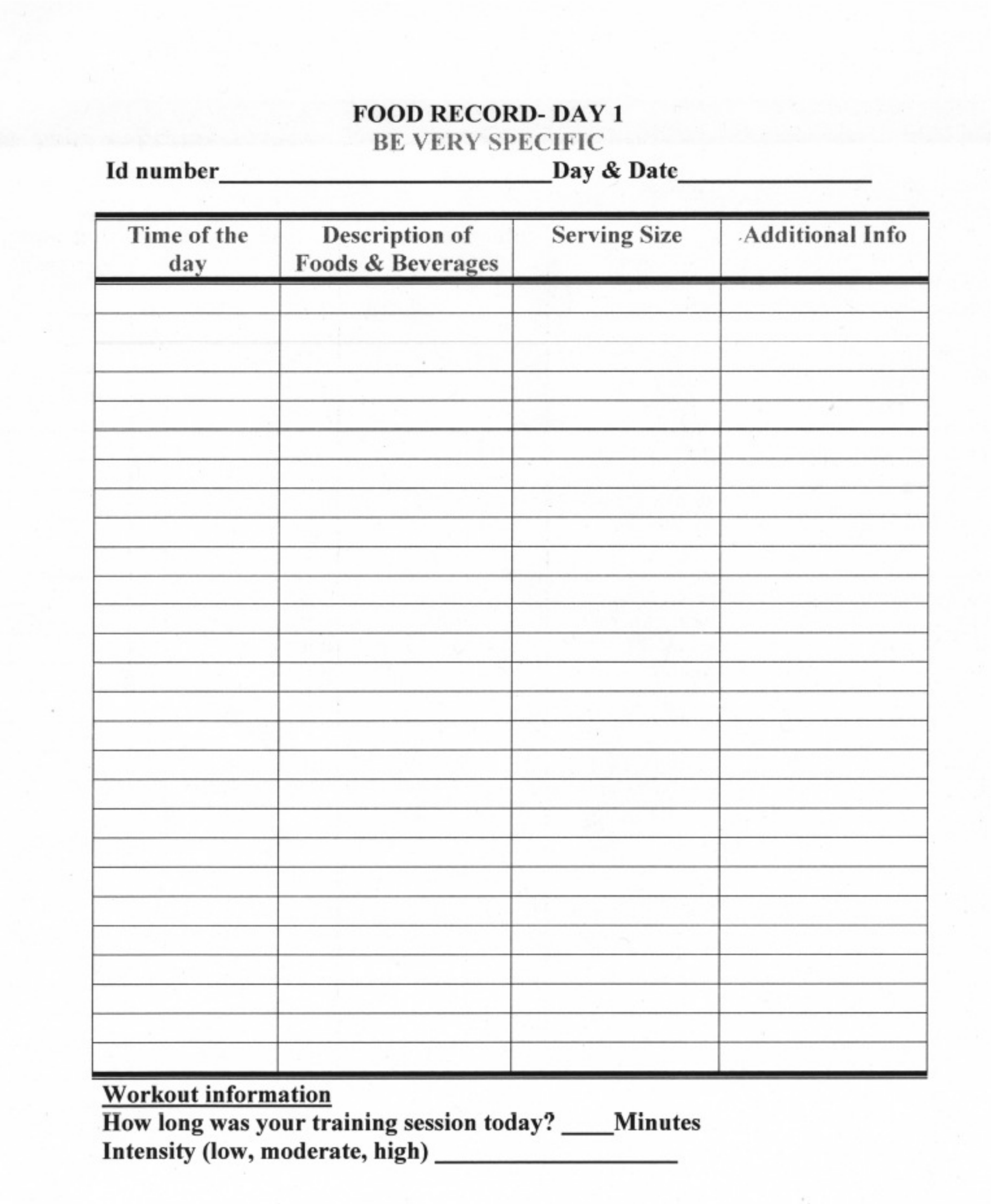
- **Record time. Record the approximate time each meal or snack is eaten.**

- **Don't forget beverages, including water. Specify how many fluid ounces you drank.**

- **If you were not able to complete the food records, don't worry. Any information that you recorded will be helpful to us.**

