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EFFECTS OF NUTRITIONAL SUPPLEMENTATION DURING OFF-SEASON COLLEGE FOOTBALL TRAINING ON BODY COMPOSITION AND STRENGTH

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ABSTRACT

Effects of Nutritional Supplementation During Off-Season College Football Training on Body Composition and Strength. RICHARD B. KREIDER, ROBERT C. KLESGES, DEAN LOTZ, MIKE DAVIS, EDWARD CANTLER, PAMELA GRINDSTAFF, LEIGH RAMSEY, DARYLL BULLEN, LARRY WOOD and ANTHONY L. ALMADA *JEP*online, 1999, 2(2):24-39. Athletes often supplement their diet with meal-replacement/weight gain powders in an attempt to increase muscle mass and strength. However, it is unclear whether these supplements affect lean tissue accretion and/or strength gains. This study evaluated whether supplementing the diet with commercially available nutritional supplements during 84 days of winter resistance/agility training and spring football practice affects body composition and/or strength alterations. In a double blind and randomized manner, 51 college football players were matched and randomly assigned to supplement their diet with either a carbohydrate placebo (P), a vitamin/mineral fortified carbohydrate/protein supplement (Met-Rx™), a vitamin/mineral fortified carbohydrate/protein powder containing 20 g/day of creatine (Phosphagain™), or a vitamin/mineral fortified carbohydrate/protein powder containing 25 g/day of creatine (Phosphagain 2™). Additionally, a group of 10 subjects maintained normal dietary practices during training and served as non-supplemented controls (NS). Total body weight, total body water, DEXA determined body composition, and isotonic strength tests were assessed on days 0, 35, and 84 of training. Results revealed that mean gains in soft tissue/lean mass were significantly greater in the Phosphagain™ (P-I) and Phosphagain 2™ (P-II) groups than changes in the NS, P, and Met-Rx™ (MRx) groups (NS 0.7±1.3; P 1.2±1.6; MRx 0.8±1.2; P-I 2.3±1.4; P-II 3.4±1.8 kg). Mean gains in 1 RM bench press in the MRx, P-I and P-II groups were significantly greater than gains observed in the NS group (NS 2.0±9; P 7.6±7; MRx 9.8±6; P-I 10.3±5; P-II 10.0±8 kg). Results indicate that P-I and P-II supplementation during training promoted greater gains in lean tissue mass in comparison to NS, P, and MRx groups and that gains in strength in the supplemented groups were greater than the NS group.

Key Words: Sport Nutrition, Resistance-Training, Weight Gain, Creatine, Carbohydrate, Protein, Taurine, Glutamine, RNA, Meal-Replacement

INTRODUCTION

One of the more popular types of nutritional supplements that athletes take are meal replacement/weight gain powders. Most of these supplements are moderate to high calorie, vitamin and mineral fortified, carbohydrate/protein powders containing various nutrients purported to enhance lean tissue accretion during training (e.g., protein, amino acids, chromium picolinate, creatine, etc.). Athletes often take these supplements during hypertrophic resistance-training periods in order to promote gains in fat free mass (FFM) and strength, and/or during intensified training/competition periods in order to help maintain weight. Unfortunately, little data are available regarding the effects of supplementing the diet with various meal replacement/weight gain powders on body composition and strength alterations during training.

We have previously reported (1) on the effects of dietary supplementation with a commercially available carbohydrate/protein supplement containing creatine monohydrate, taurine, yeast-derived RNA, and L-glutamine (Phosphagain™). We demonstrated that 28 days of dietary supplementation, in combination with resistance training, resulted in significantly greater gains in FFM in comparison to a near-isocaloric non-fortified carbohydrate placebo and a higher-calorie protein/carbohydrate supplement containing chromium picolinate and boron (Gainers Fuel® 1000). These findings indicated that formulation of a nutritional supplementation during training may influence the change in body composition. Moreover, Phosphagain™ supplementation during training may be an effective nutritional strategy to promote gains in fat free mass. However, it was clear that additional well-controlled research was necessary to evaluate the effects of this nutritional formulation as well as other popular meal replacement/weight gain powders on body composition and strength alterations during training.

The purpose of this study was to determine whether nutritional supplementation by collegiate football players would alter body composition and muscular strength. Five groups of athletes participated in the study. Three groups of collegiate football players ingested commercial meal replacement/weight gain powders (Met-Rx™, Phosphagain™, Phosphagain 2™) during two phases of off-season college football training (i.e. 35-d of resistance/agility training & 49-d of resistance training/spring football practice). Changes in FFM and muscular strength were compared to athletes maintaining normal dietary practices, as well as athletes supplementing their diet with a non-fortified carbohydrate placebo.

