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RESEARCH ARTICLE

Position Specific Changes in Body Composition, Hydration Status and Metabolism During Preseason Training Camp and Nutritional Habits of Division III Football Players

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Abstract:

Background:

To what extent pre-season training camp may impact body composition and metabolism in collegiate football players is unknown.

Objective:

The purpose of this study was to assess changes in body composition, dietary habits and metabolism following pre-season training in Division III American football players.

Methods:

Seventeen Division III football players (Ht: 1.80±0.6 m; BM: 99.1±60.1 kg; FFM: 79.7±8.6 kg; BF%: 19.3±8.6%) had their body composition and resting energy expenditure (REE) assessed in a fasted state (>12 hr.) before and upon completion of pre-season training. Pre-season training consisted of 14 days of intense training.

Results:

Linemen had a higher body mass, fat-free mass (FFM), and fat mass likely contributing to the higher REE ($p < 0.01$). A main effect for time was observed regarding changes in FFM ($p<0.001$) and body fat % ($p = 0.024$). A significant interaction was observed for FFM with linemen experiencing a greater reduction in FFM (-1.73±0.37 *vs.* -0.43±0.74 kg; $p<0.001$). Linemen (L) experienced a greater reduction in REE compared to non-linemen (NL) (L: -223.0±308.4 *vs.* NL: 3.27±200.1 kcals; $p=0.085$) albeit not statistically significant. Non-linemen consumed a higher amount of daily calories ($p=0.036$), carbohydrates ($p=0.046$), and protein ($p=0.024$) when expressed relative to body mass.

Conclusion:

The greater size in linemen prior to pre-season likely contributed to their higher REE. However, the multiple training bouts appeared to reduce REE in linemen, which may have been driven by the observed losses in FFM and low protein intake. Further, pre-season training increased body fat % in all players.

Keywords: Energy intake, Training adaptations, Football, Body fat.

INTRODUCTION

American football is a team sport that consists of intermittent bouts of high-intensity, high impact exercise with

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brief periods of recovery [1]. A preseason training camp is designed to maximize the training adaptations, which were developed during the off-season training program such as power, strength, speed, and body composition. Therefore, preseason training camps, which typically last for 2-4 weeks, consist of high volume periods of intense activity in order to elicit the desired training adaptations and prepare athletes for the upcoming season. By identifying changes in certain physiological attributes following periods of intense training a better understanding of the risks and benefits of the preseason program can be established.

In addition, it has been reported that dietary practices have a profound impact on the health and performance of an athlete because athletes require more advanced nutritional programs [2, 3]. The increased physical demands of preseason training specifically, likely results in a higher daily energy expenditure, which results in a greater total energy and macronutrient requirement in order to sustain the level of training, body mass, recovery from exercise and ultimately enhance performance [2]. The potential decrements in body mass and exercise performance resulting from periods of intense physical training may be attributed to a lack of proper nutritional practices [2]. In general many collegiate athletes tend to have a significant lack of basic nutritional knowledge and understanding of how nutrition can be used to improve their performance [4 - 8]. Several studies have assessed the nutrient intake of collegiate athletes and reported energy and micronutrient intake levels below or similar to the recommended daily allowance (RDA) values with some even below the estimated energy expenditures [4, 9 - 11]. It should be noted that athletes have higher energy requirements than those recommended by RDA values and, therefore, nutrient intakes of athletes should exceed RDA values. Failure to maintain energy balance throughout training can lead to negative changes in body composition and performance following intense training. However, it is difficult to identify if said changes would be due to increased physical demands of training or an imbalance between calorie intake and expenditure. It can be assumed that a negative energy balance in conjunction with a period of intense training would likely lead to decreases in body mass, specifically lean body mass, which could subsequently lead to decreases in strength and power [12 - 14]. In addition, larger players such as football linemen may struggle to consume an adequate energy and nutrient content to match their total energy expenditure due to the increased body size and subsequent energy needs. Further, their increased body size may make them more susceptible to water loss and dehydration resulting from greater sweat rates [15].

