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NUTRITION ASSESSMENT AND INTERVENTION IMPROVES BODY COMPOSITION
AND DIET IN NCAA FEMALE VOLLEYBALL PLAYERS

A Thesis

presented in partial fulfillment of requirements

for the degree of Master of Science

in the Department of Nutrition and Hospitality Management

The University of Mississippi

by

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ABSTRACT

Intercollegiate volleyball is a powerful sport that consists of two to three hour matches; therefore, optimal physical condition is critical for top performance. This study assessed nutrition and anthropometric parameters at the start and conclusion of both the spring 2009 (no intervention) and spring 2010 (intervention) off-seasons as well as additional measurements four months after the intervention. The subject's body composition, total energy, carbohydrate and protein needs were calculated and intakes were assessed. The intervention consisted of monthly individual nutrition counseling sessions based on analysis of intake from three-day food records. Food records were analyzed using Nutrient Data System for Research software verified by interview. Dependent T-tests were conducted on anthropometric and dietary measurements. The results revealed that during the 2009 off-season, there were no significant changes in any parameters and 89% of subjects were not within recommended anthropometric and dietary guidelines. During 2010, body composition significantly decreased to optimal levels for the sport. In addition, energy and macronutrient intake significantly improved toward recommended guidelines. Four months later, the subjects' intakes and body composition were assessed again and results were compared to the spring 2010 results with no significant changes. These results indicate that providing nutrition assessment and intervention plays a critical role in physical conditioning of athletes.

LIST OF ABBREVIATIONS AND SYMBOLS

kcal/kg	Kilocalorie per kilogram
NCAA	National Collegiate Athletic Association
IRB	Institutional Review Board
NDSR	Nutrition Data Systems for Research
RMR	Resting Metabolic Rate
kcal	Kilocalorie
kg	Kilogram
TEE	Total Energy Expenditure
g/kg	Grams/kilogram
DRI	Daily Recommended Intake

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Volleyball played at the intercollegiate level is a powerful, high impact sport that consists of two to three hour matches. Two matches are often played within a 48 hour time period. As a result, optimal nutrition is critical for top performance (1, 2). This investigation assessed nutrition and anthropometric parameters of intercollegiate female volleyball players during three time periods. The first two were conducted in academic spring semesters 2009 and 2010 during the months of January through April. The final assessment was conducted in August 2010 prior to the beginning of the competitive season. Proper nutrition and athletic performance are strongly linked with performance at the highest level. It is essential that athletes have knowledge of the nutritional guidelines appropriate for their activity level.

It is documented in scientific literature that there are positive correlations between nutritional status and athletic performance and it is widely accepted that optimal nutrition is the best way to enhance athletic performance and recovery from exhaustive exercise (1, 2). In a joint paper by the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine (2004), support was given to the body of research concluding that: 1) Post workout, athletes need to replenish their glycogen stores and consume adequate protein to promote the repair and building of new tissue, 2) Fat intake in athletic populations should be a minimum of 20-25% of total energy needs in order to consume adequate amounts of essential fatty acids and fat-soluble vitamins, and 3) An athlete's body weight and composition does affect their performance (1).

Sport nutrition guidelines vary drastically depending on the sport and the level of participation. The estimated energy needs for the population considered in this investigation fall

somewhere between the range of 37-45 kilocalories per kilogram (kcal/kg) of bodyweight (4, 1, 19). Carbohydrates should contribute 7-10 grams per kilogram of bodyweight, protein 1.2-1.4 grams per kilogram of bodyweight, and dietary fat intake should be included to make up the remainder of calories with a minimum intake of 20-25% of total calories (2, 4).

Meeting these needs can be challenging for collegiate athletes. Factors to consider include time to prepare food, time to ingest the proper food, lack of knowledge of what foods are best to select, and preconceived ideas that not eating after a workout or training session will help with weight management (4, 6, 11). For athletes to meet their nutritional needs, they do not necessarily need to supplement with expensive recovery shakes and/or bars. Athletes can consume the recommended values of calories, carbohydrates and protein from food; however, need the knowledge and support to do so. Colleges can provide their athletes access to education and food by providing a place where they are able to get meals commonly referred to as a training table. However, athletes also need the education to be able to make wise choices when they do not have access to a training table.

As previously mentioned, there is a positive correlation between nutrition and athletic performance (1). The majority of research, however, includes different types of athletes but does not address the specific needs of each sport. There is a lack of information in the literature specific to female sports. When available, the female sports most commonly investigated are: lacrosse, basketball, field hockey and track and field. The science of sports nutrition has developed somewhat of a specialization for female athletes because of the growing questions concerning gender-specific needs for optimal nutrition (6).