METHODS

Subjects

67 National Collegiate Athletic Association (NCAA) division I-A football players undergoing off-season resistance/football training at a major university in the mid-south region of the United States volunteered to participated in this study. Subjects were informed of the experimental procedures and signed informed consent statements in adherence with the human subjects guidelines of the American College of Sports Medicine and the Institutional Review Board at The University of Memphis. 61 subjects who were descriptively (mean ± standard deviations) 19.5±1.2 yrs, 99.5±19 kg, and 186±8 cm completed the study. The remaining subjects were unable to complete the study due to injury (2), quitting the team (1) or they did not adequately comply to the protocol (3).

Subjects signed statements indicating that they were not taking anabolic steroids, and that they were aware that they were subject to random/unannounced drug testing during the study according to NCAA regulations. While

conducting the study, 29 athletes were selected by the NCAA for random drug testing during two independent screenings. All drug tests were negative for the presence of anabolic-androgenic steroids according to NCAA criteria. In addition, there was no history of athletes at this university testing positive for anabolic-androgenic steroids in the previous 9 years of NCAA testing.

Experimental Design

Subjects participated in a 12-week off-season training program consisting of two phases. The first phase of training (35 days) consisted of 5 hr/wk of heavy resistance-training and 3 hr/wk of agility/sprint training. The resistance-training program was conducted on Monday, Tuesday, Thursday, and Friday afternoons, while the agility/sprint training was conducted on Monday, Wednesday, and Friday mornings. Resistance exercises included bench press, incline bench press, dumbbell incline bench press, cable crossovers, shoulder shrugs, shoulder lateral raises, shoulder press, neck exercises, seated dips, triceps extension, biceps curls, lat pull downs, seated rows, back extension, abdominal crunches, bear squats, split squats, isolateral leg press, leg extension, leg curl, calf raises, and power cleans/pulls. These exercises were prescribed in a structured periodized manner in weekly cycles. Each subject performed the same exercise and number of repetitions for a given lift at a prescribed percentage of the subject's one repetition maximum (1 RM). This was accomplished by providing the athletes with individualized daily workout sheets which described the lifts to perform, number of sets and repetitions, and pre-calculated the amount of weight to lift based on the subjects 1RM for that lift. Most exercises involved performing 2 - 4 sets of 4 - 10 repetitions at 60 to 90% of the athletes 1RM for a given lift. Resistance-training sessions were supervised by strength coaches and student assistants/interns. Athletes turned in completed training forms to the strength coaches at the end of each resistance-training session to monitor progress. Agility training consisted of a warm up for approximately 5 minutes (i.e., light stretching/running) and then the completion of five 10 minute stations of high intensity sprint, agility, and football drills under the direction of assistant football coaches and strength coaches. Attendance at resistance and agility training sessions was monitored and subjects who missed workouts were required to make them up at early morning training sessions typically within 48-h according to team policy. Since training sessions were mandatory practices for these athletes, it was rare that athletes missed training sessions.

The second phase of training began following conducting phase I post assessments and included an abbreviated spring break, spring football practice (which started during spring break), and a week of post-testing following the completion of spring football practice. During this period, subjects participated in a maintenance resistance-training program twice per week (primarily lifts such as bench press, shoulder shrugs, shoulder press, lat pull down, bear squats, leg press, etc.), spring football practice (typically 2 to 3 h practices, 4 times per week for a total of 20 practices), sprint conditioning training (performed at the conclusion of most practices), and team/position meetings. Phase II post-testing was conducted in the week following the completion of spring football practice (after 84 days of supplementation).

Subjects maintained their normal diet throughout the study. Meals were provided to the athletes in their dormitory three times per day at a team training table. Meals consisted of *ad libitum* intake of a primary entree and a limited number of side entrees served at the team training table meals. Meals were prepared according to a 7 day meal plan schedule, which designated what would be served to the athletes for each meal. The same meal schedule was repeated weekly throughout the study. Consequently, although

the athletes were allowed to select their own foods provided at the training table and ingest food outside of the training table, dietary analysis revealed that the diets of these athletes were very similar in regards to the type of foods ingested each day. Subjects were not allowed to ingest any other nutritional supplements, proposed ergogenic aids, or non-prescription drugs during the course of the study. In addition, the subjects had no history of taking creatine or creatine-containing products prior to the start of supplementation.