- **If there is not enough space provided to record everything you eat please utilize the back of the food record sheet.**

CONTINUE



FOOD RECORD- DAY 1

BE VERY SPECIFIC

Id number__________________________Day & Date_______________

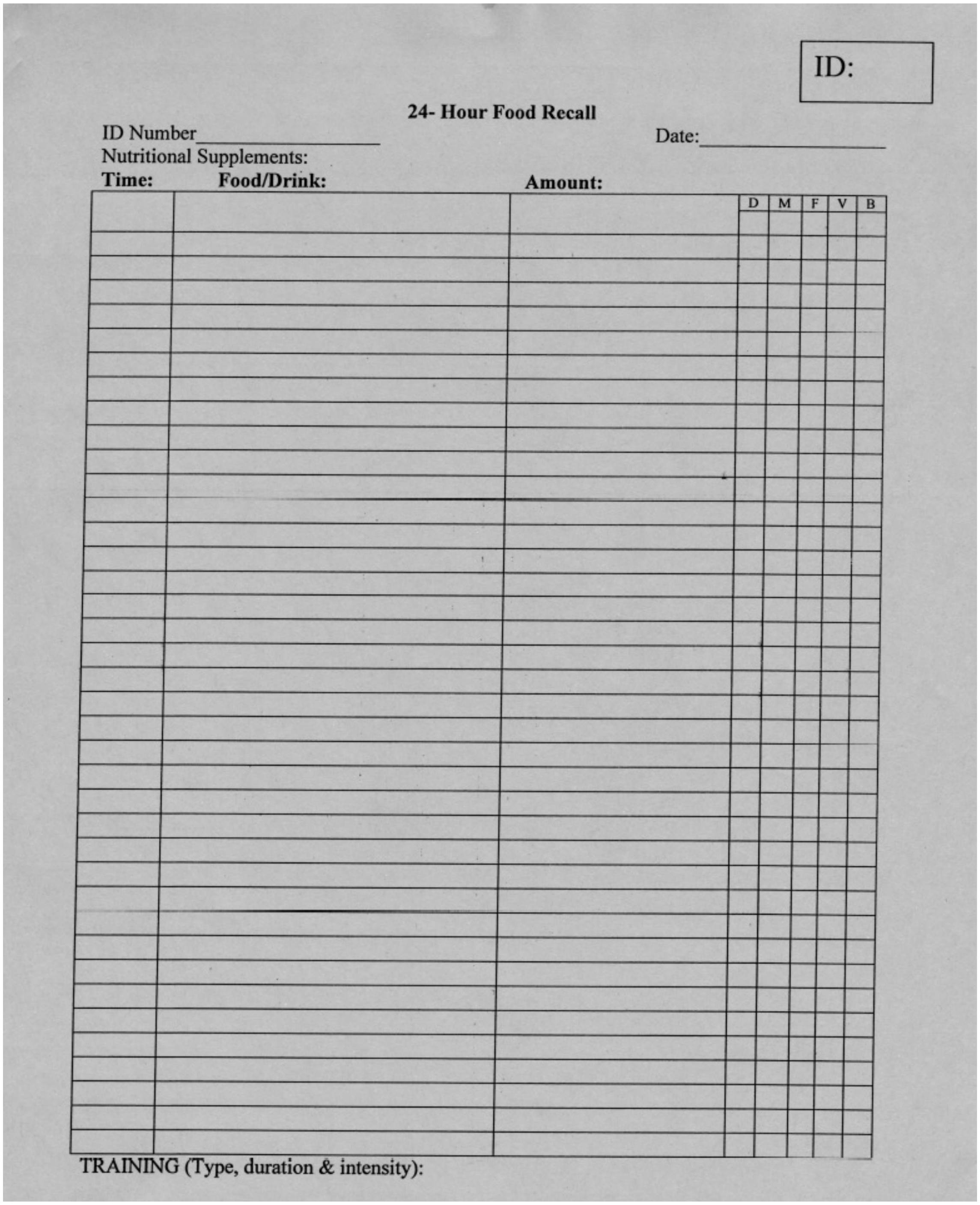
Time of the day	Description of Foods & Beverages	Serving Size	Additional Info

