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Research article

The Effects of a Sports Nutrition Education Intervention on Nutritional Status, Sport Nutrition Knowledge, Body Composition, and Performance during Off Season Training in NCAA Division I Baseball Players

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Abstract

This study investigated the effects of a sport nutrition education intervention (SNEI) on dietary intake, knowledge, body composition, and performance in NCAA Division I baseball players. Resistance trained NCAA Division I baseball players (82.4 ± 8.2 kg; 1.83 ± 0.06 m; 13.7 ± 5 % body fat) participated in the study during 12 weeks of off-season training. Fifteen players volunteered for SNEI while 15 players matched for position served as controls (C) for body composition and performance. The nutrition intervention group (NI) received a 90 min SNEI encompassing energy intake (Kcal), carbohydrate (CHO), protein (PRO), fat, food sources, and hydration. Sport nutrition knowledge questionnaires were administered to NI pre and post. Nutritional status was determined by three-day dietary logs administered to NI pre and post. Body composition and performance (5-10-5 shuttle test, vertical jump, broad jump, 1 RM squat) were measured pre and post for C and NI. Knowledge increased in NI. Pro and fat, but not CHO intake increased in NI. FM decreased pre to post in NI (11.5 ± 4.8 vs. 10.5 ± 5.4 kg) but not C (11.3 ± 4.7 vs. 11.9 ± 4.5 kg). FFM increased pre to post with no differences between groups. The 5-10-5 shuttle times decreased significantly more in NI (4.58 ± 0.15 vs. 4.43 ± 0.13 sec) compared to C (4.56 ± 0.18 vs. 4.50 ± 0.16 sec). Jump and squat performance increased pre to post with no differences between groups. Our findings indicate that an off season SNEI is effective at improving sport nutrition knowledge and some, but not all, nutrient intakes and performance measures in Division I baseball players.

Key words: periodization, collegiate nutrition, lean body mass.

Introduction

Prior to the late 1980s the practice of resistance training to improve baseball performance was considered taboo for fear players would lose mobility and speed due to increased muscle volume (DeRenne, 2007). On the contrary, a significant relationship exists between increasing body mass indexes and offensive performances in Major League Baseball players following the year 1980 (Crotin et al., 2014). Of more importance to this study population, lean body mass, lower- and upper-body power, and strength are all positively associated with greater bat velocity (a major component of hitting success) in high school and collegiate baseball players (Miyaguchi and Demura, 2012; Reyes et al., 2010). Additionally, lower body strength and body composition are associated with increased sprinting and jumping abilities in collegiate athletes (Macdonald et al., 2013; Platanou and Varamenti, 2011; Wisløff et al., 2004). The use of periodized resistance training to increase strength, lean mass, and power therefore contributes to improved batting, throwing, and base running performance (Derenne et al., 2001; Szymanski et al., 2009).

Increases in force output with resistance training are a result of both neural and hypertrophic adaptations. A direct relationship exists between muscle cross sectional area and force production (Maughan et al., 1983), however the ability to increase lean mass and force production decreases with training age (Andersen and Aagaard, 2010). As such, nutritional interventions may be necessary to further augment resistance training adaptations. In particular, encouraging athletes to eat higher protein diets (Guimarães-Ferreira et al., 2014) (1.8 – 2.2 g/kg) with more frequent protein feedings (Morton et al., 2015) (4 – 5 feedings/day) in combination with an adequate energy intake is most likely to have the greatest contributions towards enhancing resistance training efforts (Holway and Spriet, 2011).