There are numerous studies that include female athletes as subjects; however, most of these studies are nutrient dietary surveys investigating intake of various vitamins and minerals (4, 8, 9, 11, 13, 14, 16, 18). Two of these studies suggest that female athletes are less likely to increase their energy consumption during increased times of need, such as the off season, because of increased volume of exercise. The authors concluded that extra calories are needed for optimal performance and when these female athletes do not consume enough energy their performance declines (11, 17). A recent investigation examined the outcome of feedback on dietary intakes and body composition of collegiate volleyball players during their competitive season (3). This study determined that the athletes made initial improvements in their diets but failed to maintain those changes as demands of competition and volume of travel increased. A few studies have also investigated the macronutrient intake in female athletes. The results consistently suggest that female athletes have a habitual pattern of low carbohydrate intake which results in the athlete's body being unable to resynthesize glycogen to optimal levels (4, 13, 17). The resynthesis of glycogen is important for replacing and replenishing glycogen lost during exercise. The study conducted by Clark, et al. identified that frequent consumption of foods higher in protein and fat displaced more carbohydrate-rich and nutrient dense foods within the female athletes' energy requirements and satiety limits (4).

Given the documented importance of adequate nutritional intake and the challenges faced to meet needs, the purpose of this investigation was to determine if female volleyball athletes meet their nutritional needs, and if not does nutrition education improve the likelihood that they might.

Methodology

Subjects

The researcher attended a team meeting and recruited members of a NCAA Division I women's volleyball team at a university in the southern United States. Eleven agreed to participate in this investigation which was conducted over two academic spring semesters, 2009 and 2010. All subjects were informed of the risks and benefits of participating in this study and signed an informed consent form approved by the Institutional Review Board for Research with Human Subjects (IRB). Once informed consent was obtained, subjects were instructed on how to keep a food record and were scheduled for anthropometric assessment.

Experimental Protocol

Dietary Collection

Subjects in this research project did not have access to a training table, therefore were responsible for all aspects of their nutritional intake. To assess total nutritional intake, subjects kept food records for three day days (two weekdays and one weekend) which were verified by interview (10). All diet records were analyzed using the computerized nutrient analysis program, Nutrition Data Systems for Research (NDSR; Minneapolis, MN, version 2009) for total calorie, carbohydrate, and protein intake. The subjects repeated this process one time per month, during the months of January through April. The results from the NDSR were compared to the results of estimated energy needs using the Nelson equation to determine resting metabolic rate (RMR) (12).

$$\text{RMR (kcal/day)} = 25.80 \times \text{Fat-free mass (kg)} + 4.04 \times \text{Fat mass (kg)}$$

To determine total energy expenditure (TEE), an activity factor of 2.07 was multiplied to RMR. This activity factor corresponds to that of a very active female population. Calories consumed were compared to estimated TEE, carbohydrate and protein consumption were compared to estimated needs of 7g/kg and 1.4 g/kg respectively.

The investigation during the off-season of 2010 also included a nutrition intervention one week post analysis of current intake. The intervention was designed to educate the subjects on selecting foods and beverages to meet their nutritional needs. The August 2010 dietary collection consisted of a three day food record that was analyzed using the same techniques as before. All dietary assessments and intervention sessions were conducted by the same researcher.

Anthropometrics

Each subject's height, weight, and body composition (percent fat mass and percent fat free mass) were measured at the beginning and end of the 2009 (non-intervention) and 2010 (intervention). Height was recorded to the nearest 0.25 centimeter (cm), weight to the nearest 0.5 kilogram (kg), and body composition to the nearest 0.1 percent. Body composition was assessed using air displacement plethysmography using the BOD POD Body Composition System (Life Measurement, Inc., Concord, CA, USA) following the manufacturer's recommended procedures. Each of these anthropometric measurements was obtained five times, at the beginning and the

end of the non-intervention and intervention and again in August 2010. All measurements were conducted by the same researcher.

Statistical Analysis

Paired t-tests were used for comparison of energy intake and energy needs; carbohydrate intake and carbohydrate needs; protein intake and protein needs; pre and post body weight, body composition between the non-intervention and intervention results using SPSS version 17.0 (SPSS, Inc., Chicago, IL). Statistical significance was set at $p \leq 0.05$.

Results

Subject Physical Characteristics

The study started with thirteen subjects and ended with eleven due to two of the subject's separation from the volleyball team. The mean age of the subjects was 19.8 with a range of 19 - 21. In the non-intervention, mean body fat percent was 25.2% with a range of 15.1 - 38.8% and 76% of the subjects having $\geq 25\%$ body fat. At the beginning of the intervention, subjects' mean body composition was 24.5%, with a range of 16.6 - 37.6%. At the end of the intervention, mean body composition was 22.7%, with a range of 16.3%-35.1%, representing a statistically significant decrease ($p=0.01$). In August, mean body composition was 23.4% with a range of 15.5%-36.7% which does not differ significantly from the measurement taken at the end of the intervention off season. (Table 1).