A common concern for American football players during preseason training camp is also the risk of heat related illnesses resulting from warmer ambient temperatures and subsequent heat indexes confounded with the added equipment. Previous research has indicated that collegiate football players experience substantial weight loss and reductions in hydration status throughout preseason training camp [16]. There have been reports of deaths in collegiate and high school football players resulting from heat related illnesses [17]. Through an increased awareness and understanding of current dietary and hydration habits of football players, practitioners can prepare their athletes by implementing nutritional interventions and feasible nutritional strategies which address the intense physical stress of the sport.

There is limited research available in regard to position-specific changes in body composition and metabolism during a preseason training camp in collegiate football players. Furthermore, it is not understood how nutritional habits may influence these changes and whether or not position-specific differences have an effect. Therefore, the purpose of this study was to determine the effect of an intense period of preseason training on body composition, hydration status, and metabolism in Division III NCAA American football players. A secondary aim was to assess the football players' dietary habits for the same time period.

MATERIALS AND METHODS

Experimental Design

This observational study was completed during a 14-day preseason training period for Division III NCAA football players. Prior to the start of the preseason, all participants attended an informational meeting regarding details of their participation, an explanation on how to complete the food logs and provide written consent. Participants then returned to the laboratory before and after preseason training camp to undergo body composition and resting energy expenditure assessment. The preseason training period lasted 14 days which consisted of 18 practices and 4 strength training sessions during that time frame. Prior to the start of each practice, all participants completed a daily weigh-in and provided a urine sample for determination of hydration status via urine specific gravity. Following each practice, participants completed a second weigh-in to assess body water loss for each practice. Participants were asked to maintain their regular dietary habits throughout the course of the preseason in order to accurately assess current nutrition status in relation to sport-specific recommendations put forth by the International Society of Sport Nutrition and American College of Sports Medicine.

Participants

Twenty-four apparently healthy Division III football players who had been previously medically cleared for sport participation were recruited to participate in this study (Table **1**). Players were asked to complete health history and exercise history forms prior to participation in the study. Players were recruited from the football team at the University of Wisconsin – La Crosse. Those who met eligibility criteria were informed of the requirements of the study and sign informed consent forms in compliance with the Human Subjects Guidelines of the University of Wisconsin – La Crosse Institutional Review Board who approved the study. All players were divided into two groups: 1) Linemen (L) and 2) Non-linemen (NL; consisting of running backs, linebackers and defensive backs) to assess position specific changes in training adaptations and nutritional intake.

Testing Sessions

Resting Energy Expenditure and Body Composition

Players were asked to fast at least 8 hours prior to each testing session. Upon arrival to the laboratory, they were assessed for height and weight using a physician's scale (*Health-o-Meter, Hilton Medical Supply, WI, USA*). Next, they completed a resting energy expenditure (REE) analysis using indirect calorimetry and metabolic analysis (*TrueOne 2400 ParvoMedics, Utah, USA*). This was a non-exertional test performed in the fasted state with the player lying supine on an exam table. A clear, hard plastic hood and soft, clear plastic drape was placed over the participant's neck and head in order to determine resting oxygen uptake and energy expenditure as is displayed in (Fig. **1**).