While baseball competitions may be considered a “sedentary-power” sport for all but pitchers and catchers, athletes in the off- and pre-season training phase often have energy needs twice those of resting requirements due to twice-daily training sessions (Soo and Naughton, 2007). Despite increased energy needs and a recognition of increased protein requirements by NCAA Division I male athletes (Fox et al.,2011), Hinton et al. (2004) reported inadequate carbohydrate and protein intakes from a sample of 180 male NCAA Division I athletes that included baseball players. Inadequate energy and protein intake can lead to skeletal muscle atrophy, reduced strength and power performance, and increased risk of injury or illness (Rodriguez et al., 2009). Moreover, although NCAA Division I baseball players believe good nutrition will improve on field success (Pawlak et al., 2009) nutrition knowledge in NCAA Division I athletes is inadequate. Torres-McGehee reported only 9% of participants in a cohort of 185 NCAA Division I athletes scored higher than 75% on questions assessing knowledge of micro- and macronutrients, supplements and performance, weight management, and hydration (Torres-McGehee et al., 2012). Therefore, improving athlete nutritional knowledge may improve nutritional status thus leading to

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leaner body compositions and enhanced performance.

Despite the importance placed on nutrition by collegiate strength and conditioning coaches, a paucity of studies have evaluated the effectiveness of sport nutrition education interventions on nutritional knowledge and dietary status in NCAA Division I athletes. Abood et al. (2004) reported that 8 1-hour nutrition education sessions improved nutritional knowledge and nutritional self-efficacy but not total energy, carbohydrate, or protein intake in NCAA Division I female athletes. Because the content was delivered once a week over the course of 8 weeks, and the post-test took place following the 8th session, the authors suggested that more time may have been required to provide the athletes more time to practice the nutritional strategies and skills acquired during the intervention.

Valliant et al. (2012) investigated the effects of a nutrition education intervention in NCAA Division I female volleyball players during a 16 week offseason. The subjects met with the primary research once monthly for nutrition education. Compared to the control offseason (offseason of the previous year), the nutrition education intervention increased total energy, carbohydrate, and protein intake, but subject intake of total energy and carbohydrate were still less than that required. Fat mass decreased and lean mass increased over the course of the intervention season, however body composition changes were not assessed during the control offseason, so whether these changes were a result of increased training demands or improved nutrition is unknown. Moreover, the relationships between improvements in nutritional status and metrics of strength and power performance have yet to be investigated. Additionally, many NCAA Division I programs do not have the resources or man power to provide one-on-one nutrition education to every athlete. Thus, the results obtained by investigating the effectiveness of brief, group based sport nutrition education interventions (SNEI) on nutritional knowledge and behavior may be of importance to coaches and athletic directors.

The purpose of this study is to investigate the effects of a brief SNEI on nutritional knowledge, nutrition status, body composition, and performance during a 12 week offseason in NCAA Division I baseball players.

Methods

Experimental approach to the problem

The present study was designed to evaluate dietary intake and nutrition knowledge during the fall baseball season, and to determine if a SNEI improves dietary intake, nutrition knowledge, body composition, and physical performance during 12 weeks of offseason training in collegiate baseball players. An independent groups design was used. Nutritional status was defined as energy and macronutrient intake, and was assessed using 3-day food records pre- and post-intervention. Subjects were instructed on how to keep a dietary log and were given information regarding the estimation of portion size without receiving any nutrition education. A sport nutrition specific knowledge questionnaire was administered pre- and post-intervention. Body composition was measured pre- and post-intervention. Measures of physical performance were defined as 5-10-5 shuttle test, vertical jump, broad jump, and 1 RM back squat, and were measured pre- and post-intervention. All subjects took part in the same structured National Strength and Conditioning Association Certified Strength and Conditioning Specialist (NSCA-CSCS) supervised resistance training, conditioning, and off-season baseball practice.

Subjects

Subjects were recruited from a Division I baseball team with approval of the athletic department and head baseball coach. Subjects were required to pass a collegiate athletic physical which screens for gastrointestinal disorders; cardiovascular conditions that may have placed them in serious risk upon exertion; spinal injuries, and limiting musculoskeletal injuries. Subjects that did not pass the athletic physical requirements were excluded from the study. Baseline subject characteristics are displayed in Table 1. All methods and procedures were approved via expedited review by the University Institutional Review Board prior to data collection. Subjects were fully informed of the scope and risks of the study prior to signing an IRB approved informed consent.