During the first two weeks of the spring semester, the athletes participated in training/study familiarization sessions. This involved familiarizing the subjects to the resistance-training program to be implemented, conducting familiarization sessions, and performing pre-supplementation assessments. Pre-supplementation assessments included: 1.) a 3 day nutritional intake assessment; 2.) measurement of total body weight, total body water, and body composition; and, 3.) 1 RM and 70% of 1RM tests on the isotonic bench press.

Subjects recorded nutritional intake on 3 day dietary record forms with the assistance of research assistants who had expertise in conducting nutritional analysis studies. This involved having research assistants present at training table meals to ensure that food intake was accurately recorded during these meals and that the subjects recorded any food intake consumed between meals. Nutritional records were analyzed by one experienced research assistant using the Food Processor III nutritional analysis software (*Nutritional Systems, Salem, OR*).

Subjects were not allowed to exercise or ingest food or drinks for 4 hours prior to body composition assessments. Total body weight was measured on a calibrated digital scale with a precision of ±0.02 kg *(Sterling Scale Co., Southfield, MI)*. Total body water was estimated (2) using a Valhalla 1990b Bioelectrical Impedance Analyzer (*San Diego, CA*) using standard assessment criteria. Whole body (excluding cranium) body composition measurements were determined using a Hologic QDR-2000 dual energy x-ray absorptiometer (DEXA) with the Hologic version V 7, REV F software (*Waltham, MA*). Subjects were positioned according to standardized criteria during the initial scan. This position was referenced into the computer for positioning of subjects in subsequent trials. DEXA scans were performed primarily by one certified radiology technician (177 of 183 scans) with the remaining scans performed by another certified radiology technician following identical positioning criteria.

DEXA measures the amount of bone, fat, and fat-free/soft tissue mass which falls within standardized density ranges using dual energy x-ray absorptiometry methodology. The DEXA scans regions of the body (right arm, left arm, trunk, right leg, and left leg) to determine the amount of bone mass, fat mass, and soft tissue lean mass (STLM) within each region. The scanned bone, fat, and STLM for each region are then subtotaled to determine whole body (excluding cranium) values. Percent body fat is calculated by dividing the amount of measured fat mass by total scanned mass (sum of bone mass, fat mass, and fat-free/soft tissue mass). DEXA has been shown to be a highly reliable (r=0.99) and precise method (coefficient of variation of 0.5-1%) for determining individual body composition segments (3-6).

Quality control calibration procedures were performed on a spine phantom (Hologic X-CALIBER Model DPA/QDR-1 anthropometric spine phantom) prior to each testing session following procedures previously described (1,7,8). Mean coefficients of variation in BMC and BMD measurements obtained in the lateral and array modes ranged between 0.41 to 0.55% throughout the life of the unit. Test-retest

reliability studies performed on male athletes with this DEXA machine yielded mean deviation for total BMC and total fat free/soft tissue mass of 0.31% with a mean intraclass correlation of 0.985 (7).

Subjects performed a standardized 1RM isotonic bench press test. This involved warming up and then performing 1 repetition lifts until reaching their 1RM maximum. Hand position on the bar was recorded for standardization between trials. In addition, subjects had to maintain good lifting form (i.e., feet maintaining contact with the floor, no arching of the back off of the bench, no bouncing of the weight off the chest). Once a 1 RM was determined on the bench press, subjects rested for 5-min and then performed a maximum effort bench press repetition test at 70% of 1RM. The number of repetitions and 70% of 1RM weight were recorded. Total lifting volume was determined by multiplying the number of repetitions performed by the amount of weight lifted. Isotonic tests were performed in a competitive environment under supervision of strength coaches and research assistants using standardized lifting criteria.

Of the 61 subjects who participated in this study, 51 subjects volunteered to ingest nutritional supplements during training. These subjects were matched by FFM and team position and assigned to supplement their diet in a double-blind and randomized manner either: 195 g/day of a maltodextrin placebo (n=11); MET-Rx® (*MET-Rx Substrate Technology, Inc.,Newport Beach, CA*) containing 72 g/day carbohydrate, 111 g/day protein, 6 g/day fat and 9 g/day L-glutamine (n=13); Phosphagain® (*Experimental & Applied Sciences, Inc., Golden, CO*) containing 57 g/day carbohydrate, 60 g/day protein, 5 g/day fat, 20 g/day of HPCE pure creatine monohydrate, 775 mg/day of yeast-derived RNA, 7.2 g/day of L-glutamine, & 6.2 g/day of taurine (n=14); or, Phosphagain 2® (*Experimental & Applied Sciences, Inc., Golden, CO*) containing 39 g/day carbohydrate, 72 g/day protein, 6 g/day fat, 25.5 g/day of HPCE pure creatine monohydrate, 1,500 mg/day of yeast-derived RNA, 9 g/day of L-glutamine,

Table 1. Ingredient list for the placeo (P), Met-Rx (MRx), Phosphagain (P-I) and Phosphagain 2 (P-II) supplements (Calculated from total daily servings).