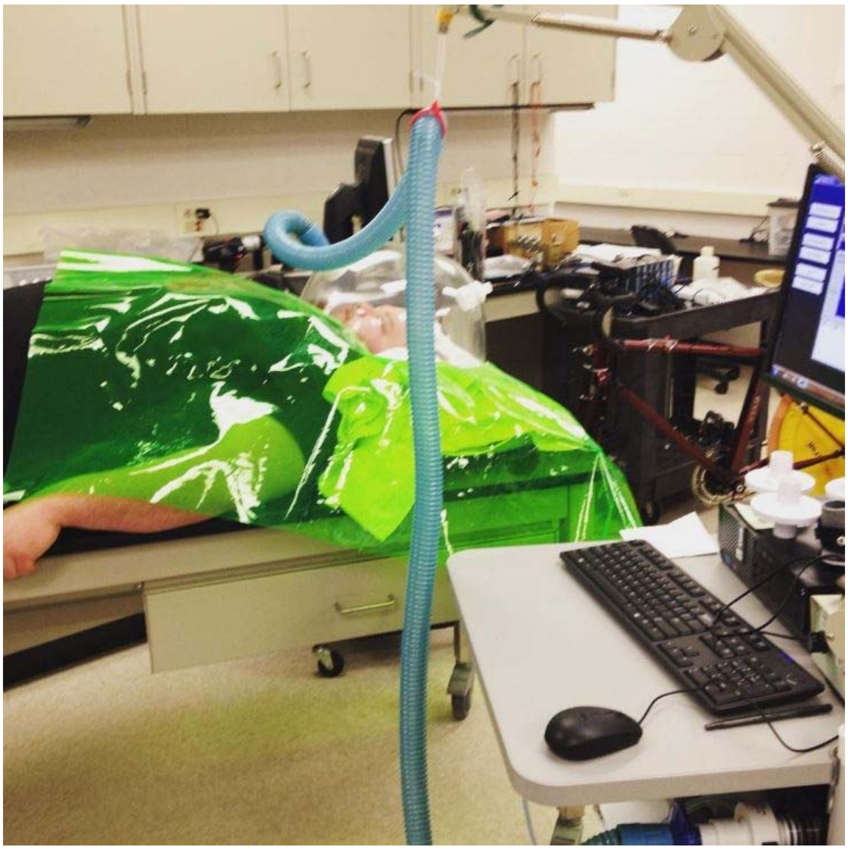

Fig. (1). Representation of resting energy expenditure assessment.

All players remained motionless without falling asleep for approximately 20 minutes. Data were recorded after the first ten minutes of testing during a five minute period of time in which criterion variables (e.g., VO_2 L/min) change less than 5%. Following the REE assessment, participants had their body composition assessed using air displacement plethysmography (*BODPOD, Cosmed, USA*). The assessment of resting energy expenditure via indirect calorimetry using the TrueOne 2400 metabolic cart system has been shown to be a valid and reliable tool with within subject coefficient of variations ranging from 5.4-10.0% in male and female populations [18, 19]. Test to test reliability analysis of this model has yielded a mean intra-class coefficient (ICC) value of 0.942, p <0.001 [19]. Fat and fat-free mass values were determined based upon the body densities obtained from the BODPOD. Prior to each testing session, calibration procedures were completed according to the manufacturer guidelines using an empty chamber and a calibrating cylinder of a standard volume (49.55 L). Participants were instructed to wear spandex or tight-fitting clothing, remove all jewelry, and wear a swim cap. Lung volume was directly assessed for determination of relative body volume based upon thoracic volume. The player's body mass and body volume were then used to estimate body fat composition based upon the Siri equation for males [20]. Previous studies indicate air displacement plethysmography to be an accurate and reliable means to assess changes in body composition [21]. Test to test reliability of performing this body composition assessment in our lab with athletic populations has yielded high reliability for body mass (r=0.999), body fat percent (0.994), and fat-free mass (0.998). Detecting changes in measures of body composition over time have also been validated using air displacement plyethysmography [22].

Dietary Analysis

Dietary intake was assessed throughout training camp using a commercially available food tracking program (MyFitnessPal©, USA). Prior to the study, all players attended an educational meeting during which time a sports nutritionist provided verbal and written instructions for recording food intake. The instructions included visual aids, food models, and serving size tips in order to ensure the accuracy of the nutrient tracking. Daily average values were calculated for total and relative energy, protein, carbohydrate and fat intake. Daily mean values were then divided into days consisting of a single practice versus two practices to determine differences in nutritional habits based upon the number of practices per day.