Table 1. **Baseline Characteristics. Data are means (±SD).**

	Nutrition Intervention	Control
Age (yrs)	19.3 (1.0)	19.8 (1.4)
College (yrs)	2.2 (.6)	2.3 (.9)
Weight (kg)	81.4 (6.3)	83.9 (10.1)
Body Fat Percentage	13.9 (5.3)	13.2 (4.6)
5-10-5 Shuttle Run	4.58 (.15)	4.56 (.18)
Vertical Jump (cm)	74.2 (5.8)	71.0 (6.1)
Broad Jump (cm)	260.0 (14.0)	248.2 (19.3)
Squat 1 RM (kg)	139.1 (16.1)	133.5 (18.6)

Eighteen players volunteered for the SNEI, however three missed intervention sessions and thus only the data from the players (n = 15) that completed all intervention sessions were included in the final analysis. The intervention group (NI) was matched with non-participating players that served as controls (C; n = 15) for body composition and performance according to the position played (infielders, outfielders, catchers, and pitchers). NI met with the principal investigator at the start of the intervention to receive 90 min of nutrition education and then in groups of 5 every 3 weeks thereafter at dinner for educational reinforcement and questions. All group comparative measures taken (body composition and performance) remained blind to the principal investigator until all data had been collected and analyzed statistically.

Procedures

Dietary intake

Nutrient intake was measured at the start of the fall season (pre-intervention) and at the end of the 12 week offseason (post-intervention) via three-day food diaries that consisted of two weekdays and one weekend day to best reflect typical intakes. Total intake for the three days was then averaged and represented as pre- and post-intervention intakes. Subjects met with the investigators at pre- and post-intervention and were interviewed about food records to increase accuracy. Total energy intake, fluids, protein, carbohydrates, and fats will be analyzed using Diet Analysis Plus Version 10 (Cengage, USA).

Nutritional needs

Total energy expenditure (TEE) was estimated by adapting the Gerrior et al. (2006) method for baseball players. The time spent in practice and resistance training was acquired from the coaching and strength and conditioning staff. TEE estimations were calculated via the sum of resting metabolic rate (RMR), average training physical activity expenditure per day (PAE) based upon METs (Heyward, 2010), average unplanned physical activity (UPA) per day, and thermogenic effect of food (TEF). Thus, TEE = RMR + UPA + PAE + TEF, whereby:

RMR = Body Surface Area × 912 kcal/day × [1 – (age – 20]
TEF = 0.1 × RMR
UPA = 0.2 × RMR
PAE = (Resistance training EE + Baseball practice EE)×1.2
RT = 5 kcal/kg × 3.75 hrs
BP = 5 kcal/kg × 20 hrs

Macronutrient needs were based upon recent recommendations to improve strength and lean mass accretion during a resistance training program (Campbell et al., 2007) and calculated as follows:

Protein = 2.0 g/kg
Fat = 25% TEE
Carbohydrate (~6.7 g/kg) = TEE – Kcal Fat – Kcal Pro

Sport nutrition knowledge

Nutritional knowledge was assessed pre- and post-intervention via the Reilly and Maughan (2007) Sports Nutrition Questionnaire. The questionnaire is divided into 10 sections and includes: demographics, dietary behaviors, hydration, weight control, dietary supplements, general nutrition, sports nutrition, protein, strategies for training and food choices, and a swimmer specific section. Open ended questions were omitted to improve reliability, and the swimmer specific section was omitted due to the population of the present study. A score of 1 was given for each correct answer with a score of 0 for each incorrect or “unsure” response allowing for a total possible score of 46. The results of the test are reported as percentage correct. Cronbach’s α for university athletes has been reported as .70.

Body composition

Height was measured using standard anthropometry and body mass was measured using a calibrated scale. Body composition was measured pre- and post-intervention and was determined by whole body densitometry using Air Displacement Plethysmography (Bod Pod®, Cosmed, Concord, CA USA). All testing was performed in accordance with the manufacturer’s instructions. Briefly, subjects were tested while wearing only tight fitting compression shorts and a lycra swim cap. The subjects wore the exact same clothing for all testing. Thoracic gas volume was estimated for all subjects using a predictive equation integral to the Bod Pod® software. The calculated value for body density used the Siri equation to estimate body composition. Data from the Bod Pod® included body weight, percent body fat (BF%), fat free mass (FFM) and fat mass (FM). All testing was performed with each subject at approximately the same time of day at least two hours post prandial.