Workout information

How long was your training session today? ____Minutes

Intensity (low, moderate, high) ____________________

Appendix B



ID:

24- Hour Food Recall

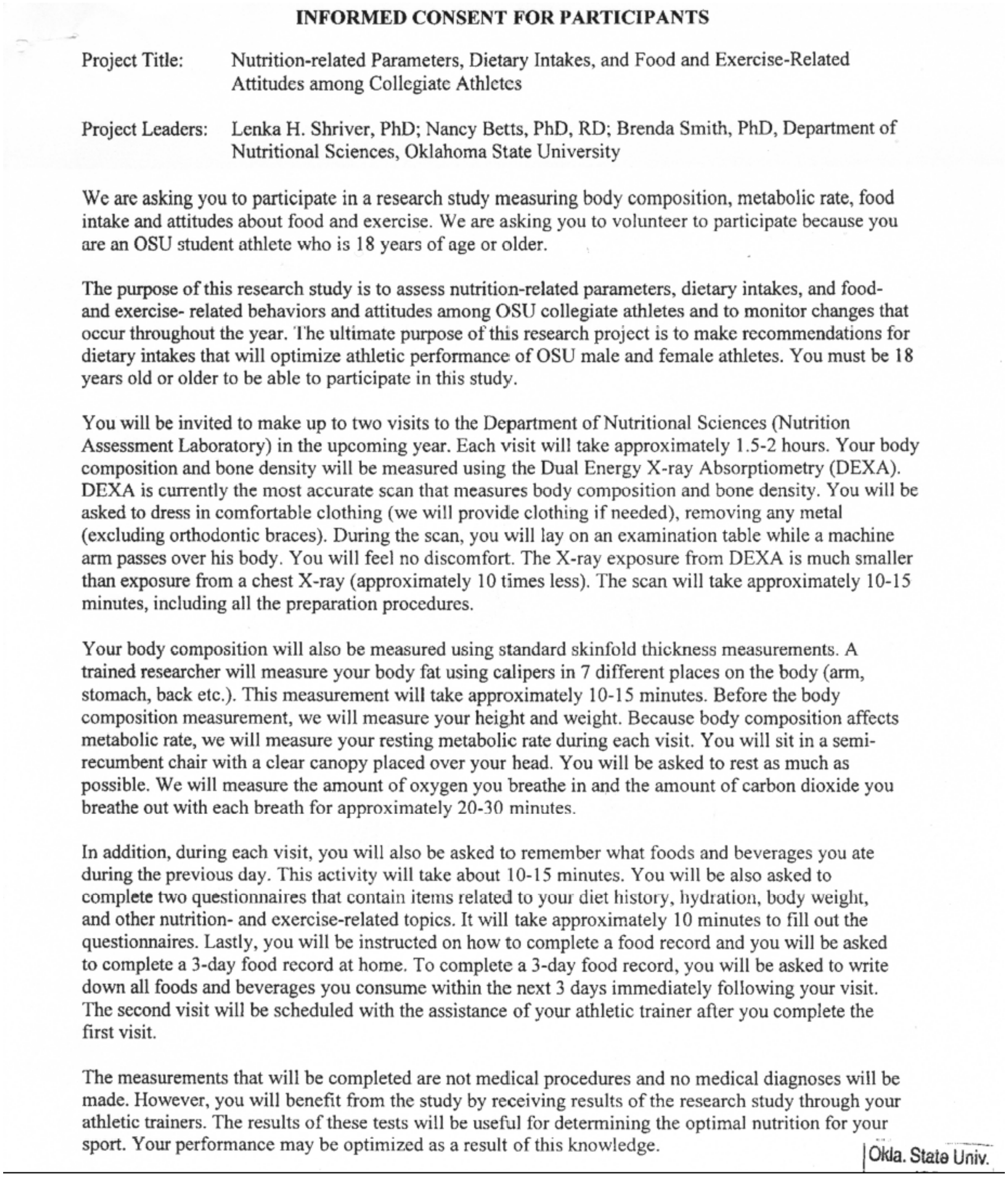
ID Number__________________ Date:__________________

Nutritional Supplements:

Time:	**Food/Drink:**	**Amount:**	D	M	F	V	B

TRAINING (Type, duration & intensity):

Appendix C



INFORMED CONSENT FOR PARTICIPANTS

Project Title:	Nutrition-related Parameters, Dietary Intakes, and Food and Exercise-Related Attitudes among Collegiate Athletes
Project Leaders:	Lenka H. Shriver, PhD; Nancy Betts, PhD, RD; Brenda Smith, PhD, Department of Nutritional Sciences, Oklahoma State University

We are asking you to participate in a research study measuring body composition, metabolic rate, food intake and attitudes about food and exercise. We are asking you to volunteer to participate because you are an OSU student athlete who is 18 years of age or older.