Daily Urine Specific Gravity and Body Weight Analysis

Prior to each practice, all players provided a urine sample for determination of hydration status. At this time, players also completed a pre-practice weigh-in using a self-calibrating, Tanita BWB-800AS medical digital scale (*Tanita Corp. of America, Arlington Heights, IL*). Players were instructed to remove all equipment and clothing with the exception of compression shorts. Immediately following practice, players completed a post-practice weigh-in for determination of body weight loss during practice. The same instructions were provided for post-practice weigh-in. A digital refractometer Atago (*4410 PAL-10S, Tokyo, Japan*) was used to measure the urine specific gravity (USG) prior to practice. The refractometer was calibrated with distilled water before each sample. The use of a handheld refractometer has been shown to be a reliable tool for the assessment of urine specific gravity with an ICC value of 0.998 [23]. Players were asked to urinate into the toilet, and mid-stream, collect at least 200 mL of urine into a clean cup. A small liquid sample of the urine was applied to the designated measuring area of the digital refractometer and USG was recorded to the nearest 0.010 unit. A USG value of 1.020 was used as criteria for dehydration determination as is common practice in the literature [16].

STATISTICAL ANALYSIS

Descriptive statistics were run on demographic data. A one-way analysis of variance (ANOVA) was used to assess differences between linemen (L) and non-linemen (NL) groups. Changes in body composition and REE were analyzed using a repeated measures ANOVA with position group serving as the between-subjects factor. Delta values were calculated for each variable. Mean energy, protein, carbohydrate and fat intake over the span of the 14-day preseason training period were calculated. Mean differences were calculated for each player's nutritional intake and their ability to follow recommendations put forth for strength and power athletes. Paired sample T-tests were used to compare differences in nutritional values for single versus multiple practices per day. Data were considered statistically significant when the probability of type I error was 0.05 or less.

RESULTS

Seventeen players completed the study (L: n=6; NL: n=11) with seven players being excluded from the analysis due to minor injuries and/or failure to participate in at least 80% of the practices. Table **1** represents baseline demographic data by group. Linemen exhibited significantly greater body mass (BM), fat-free mass (FFM), fat mass (FM), body fat percent (BF %) and resting energy expenditure (REE) values.

Table 1. Baseline demographics.

	Height (cm)		Body Mass (kg)		Fat-free Mass (kg)		Fat Mass (kg)		Body Fat %		Resting Energy Expenditure	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
L	183.7	7.5	119.2	10.4	86.8	7.2	32.3	11.4	26.8	7.7	2,802	188
NL	178.1	4.3	88.1	4.3	75.9	6.8	12.2	6.1	13.4	6.8	2,342	201
Total	180.1	6.1	99.1	6.1	79.7	8.6	19.3	12.7	19.3	8.6	2,505	296
p value	0.068		<0.001		0.007		<0.001		0.001		<0.001	

Significant reductions in FFM ($p<0.001$) were observed in both groups with a significant group x time interaction ($p<0.001$). Specifically, linemen experienced a greater reduction in FFM following preseason training camp compared to non-linemen as is depicted in Table **2**. At the same time, both groups experienced a significant increase in BF% ($p = 0.024$).

Table 2. A comparison of position specific differences in body composition and resting energy expenditure during pre-season camp.

Variable	Pre		Post		Change		p value	
	Mean	SD	Mean	SD	Mean	SD		
Body Mass (kg)								
Linemen	119.17	10.35	118.34	11.19	-0.83	1.86	T	0.15
Non Linemen	88.12	11.08	87.92	11.3	-0.21	0.96	G	<0.001
Total	99.08	18.55	98.66	18.53	-0.43	1.32	GxT	0.374
Fat-Free Mass (kg)								
Linemen	86.82	7.22	85.09	7.45	-1.73	0.37	T	<0.001*
Non Linemen	75.88	6.77	75.45	6.70	-0.43	0.74	G	0.01*
Total	79.74	8.60	78.85	8.2	-0.89	0.89	GxT	<0.001*
Fat Mass (kg)								
Linemen	32.35	11.41	33.25	12.26	0.90	1.74	T	0.099
Non Linemen	12.25	6.1	12.47	6.10	0.22	0.93	G	<0.001*
Total	19.34	12.73	19.80	13.23	0.46	1.26	GxT	0.306
Body Fat %								
Linemen	26.78	7.65	27.68	8.10	0.90	0.96	T	0.024*
Non Linemen	13.41	5.33	13.70	5.06	0.29	0.92	G	0.001*
Total	18.13	8.92	18.64	9.15	0.51	0.95	GxT	0.219
Resting Energy Expenditure (kcal)								
Linemen	2,803	189	2,578	236	-223.0	308.4	T	.093
Non Linemen	2,342	201	2,345	234	3.27	200.1	G	0.002*
Total	2,505	294	2428	255	-76.6	259.0	GxT	0.085