Strength training

All strength training was conducted under the supervision of a NSCA-CSCS in the performance training center at Coastal Carolina University. All subjects completed three 4-week blocks of progressive strength training consisting of three 75 min resistance training sessions per week. Additionally, subjects completed two 45 min speed and agility sessions per week and spent approximately 15-20 hours each week at baseball practice. Select strength and power exercises and their respected volumes and intensities for the first week of the 3 training blocks are presented in Table 2.

Physical performance testing

Performance tests were conducted under the supervision of an NSCA-CSCS and were selected by the strength and conditioning staff to be carried out on the entire team prior to the conception of the study. Measures of performance were collected pre- and post-intervention following a week of low load resistance training at the same time of day to account for any diurnal variations. Performance testing was carried out on two separate days separated by 48 hours, with the 5-10-5 shuttle test completed on day 1 and the vertical jump, broad jump, and 1 repetition maximum (1 RM) back squat test performed on day 2, respectively. Prior to performance tests subjects performed a standardized warmup consisting of 5 min of foam rolling followed by dynamic warm up drills (high knees, high heels, spider man walks, traveling twisting lunges, and high kicks). Because this study evaluated the effect of nutrition education on nutritional status, dietary intakes prior to testing were not standardized between groups or within subjects.

5-10-5 Shuttle Test

The 5-10-5 shuttle test was performed according to NSCA protocols (Triplett, 2012) and measured with photo cell timing gates (Brower Timing Systems, Draper, UT). Briefly, 3 cones were placed 5 yards apart on an artificial field surface. The subject started in a 3 point stance and upon command sprinted right and touched the line at the first cone with his hand, the subject then turned 180 degrees and sprinted to touch the far left cone line with his hand, he then turned 180 degrees to sprint back to the start. Subjects were provided with 5 min of rest between attempts and the best of the two attempts was recorded in seconds. The 5-10-5 shuttle run has been shown to be a reliable (ICC = 0.90, SEM = 0.12) test of change of direction (Stewart et al., 2014).

Table 2. Block training schematic.

		Movement	Volume	Intensity
Block 1	Major Strength	Day 1: Box Squat	3 x 5 1 x max	65,70,75% 85%
		Day 2: Mulitgrip Bench Press	3 x 5 1 x max	65,70,75% 85%
		Day 3: Landmine Press	4 x 5	NA
	Major Power	Day 1: 6 Exercise Med Ball Series	4 x 4	NA
		Day 2: Speed Deadlifts	4 x 5	35%
		Day 3: Speed Squats	4 x 5	35%
Block 2	Major Strength	Day 1: Back Squat	3 x 5 1 x Max	65,70,75% 85%
		Day 2: Multigrip Bench Press	3 x 5 1 x Max	65,70,75% 85%
		Day 3: Trap Bar Deadlift	3 x 5 1 x Max	65,70,75% 85%
	Major Power	Day 1: Box Jump 3 Exercise Med Ball Throw Series	3 x 2 3 x 6	NA NA
		Day 2: Hang Clean Broad Jump	4 x 2 3 x 1	40% NA
		Day 3: Speed Squat w/ 50 lbs Chain Vertical Jump	4 x 2 3 x 2	40% NA
Block 3	Major Strength	Day 1: Back Squat w/ 100 lbs chains	4 x 3	85%
		Day 2: Multigrip Bench Press w/ 100 lbs chains	4 x 3	85%
		Day 3: Trap Bar Deadlift	4 x 3	85%
	Major Power	Day 1: 3 Exercise Med Ball Series	4 x 4	NA
		Day 2: Power Cleans Broad Jump	5 x 2 4 x 1	60% NA
		Day 3: Speed Box Squat Vertical Jump	4 x 2 4 x 2	60% NA