Energy

In the non-intervention investigation, the subjects did not meet their energy needs. During the intervention period, baseline energy intake was 56%, with estimated needs in a range of 25%-88%. At the conclusion of the intervention, the mean energy intake was 70% of estimated needs, with a range of 44%-95%, representing a significant improvement (Figure 1). During August 2010, the mean energy intake was 80% of estimate needs, with a range of 48-98%.

Macronutrients

In the non-intervention period, the subjects did not meet their carbohydrate or protein needs. At the beginning of the intervention period, the subjects' average carbohydrate intake was 3.1 grams per kilogram (g/kg) with a range of 1.6-5.0 g/kg (Figure 2). The subject's average protein intake was 1 g/kg of bodyweight, with a range of 0.2-1.5 g/kg (Figure 3). At the end of the intervention, the team's mean carbohydrate intake was 4.1 g/kg with a range of 2.0-6.2 g/kg. Their mean intake of protein was 1.1 g/kg with a range of 0.6-1.6 g/kg. In August, the mean carbohydrate intake was 4.0 g/kg with a range of 2.4-5.4 g/kg. The team's average protein intake was 1.4 g/kg with a range of 0.6-2.6g/kg/

Discussion

The primary finding of this investigation was during the non-intervention period, nutrition intakes were found to be inadequate in calories, carbohydrates and protein which is consistent with other findings (3, 4, 7). Additionally the subjects' body composition did not change significantly. To further examine, a unique characteristic of this investigation was the inclusion of a nutrition intervention during the off season. The baseline measurement of the intervention

period revealed that there was not a significant difference in body composition and nutritional intakes compared to the non-intervention period. However significant improvements were seen at the end of the intervention period in body composition and nutritional intakes. These improvements indicate that providing individual nutrition education to this population improved their body composition and nutritional intake.

Additionally, once the monthly interventions ended and the subjects were reassessed, prior to the start of the competitive season, there were no significant differences in body composition or nutritional intake between the end of the intervention period and the start of the competitive period. This indicates that the information presented to the subjects during the intervention provided planning and decision-making strategies that were implemented and maintained. Although a significant improvement was seen in the nutritional intakes of these athletes, their intakes are still remain inadequate compared to the current standards for this population.

Meeting nutritional needs for many elite, intensely training athletes presents challenges that need to be addressed. For example, consuming foods at a regular interval (every two to three hours) presents a challenge to collegiate athletes considering that they have the added responsibility of class and class work, managing a budget, access to a cafeteria, travel requirements, and a varying appetite. All of these factors decrease the likelihood that they will achieve adequate intakes and must be considered when educating them (3, 4, 6, 11). Many of these aforementioned challenges were stated by the subjects to the researcher during the

intervention sessions of this investigation. In response, these concerns were commonly part of the discussion.

The first NDSR conducted January 2010 revealed that an unexpected 88.9% of the subjects did not meet their total energy needs and many of these were at 50% of their estimated TEE, which is consistent with other findings (4). Not only were subjects' caloric intakes deficient, but their carbohydrate and protein intakes were also deficient with none of the subjects meeting their carbohydrate needs and only two of eleven subjects meeting protein needs. After a short intervention, significant improvements were seen in all three areas.

Athletes who do not have sufficient energy intakes have reduced skeletal muscle protein synthesis (15). Acute energy deprivation affects skeletal muscle protein synthesis and associated intracellular signaling proteins in physically active adults and also impaired glycogen resynthesis along with impaired performance (5). These two factors have an influence on muscular strength, endurance, and ultimately performance.

The findings in this and other investigations suggest that athletes are not consuming adequate nutrients and require education on fueling their bodies to achieve optimal performance. Providing this education must be individualized and address all factors related to meal planning. This investigation is the first to highlight the importance of providing athletes the information and knowledge about nutrition they need to be competitive. After meeting with the investigator in this study only three times on ways to improve their diet, the subjects' intakes significantly increased closer to the goals of the DRIs for an active population. The authors of this investigation suggest that nutritional intervention and education are imperative in an athletic

population to improve performance. Dietary instruction and interventions by a Registered Dietitian with knowledge in the area of sport nutrition should be incorporated to enhance outcomes.

Summary and Application

The intent of the current study was to determine if female volleyball players were consuming adequate energy and macronutrients to meet their estimated needs and if they did not, would providing individualized education and encouragement improve their nutritional intakes and body composition. The finding in this investigation showed a trend towards improvements in dietary intakes and body composition with nutrition intervention as well as maintenance of the changes made when the intervention with ceased. Many of the discussions during the individual intervention sessions focused on practical ways to consume regular meals and snacks, basic meal planning and food preparation, general nutrition information and food purchasing. Much of the sports nutrition information that is available to athletes does not meet individual needs as the information focuses on specific nutrients, supplements and dietary regimens rather than practical information that many collegiate athletes do not know and thus need guidance and encouragement. This is especially important for those schools that do not offer a training table to their athletes.

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