*Signifies $p<0.05$.
Repeated measures ANOVA for body comp and REE values by position group.

A summary of average daily nutritional intakes by position throughout the preseason training period is presented in Table **3**. Non-linemen consumed a higher amount of daily calories ($p=0.036$), carbohydrates ($p=0.046$), and protein ($p=0.024$) when expressed relative to body mass. All 17 players were successful in the completion of reporting dietary intakes on the specified days.

Table 3. Summary of average daily nutritional intakes throughout pre-season training.

Variable	Linemen		Non-Linemen		All Players		p value
	Mean	SD	Mean	SD	Mean	SD	
Daily Calories (kcal)	4027	868	3707	902	3820	877	0.49
Relative Daily Calories (kcal/kg)	33.8	6.6	41.8	6.9	40.0	7.7	0.036*
Daily Carbohydrates (g)	431.3	106.7	435.4	144.3	434.0	128.7	0.952
Daily Carbohydrates (g/ kg)	3.64	0.87	4.87	1.22	4.44	1.24	0.046*
Daily Protein (g)	153.9	34.5	173.5	60.4	166.6	52.39	0.48

(Table 3) contd.....

Variable	Linemen		Non-Linemen		All Players		p value
	Mean	SD	Mean	SD	Mean	SD	
Daily Protein (g/kg)	1.31	0.36	1.95	0.56	1.73	0.58	0.024*
Daily Fat (g)	153.78	48.21	146.48	38.40	149.06	40.75	0.737
Daily Fat (g/kg)	1.28	0.33	1.67	0.45	1.54	0.45	0.083
Calories from Fat (%)	33.99	4.0	36.38	10.1	35.54	8.35	0.588

*Signifies p<0.05.

A summary of nutritional intake for all players on days consisting of single versus multiple practices per day is included in Table **4**. A significantly lower protein intake was reported on days with 2 practices compared to 1 (p=0.019).

Table 4. A comparison of nutritional intakes for 1 *vs.* 2 practices per day.

Variable	1-Practice		2-Practices		p value
	Mean	SD	Mean	SD	
Calories (kcal)	3904	988	3641	907	0.127
Relative Calories (kcal/kg)	39.9	9.1	37.0	7.6	0.117
Daily Carbohydrates (g/ kg)	4.3	1.3	4.2	1.0	0.509
Daily Protein (g/kg)	1.8	0.7	1.6	0.6	0.019*
Daily Fat (g/kg)	1.6	0.5	1.5	0.5	0.264

*Signifies p<0.05.

No significant position x practice interactions were observed for USG (p=0.132) or body weight loss (p=0.093) values. At no point throughout the 14-day preseason training period did the group USG values record above the 1.020 threshold for dehydration criteria. There was a significant difference in body weight loss observed between groups with L tending to lose more than NL (L: -0.98 *vs.* NL: 0.49 kg.; p<0.001).

DISCUSSION

Preseason collegiate football training camp puts an increased amount of stress on the athlete, specifically in terms of energy requirements. Training camp is a common practice used during the preseason period to prepare the athletes for the upcoming season as athletes are returning from various activity levels during the off-season. Further, lower training loads are often utilized during the actual season as the primary focus then becomes preparation for competition therefore higher training volumes and intensities are often implemented during the preseason period. However, a lack of proper nutritional intake could potentially lead to unfavorable changes in body composition and metabolism following a period of intense training. The purpose of this study was to examine the effect of a preseason training period on body composition and to determine differences between position groups. A secondary purpose was to assess the nutritional intakes of the players and to determine if they were appropriate for the current level of training.