Vertical jump

Vertical jump was assessed using the Just Jump! Mat (Probotics Inc.: Huntsville, AL). Leard et al. (Leard et al., 2007) demonstrated that the Just Jump! Mat is highly correlated (r = 0.97) with the 3-camera video analysis "gold standard" method of assessing vertical jump performance. Subjects were instructed to stand on the mat with feet hip-width apart and perform a rapid lower body eccentric contraction followed immediately by a maximal intensity concentric contraction. Subjects were instructed to jump straight up and minimize any in-air hip flexion. The best of the three trials was recorded in cm as vertical jump height.

Broad jump

Following a 5 min rest subjects performed the broad jump. Athletes were instructed to place their toes on a marked starting line with the feet placed at approximately hip-width apart. Subjects were instructed to perform a rapid lower body counter movement followed by a rapid two-foot forward leap. Broad jump measurements were taken from the starting line to where the heels contacted the mat. Two separate investigators placed a coin to mark where the subject landed, and the average of the two distances was computed. The best of three trials was recorded in cm as the broad jump height.

1 RM Squat

Following a 5 min rest subjects 1 RM squat was tested. Repetition maximum testing was consistent with recognized guidelines as established by the NSCA (Baechle and Earle, 2000). Subjects performed specific warm-up set of 5 repetitions performed at ~50% 1RM followed by one to two sets of 2-3 repetitions at a load corresponding to ~60-80% 1RM. Subjects then performed sets of 1 repetition of increasing weight for 1RM determination. Three to 5 minutes rest was provided between each successive attempt. All 1RM determinations were made within 5 attempts. Subjects were required to reach parallel in the 1RMBS for the attempt to be considered successful as determined by an NSCA-CSCS. One RM testing has been shown to be a valid (r = 0.88) (Verdijk et al., 2009) and reliable (ICC = 0.96) (Ritti-Dias et al., 2011) measure to assess changes in muscle strength following resistance training in a trained population.

Nutrition education

The intervention group attended a 90 min session at the start of the intervention period. The lead investigator conducted the education in a relaxed atmosphere using a slide show presentation and guided discussion focused on the importance of nutrition for baseball performance. This session discussed the following topics and was adapted from suggestions to develop an academic sport nutrition course for student athletes (Karpinski, 2012): personal responsibility in food preparation, transport, and storage; the role of macro- and micro-nutrients for fuel during training and recovery from training, food sources of these nutrients, individual requirements, portion sizes, and timing of intake with regards to physical activity; maintaining a healthy body weight, safety of supplements, and hydration. In addition, habits of select professional baseball players were cited to increase athlete engagement. Additional sessions occurred every three weeks during the study with 5 players at a time for 45 min at the University dining hall to reinforce the nutrition education.

Statistical analysis

All data is reported as means ± standard deviations. Pre-intervention differences in body composition and performance were assessed using independent samples *t*-tests. Independent samples *t*-test with the Bonferroni corrections were used to compare differences in pre- and post-intervention dietary intake with nutrient needs. A repeated measures t-test was used to compare pre- and post-intervention dietary intakes and nutritional knowledge for the nutrition intervention. A 2 x 2 mixed factorial ANOVA with repeated measures (group x time) was used assess differences in performance and body composition. When a significant interaction was found relative percent differences were calculated (percent difference = ([post-intervention measure – baseline measure] / baseline measure) x 100) and compared with an independent samples *t*-test. The normality of the data was checked and subsequently confirmed with the Shapiro-Wilk test. For all measured variables, the estimated sphericity was verified according to Mauchly's W test, and the Greenhouse–Geisser correction was used when necessary. Pre- and post-values and the pooled standard deviation were used to calculate effect sizes for body composition and performance variables. Effect sizes were defined as small, medium and large and are represented by Cohen's *d* of greater than 0.2, 0.5, and 0.8, respectively. All analyses were completed using SPSS Version 22 (IBM, USA) and an alpha level of $p < 0.05$ was set *a priori*.