The purpose of this research study is to assess nutrition-related parameters, dietary intakes, and food- and exercise- related behaviors and attitudes among OSU collegiate athletes and to monitor changes that occur throughout the year. The ultimate purpose of this research project is to make recommendations for dietary intakes that will optimize athletic performance of OSU male and female athletes. You must be 18 years old or older to be able to participate in this study.

You will be invited to make up to two visits to the Department of Nutritional Sciences (Nutrition Assessment Laboratory) in the upcoming year. Each visit will take approximately 1.5-2 hours. Your body composition and bone density will be measured using the Dual Energy X-ray Absorptiometry (DEXA). DEXA is currently the most accurate scan that measures body composition and bone density. You will be asked to dress in comfortable clothing (we will provide clothing if needed), removing any metal (excluding orthodontic braces). During the scan, you will lay on an examination table while a machine arm passes over his body. You will feel no discomfort. The X-ray exposure from DEXA is much smaller than exposure from a chest X-ray (approximately 10 times less). The scan will take approximately 10-15 minutes, including all the preparation procedures.

Your body composition will also be measured using standard skinfold thickness measurements. A trained researcher will measure your body fat using calipers in 7 different places on the body (arm, stomach, back etc.). This measurement will take approximately 10-15 minutes. Before the body composition measurement, we will measure your height and weight. Because body composition affects metabolic rate, we will measure your resting metabolic rate during each visit. You will sit in a semi-recumbent chair with a clear canopy placed over your head. You will be asked to rest as much as possible. We will measure the amount of oxygen you breathe in and the amount of carbon dioxide you breathe out with each breath for approximately 20-30 minutes.

In addition, during each visit, you will also be asked to remember what foods and beverages you ate during the previous day. This activity will take about 10-15 minutes. You will be also asked to complete two questionnaires that contain items related to your diet history, hydration, body weight, and other nutrition- and exercise-related topics. It will take approximately 10 minutes to fill out the questionnaires. Lastly, you will be instructed on how to complete a food record and you will be asked to complete a 3-day food record at home. To complete a 3-day food record, you will be asked to write down all foods and beverages you consume within the next 3 days immediately following your visit. The second visit will be scheduled with the assistance of your athletic trainer after you complete the first visit.

The measurements that will be completed are not medical procedures and no medical diagnoses will be made. However, you will benefit from the study by receiving results of the research study through your athletic trainers. The results of these tests will be useful for determining the optimal nutrition for your sport. Your performance may be optimized as a result of this knowledge.