From the results of the study we can conclude that there were position-specific differences in body composition between linemen and non-linemen, which has been previously shown [24, 25]. However, to our knowledge this is the first study to observe position-specific differences in REE. This finding is likely attributable to the differences in FFM observed between groups, specifically with linemen having a greater FFM, which has been found to be highly correlated with REE [26]. The values for body mass, fat-free mass, and height in this study are slightly below those previously reported with NCAA Division I football players [24, 27], demonstrating that Division III collegiate football players may be smaller in stature. Following preseason training, both position groups experienced significant reductions in FFM with linemen experiencing a greater loss in FFM. This greater decrease in FFM likely attributed to the greater reduction in REE albeit not statistically significant (L: -223.0 ± 308.4 *vs.* NL: 3.27 ± 200.1 kcal/d; p = 0.085) in the linemen position group.

As was mentioned previously, this is the first study to examine changes in body composition during the preseason training period in collegiate American football players. However, other studies have examined similar body composition changes throughout the entirety of a season and found reductions of 1.2-1.4 kg of FFM in football [27] and rugby players [28] which is greater than the 0.89 kg loss observed in the shorter time period of the current study. It is difficult to identify if these changes were a result of increased physical demands of training or an imbalance between calorie intake and expenditure or both. Several professional organizations have put forth position stands and nutritional recommendations for athletes based upon their respective level of training and performance requirements [2, 3] and the findings from the current study indicate that the football players failed to meet a lot of the recommended nutrient guidelines. For example, recommend values for total energy intake of strength and power athletes are typically in the range of 45-60 kcals per kilogram of body weight per day (kg/d) with potentially higher needs for those engaged in rigorous training multiple days per week as would be the case for football players during preseason training camp [3]. When nutritional intakes of the current study were compared to recommended values for strength athletes participating in intense training (3-4 hrs. per day), multiple days per week, the results demonstrate that the current football players failed to meet the guidelines put forth for total energy. Specifically, the mean energy intake observed in the current study was approximately 40.0 ± 7.7 kcal/kg, which is below the aforementioned recommendation of 45-60 kcals/kg mentioned previously. When total energy intake was assessed for position-specific differences, linemen were less likely to meet the recommendations compared to non-linemen (L: 33.8 ± 6.6 *vs.* NL: 41.8 ± 6.9 kcals/kg/d; p=0.036). The failure to meet adequate energy requirements, likely resulting in a negative energy balance, could have contributed to the observed reduction in FFM. It is worth noting, that despite total energy intakes far below the recommended values, both groups did not experience significant decreases in overall body mass; however, both groups did experience reductions in FFM with a concomitant increase in overall body fat percent. These tendencies for the occurrence of an overall negative body "re-compositioning" such that players decrease FFM and resultantly experience a relative increase in body fat percent has been observed previously in athletes who are in a caloric deficit [29]. For example, Deutz *et al.* [29] reported that within-day energy deficits were found to be associated with higher body fat percentages in both anaerobic and aerobic athletes, and concluded that this relationship may be a result of an adaptive reduction in REE, which was also observed in the current study, particularly with the linemen group. Further, it has also been postulated that body mass may not be a reliable indicator of energy balance in athletes as protein and glycogen stores carry higher amounts of water weight [30, 31]. Therefore, an increase in body mass due to small increases in protein or glycogen may offset weight loss resulting from body fat yielding an overall net gain of zero despite body composition changes and vice versa [30]. Despite the minor reductions in body weight observed during practice, the observed USG values indicate that the players did an adequate job of replenishing fluids as they remained below the 1.020 threshold for each pre-practice assessment. Further, it also suggests that reductions in body mass and FFM were not likely influenced by changes in hydration status.