Results

There were seven pitchers and eight position players in each group. There were no significant ($p > 0.05$) differences between groups for weight, body fat percentage, fat free mass, fat mass, 5-10-5 shuttle run, vertical jump, broad jump, or squat 1 RM at baseline.

Nutrition knowledge and intake

Knowledge and dietary intake data for NI is displayed in Table 3. Knowledge significantly ($p < 0.001$) increased from pre-intervention to post-intervention. Pre-intervention energy intake was significantly ($p < 0.001$) less than required energy intake. Post-intervention energy intake was significantly ($p < 0.001$) greater than pre-intervention intake, but not significantly ($p > 0.05$) different than required. Pre-intervention protein intake was significantly ($p = 0.006$) less than required protein intake. Post-intervention protein intake was significantly ($p = 0.002$) greater than pre-intervention, but not significantly ($p > 0.05$) different than required. Pre-intervention carbohydrate intake was significantly ($p < 0.001$) less than required carbohydrate intake. Post-intervention carbohydrate intake was also significantly ($p < 0.001$) less than required, and there were no significant ($p > 0.05$) differences between pre- and post-intervention. Pre-intervention fat intake was not significantly ($p > 0.05$) different than required fat intake. Post-intervention fat intake was significantly ($p = 0.001$) greater than required and pre-intervention ($p = 0.011$) fat intake.

Table 3. Nutritional knowledge and dietary intakes for the nutritional intervention group. Data are menas (±SD).

	Required	Pre-Intervention	Post-Intervention
Knowledge (%)	NA	56.7 (11.4)	70 (9.4) [a]
Energy (kcal)	3558 (324)	2878 (443) [b]	3366 (451) [a]
Protein (g)	174 (22)	143 (25) [b]	175 (34) [a]
Carbohydrate (g)	444 (94)	291 (77) [b]	311 (59) [b]
Fat (g)	123 (10)	129 (21)	162 (37) [a, b]

[a] significantly different from pre-intervention; [b] significantly different from required.

Body composition

Body composition data for NI and C is displayed in Table 4. A significant ($p < 0.001$) main effect of time was found for body weight: body weight increased in both groups from pre- to post-intervention; however, there were no significant differences between groups. A significant ($p = 0.014$) interaction was found body fat percentage. *Post hoc* analysis revealed that body fat percentage decreased significantly from baseline in NI but not C. A significant ($p < 0.001$) main effect was found for fat free mass: fat free mass increased in both groups from pre- to post-intervention; however, there were no significant differences between groups ($p > 0.05$). A significant ($p = 0.023$) interaction was found for fat mass. *Post hoc* analysis revealed that fat mass significantly decreased in NI but not C.

Performance

A significant main effect ($p < 0.001$) and interaction ($p = 0.030$) was found the 5-10-5 shuttle run (Table 5). Post-intervention values were significantly less than pre-intervention values; however, *post hoc* analysis revealed that the relative change from pre-intervention was significantly greater for NI compared to C. Significant main effects of time whereby all post-intervention values were

Table 4. Body composition changes for nutrition intervention and control. Data are means (±SD).

		Pre-Intervention	Post-Intervention	Absolute Change	Effect Size (*d*)
Weight (kg)	NI	81.4 (6.3)	82.6 (6.9)	1.2 (2.6)	.15
	C	83.9 (10.1)	85.7 (10.0)	1.8 (1.6)	.23
Body Fat (%)	NI	13.9 (5.3)	12.6 (5.5)	-1.4 (2.2) [b]	.27
	C	13.2 (4.6)	13.6 (4.1)	.5 (2.6)	.08
Fat Free Mass (kg)	NI	69.9 (5.6)	72.1 (6.1) [a]	2.2 (2.0)	.37
	C	72.5 (7.0)	73.8 (7.0) [a]	1.2 (1.2)	.22
Fat Mass (kg)	NI	11.5 (4.8)	10.5 (5.4)	-1.0 (2.0) [b]	.21
	C	11.3 (4.7)	11.9 (4.5)	.6 (1.4)	.01

[a] significantly different from pre-intervention; [b] significantly different from control

Table 5. Performance changes for nutrition intervention and control. Data are means (±SD).