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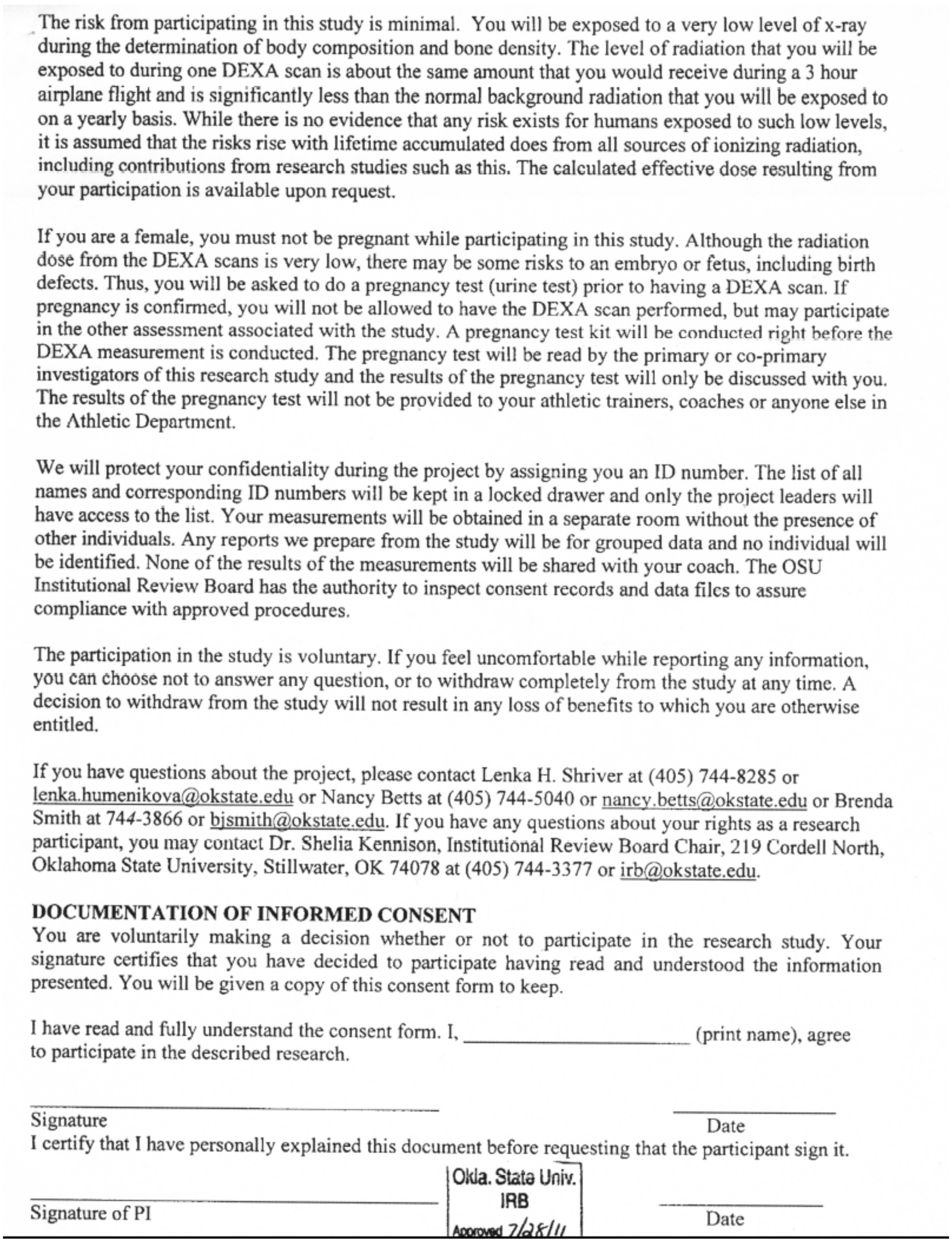


The risk from participating in this study is minimal. You will be exposed to a very low level of x-ray during the determination of body composition and bone density. The level of radiation that you will be exposed to during one DEXA scan is about the same amount that you would receive during a 3 hour airplane flight and is significantly less than the normal background radiation that you will be exposed to on a yearly basis. While there is no evidence that any risk exists for humans exposed to such low levels, it is assumed that the risks rise with lifetime accumulated does from all sources of ionizing radiation, including contributions from research studies such as this. The calculated effective dose resulting from your participation is available upon request.

If you are a female, you must not be pregnant while participating in this study. Although the radiation dose from the DEXA scans is very low, there may be some risks to an embryo or fetus, including birth defects. Thus, you will be asked to do a pregnancy test (urine test) prior to having a DEXA scan. If pregnancy is confirmed, you will not be allowed to have the DEXA scan performed, but may participate in the other assessment associated with the study. A pregnancy test kit will be conducted right before the DEXA measurement is conducted. The pregnancy test will be read by the primary or co-primary investigators of this research study and the results of the pregnancy test will only be discussed with you. The results of the pregnancy test will not be provided to your athletic trainers, coaches or anyone else in the Athletic Department.