This is not the first report of football players failing to consume adequate energy. For example, Cole *et al.* [4] also found that collegiate American football players failed to consume adequate amounts of energy to meet the demands of the sport, body size, and level of training. It is interesting to note that on days consisting of multiple practices, the players in the current study consumed a lesser amount of total energy, when expressed relative to body size, when in all actuality they should have consumed more to offset the additional energy expenditure of the second practice. Anecdotal reports from the players suggested that it was logistically challenging to consume more food on those days because of the additional time spent in practice.

In regard to carbohydrate requirements, it is generally recommended that athletes, particularly strength and power athletes consume 5-8 g/kg per day [2, 3] with potentially higher amounts required (8-10 g/kg) when participating in intense multiple training sessions per day and week [32]. The results of the current study demonstrate that players failed to meet the guidelines put forth for carbohydrates as mean carbohydrate intake for all players was 4.44 ± 1.24 g/kg, which is below the 5-8 g/kg recommended. As was the case with total energy intake when carbohydrate intake was assessed for position-specific differences, linemen were less likely to meet the recommendations compared to non-linemen (L: 3.64 ± 0.87 *vs.* NL: 4.87 ± 1.22; p = 0.046) as well.

A protein intake of 1.2 - 1.7 g/kg/d is recommended for strength athletes [2] with needs potentially increasing up to 2.0 g/kg/d when athletes are participating in intense practices multiple times per day and week [3]. The mean protein intake of the players in the current study was 1.73 ± 0.58, which is within the recommend range for strength athletes. Linemen appeared to consume less protein when expressed relative to body mass (L: 1.31 ± 0.36 *vs.* NL: 1.95 ± 0.56; p = 0.024). This finding may have contributed to the greater reduction in FFM observed for the linemen (-1.73 ± 0.37 *vs.* NL: -0.43 ± 0.74; p<0.001). It is worth noting that overall both groups experienced a reduction in FFM and, therefore, a protein intake of 2.0 g/kg/d for players during a rigorous training period may be more appropriate [3]. A fat intake equating to 20-35% of total energy intake is often recommended for athletes [2] and the results of the current study demonstrated that the players met that recommended intake with no differences observed between position groups.

It is worth noting that the self-reported dietary intakes of the players is an inherent limitation of the study as there are risks of inaccurate reporting which could therefore provide a misrepresentation of the data. Further, the use of body density to estimate body composition is another limitation of the study as fluctuations in total body water may subsequently influence body density and composition values despite a lack in actual tissue changes. However, the daily urine specific gravity values suggest that total body water and hydration status was relatively constant throughout the pre-season training period.

CONCLUSION

From the results of the current study we can conclude that football players are likely at risk for experiencing reductions in fat-free mass with concomitant increases in body fat percent during periods of intense training such as a preseason football period. These negative changes in body composition are likely the result of an inadequate energy intake, specifically in regard to carbohydrates and protein as was the case with the current study. However, it is also possible that these resulting changes could be the product of excessive energy expenditures experienced by the players throughout the high frequency and intensity of practices in such a short period of time. It may be assumed that a negative energy balance in conjunction with the period of intense training likely led to the observed decreases in body mass, specifically lean body mass; this is supported by the fact that daily hydration status was maintained suggesting any reductions in body mass were likely attributable to observed reductions in fat-free mass. This in turn could lead to decreases in strength and power as has been previously shown within athletic populations [12 - 14]. Furthermore, it appears as though non-linemen are better able to meet the nutritional recommendations for strength and power athletes. Division III football players may be particularly susceptible to these dietary deficiencies as they do not have access to “training tables” or other nutritional options provided by the University as is often the case at the Division I level. At smaller institutions that do not have resources to hire full-time nutritional staff it may be of interest for coaches to offer an educational seminar on optimal eating strategies for players, particularly during periods of intense training in order to prevent negative changes in body composition and metabolism.

CONFLICT OF INTEREST

The authors confirm that the content of the article has no conflict of interest. Funding for this project was provided by an internal Faculty Research Grant through the University of Wisconsin – La Crosse.

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