		Pre-Intervention	Post-Intervention	Absolute Change	Effect Size (*d*)
5-10-5 Test (sec)	NI	4.58 (.15)	4.43 (.13) [a]	-.15 (.13) [b]	.91
	C	4.56 (.18)	4.50 (.16) [a]	-.06 (.10)	.36
Vertical Jump (cm)	NI	74.2 (5.8)	80.8 (7.1) [a]	6.6 (9.4)	1.11
	C	71.0 (6.1)	75.7 (7.1) [a]	5.1 (5.1)	.79
Broad Jump (cm)	NI	260.6 (14.0)	270.5 (17.7) [a]	9.9 (6.9)	.63
	C	248.2 (19.3)	260.1 (14.0) [a]	12.0 (10.7)	1.32
1 RM Squat (kg)	NI	139.1 (16.1)	166.8 (20.1) [a]	27.7 (16.6)	1.59
	C	133.5 (18.6)	153.5 (17.5) [a]	20.0 (12.5)	1.15

[a] significantly different from pre-intervention; [b] significantly different from control

greater than pre-intervention were found for vertical jump ($p < 0.001$), broad jump ($p = < 0.001$), and back squat ($p < 0.001$); however, there were no significant ($p > .05$) interactions.

Discussion

The aim of the present study was to evaluate the effectiveness of a brief SNEI during off-season training on nutritional knowledge, nutritional status, body composition, and performance. The main findings of the present study were that: (i) SNEI increased nutritional knowledge and nutritional status; (ii) SNEI reduced body fat percentage, total fat mass, 5-10-5 shuttle times, and trended towards greater increases in lean mass compared to controls; and (iii) both groups increased strength and jump ability similarly.

The results of the pre-intervention intake is similar to previous studies demonstrating that NCAA Division I male athletes regularly do not consume enough total energy or protein (Hinton et al., 2004). The mean energy, protein, and carbohydrate intake at baseline was 488 kcal, 31 g, and 153 g less than required, respectively. Reduced carbohydrate and protein intake is a major nutritional concern. Given the relationships between force output and batting/throwing success (Derenne et al., 2001; Szymanski et al., 2009) and the importance of higher protein intakes for adaptation to intense strength and power training (Guimarães-Ferreira et al., 2014; Moon et al., 2007; Morton et al., 2015), inadequate protein consumption could lead to reduced recovery and compromised adaptation. Additionally, given the subjects high weekly training volume (approximately 20 hours per week), glycogen depletion via inadequate carbohydrate consumption may also lead to impaired focus during skills practice and reduced performance during higher intensity training (Holway and Spriet, 2011), ultimately compromising adaptation and performance.

Subjects participating in the SNEI increased their sport nutrition knowledge as measured by a 46 question questionnaire from a pre-intervention score of 56.7% ± 11.4 to 70% ± 9.4 post intervention. This increase in knowledge was associated with increased total energy and protein intake that at post-intervention was not significantly different than those required. Although total energy intake increased to reach demands, it was via greater fat ingestion that exceeded requirements and not through higher carbohydrate consumption. The effectiveness of our SNEI was similar to previous research in NCAA Division I female athletes that reported increased nutritional knowledge (Abood et al., 2004; Valliant et al., 2012) and nutritional status (Valliant et al., 2012). A major difference between this study and those previously conducted was the time commitment by the athletes and/or coaching staff if implemented by NCAA programs. In the previous studies the primary researcher either met with the athletes once weekly for 8 weeks or one-on-one for a total of 4 meetings. These methods are time consuming for the athletes and coaching staff. In contrast, our study demonstrates that improvements in knowledge and nutritional status can occur with just one 90 min SNEI followed by thrice-weekly brief follow up reinforcement sessions occurring at the training table.