We will protect your confidentiality during the project by assigning you an ID number. The list of all names and corresponding ID numbers will be kept in a locked drawer and only the project leaders will have access to the list. Your measurements will be obtained in a separate room without the presence of other individuals. Any reports we prepare from the study will be for grouped data and no individual will be identified. None of the results of the measurements will be shared with your coach. The OSU Institutional Review Board has the authority to inspect consent records and data files to assure compliance with approved procedures.

The participation in the study is voluntary. If you feel uncomfortable while reporting any information, you can choose not to answer any question, or to withdraw completely from the study at any time. A decision to withdraw from the study will not result in any loss of benefits to which you are otherwise entitled.

If you have questions about the project, please contact Lenka H. Shriver at (405) 744-8285 or lenka.humenikova@okstate.edu or Nancy Betts at (405) 744-5040 or nancy.betts@okstate.edu or Brenda Smith at 744-3866 or bjsmith@okstate.edu. If you have any questions about your rights as a research participant, you may contact Dr. Shelia Kennison, Institutional Review Board Chair, 219 Cordell North, Oklahoma State University, Stillwater, OK 74078 at (405) 744-3377 or irb@okstate.edu.

DOCUMENTATION OF INFORMED CONSENT

You are voluntarily making a decision whether or not to participate in the research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

I have read and fully understand the consent form. I, ______________________ (print name), agree to participate in the described research.