To our knowledge, there have been no studies evaluating the effects of an SNEI on body composition. Valliant et al. (Valliant et al., 2012) reported improvements in body composition in NCAA Division I female volleyball players over the course of the SNEI; however, body composition was not measured in the previous control season, and therefore it cannot be distinguished whether increased training demands or the SNEI was responsible for these improvements. In this study the SNEI had small effect sizes on body fat percentage and fat mass compared to the negligible effect sizes found in position-matched controls participating in the same training program. From a nutritional standpoint the increase in protein consumption likely played a role in these improvements as higher protein diets have been suggested to increase metabolic rate (Morton et al., 2015) and have been shown to favor positive improvements in body composition independent of total energy intake (Krieger et al., 2006).

On the other hand, the reduction in fat mass despite an increased energy intake may seem counter-intuitive but is likely a result of the yearly training plan. The baseline measurements were taken upon the return of the athletes from summer break which corresponds to a very low volume and frequency of resistance training and conditioning and no organized baseball activities. During the study period the volume of strength and conditioning was largely increased and the players took part in 15-20 hours of baseball practice per week, leading to a significant increase in energy expenditure. Therefore, although energy intake increased and there were no statistically significant differences between calculated needs and intake, small deficits in intake (approximately 200-300 kcal/day) may also have partially contributed to the reductions in fat mass found in the NI group.

Based upon the association between body composition and jumping and sprinting ability (Macdonald et al., 2013), we expected greater improvement in 5-10-5 shuttle times, vertical, and broad jump compared to controls since subjects participating in the SNEI reduced fat mass by an average of 1 kg whereas fat mass increased an average of 0.6 kg in control. The results of the study partially support our hypothesis: both groups significantly improved 5-10-5 shuttle run, squat, vertical, and broad jump similarly; however, the NI group improved shuttle run performance to a greater degree. Reductions in fat mass likely contributed to this improvement, as a positive relationship between body fat % and 300 m shuttle run time has been previously reported (Collins et al., 2014)

Although this was the first study to our knowledge to demonstrate that a brief SNEI improves body composition and some measures of performance in NCAA male athletes, some limitations must be considered when interpreting the data. First, we were unable to measure dietary intake or knowledge changes in controls as the athletics department mandated that all athletes that chose to participate in the study received the nutrition education. Second, although subjects were instructed how to fill out the dietary records and questioned for accuracy when they were turned the records in, there is a degree of inherent error when measuring dietary intake via journals. Finally, limited food choices offered at the campus dining halls may have also impacted the effectiveness of the SNEI and were partially responsible for the increased fat intake as many of the protein and carbohydrate rich foods offered had a significant amount of added oils or butter. Although players lived in university housing with full kitchens, in discussions with players during follow up sessions many stated that they did not have time to grocery shop and prepare foods, which highlights the importance of food on-campus food availability for NCAA athletes when implementing an SNEI. Future studies should investigate the effects of an SNEI on dietary intake and body composition the semester following the cessation of the intervention.

Conclusion

NCAA athletes have limited time due to academic and practice demands; however, NCAA Division I baseball players believe that good nutrition will improve their performance (Pawlak et al., 2009). This study demonstrates to coaches that a 90 min nutrition education with tri-weekly reinforcement sessions during team dinners is an effective intervention to improve nutritional status, body composition, and shuttle run performance. Although the change in body composition during the study period was perhaps not of an appreciable enough degree to affect jumping ability, it did seem to have an impact on the athletes' agility. We can speculate that if these trends in body composition continued for a longer period of time they would become significant enough to positively influence jumping ability.

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JMC designed the study and delivered the nutrition education interventions. AL, TJ, FER, SB, and JMC collected performance and body composition data. TJ designed and implemented the training. JMC, FER, and LN wrote the manuscript. No funding was received for this study. All authors report no conflicts of interest.

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Key points

- Sport nutrition education intervention increased nutritional knowledge and nutritional status.
- Sport nutrition education intervention reduced body fat percentage, total fat mass, 5-10-5 shuttle times, and trended towards greater increases in lean mass compared to controls.
- Both groups increased strength and jump ability similarly.

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