____ ________________

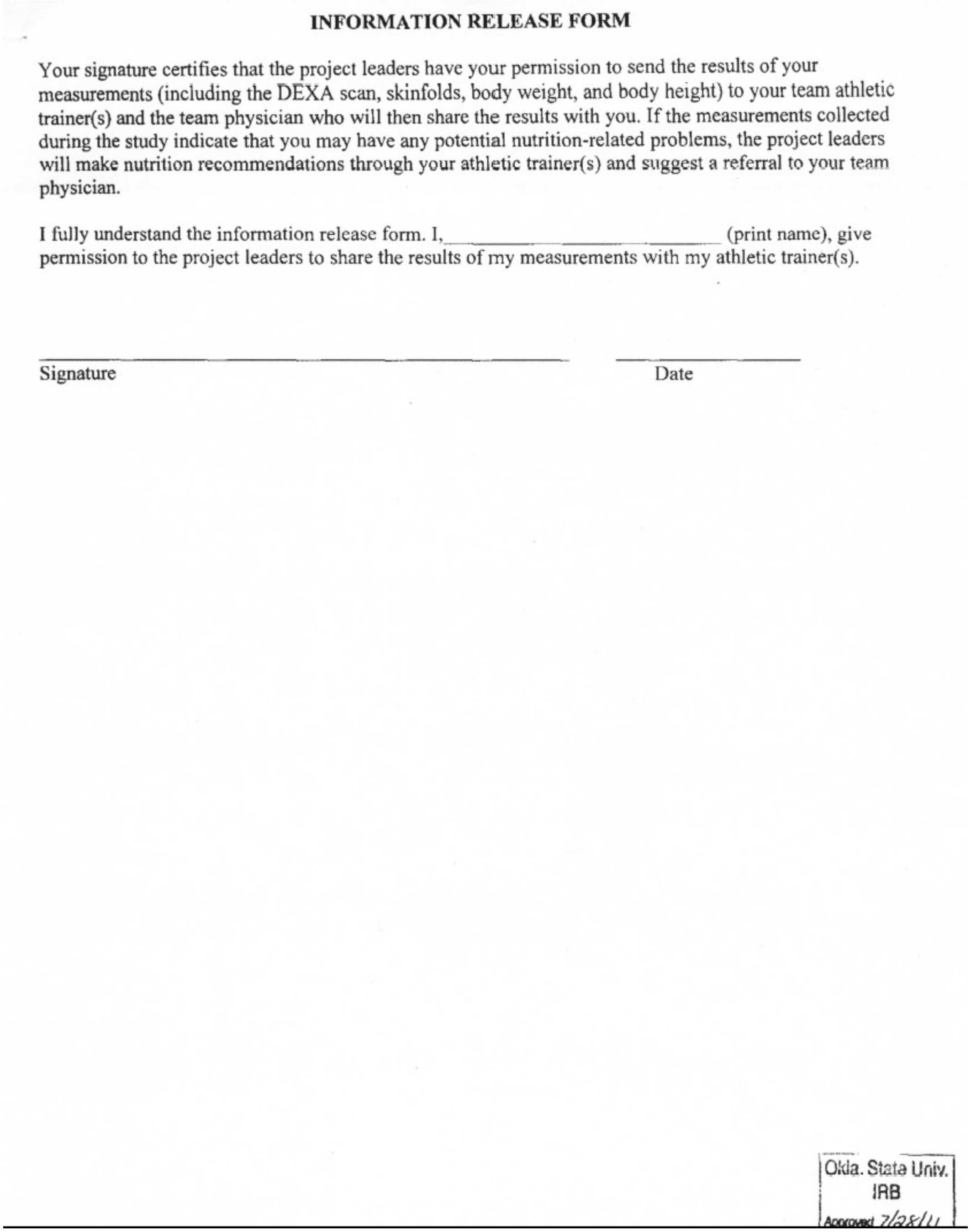
Signature Date

I certify that I have personally explained this document before requesting that the participant sign it.

Okla. State Univ.
IRB
Approved 7/28/11

____ ________________

Signature of PI Date



INFORMATION RELEASE FORM

Your signature certifies that the project leaders have your permission to send the results of your measurements (including the DEXA scan, skinfolds, body weight, and body height) to your team athletic trainer(s) and the team physician who will then share the results with you. If the measurements collected during the study indicate that you may have any potential nutrition-related problems, the project leaders will make nutrition recommendations through your athletic trainer(s) and suggest a referral to your team physician.

I fully understand the information release form. I,____________________________ (print name), give permission to the project leaders to share the results of my measurements with my athletic trainer(s).

____ __________________

Signature Date

Okla. State Univ.
IRB
Approved 7/28/11

VITA

Jonathan Yuhas

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF OFF-SEASON TRAINING ON BODY COMPOSITION AND PERFORMANCE MEASURES IN FEMALE COLLEGIATE SOCCER PLAYERS

Major Field: Nutritional Sciences

Biographical:

Education:
Graduated from Richland Senior High School, Johnstown, PA. Received Bachelor of Science in Nutrition/Dietetics at Indiana University of Pennsylvania, Indiana, PA in December 2010. Completed the requirements for the Master of Science in Nutritional Sciences at Oklahoma State University, Stillwater, Oklahoma in May 2013.

Experience:
Work experience includes employment in a room-service style, hospital dietary department; food-service experience in several areas; research on the community nutrition environment in Oklahoma; and research on the general collegiate student population and collegiate athletes.

Professional Memberships:
Academy of Nutrition and Dietetics (AND) Member
Oklahoma Academy of Nutrition and Dietetics (OkAND) Member

Name: Jonathan Yuhas Date of Degree: May, 2013

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECTS OF OFF-SEASON TRAINING ON BODY COMPOSITION AND PERFORMANCE MEASURES IN FEMALE COLLEGIATE SOCCER PLAYERS

Pages in Study: 57 Candidate for the Degree of Master of Science

Major Field: Nutritional Sciences

Scope and Method of Study: Research on the effects of training in female collegiate soccer players is currently limited. The purpose of this study was to determine the effects of a typical 12-week off-season resistance training and conditioning program on body composition and selected performance measures in female collegiate soccer players. Twenty one members of a Division I women's soccer team completed body composition testing (DEXA), power and endurance performance testing (VO_{2max}, Wingate testing, vertical jump), and 3-day food records.

Findings and Conclusions: Average baseline body mass was 63.3 ± 6.4 kg. Fat mass and body fat percentage significantly decreased and lean body mass significantly increased from baseline to post-test. Performance measures of VO_{2max}, mean wattage (Wingate testing), anaerobic capacity, and fatigue index significantly improved from baseline. Change in fat mass was shown to have a significant correlation to the changes in VO_{2max}, fatigue index, and peak watts. Aside from percentage energy consumed from protein, no significant changes in energy or macronutrient intake were found. The players consumed energy levels below the minimal recommended energy levels (min. 30 kcal/kg) and carbohydrate levels (min. 5 g/kg). This research study suggests an association of body composition changes to changes in physical performance measures following off-season training in this population.

ADVISER'S APPROVAL: Dr. Lenka Shriver