Ingredient	*P*	*MRx*	*PI*	*PII*
Macronutrients				
Carbohydrate (g)	195	72	57	39
Protein (g)	-	111	60	72
Fat (g)	-	6	5	5
Kilocalories (kcal)	780	786	513	489
Vitamins				
Vitamin A (mg RE)	-	2,700	1,050	1,200
Vitamin D (mg)	-	11.7	9.75	9.75
Vitamin C (mg)	-	108	95	90
Vitamin E (mg TE)	-	16.2	13.5	13.5
Vitamin K (mg)	-	120	120	120
Thiamin (mg)	-	2.16	1.8	1.8
Riboflavin (mg)	-	2.5	2.1	2.1
Niacin (mg)	-	48	24	24
Vitamin B-6 (mg)	-	2.7	2.25	2.25
Vitamin B-12 (mg)	-	3	3	3
Pantothenic Acid (mg)	-	6.6	8.25	8.25
Folic Acid (mg)	-	270	270	270
Biotin (mg)	-	108	90	90
Minerals				
Sodium (mg)	-	1,170	1,170	1,200
Calcium (mg)	-	189	1,350	1,350
Magnesium (mg)	-	360	450	450
Potassium (mg)	-	2,250	1,500	2,190
Zinc (mg)	-	15.6	19.5	19.5
Manganese (mg)	-	3	3	3
Copper (mg)	-	0.2	3	3
Iron (mg)	-	14.4	18.0	7.2
Phosphorus (mg)	-	1,080	1,350	1,350
Iodine (mg)	-	158	225	225
Selenium (mg)	-	90	90	90
Chromium (mg)	-	150	150	150
Molybdenum (mg)	-	180	180	180
Other Nutrients				
Creatine Monohydrate (g)			20	25.5
Taurine (g)	-		6.2	10.5
L-Glutamine (g)	-	9.0	7.2	9.0
RNA (mg)	-		775	1,500
Choline (mg)	-		240	240
Calcium α-ketoglutarate	-		-	6.75

Values are calculated based on Reference Daily Intake (RDI) values for food label percent translations.

10.5 g/day of taurine, and 6.75 g/day of calcium α-ketoglutarate (n=13). In addition, in a non-blinded and non-randomized manner, 10 athletes who did not want to take nutritional supplements during training served as non-supplemented controls. The FFM and team position of these athletes were similar to the subjects ingesting nutritional supplements. Evaluation of this control group allowed for the determination of the effects of training on body composition and strength without nutritional intervention. Table 1 describes the nutritional composition of the supplements.

Supplements were prepared in powder form and were flavored/colored by a flavor lab/packaging company to have near identical texture, taste and appearance. Supplements were independently packaged in generic foil packets for double-blind administration. Subjects mixed the supplement powder into approximately 0.5 L of fluid and ingested the solution with morning, mid-day and evening meals. Subject compliance in taking the supplements was verified and recorded by student athletic trainers at each meal attendance check-in throughout the study.

Post-supplementation assessments were conducted in a similar manner as pre-supplementation tests, following 35 and 84 days of training and included: 1.) 3 day dietary records; 2.) measurement of total body weight, total body water, and body composition; and, 3.) tests of 1 RM and 70% of 1RM isotonic bench press.

Statistical Analyses

Day 0 values were analyzed by one-way analysis of variance (ANOVA) using SPSS for Windows version 8.0 software to ensure that no significant differences were observed among groups in pre-supplementation values. Since no significant differences were observed in pre-supplementation variables, data were then analyzed using general linear model repeated measures ANOVA with Tukey and LSD *post-hoc* procedures. Interactions among groups were also examined by calculating delta scores (subtracting day 0 values from day 35 and 84 values) and analyzing them by ANOVA for repeated measures with Tukey and LSD *post-hoc* procedures. During post-hoc analysis, significant differences were observed in day 0 body weight, scanned mass and soft tissue/lean mass values among groups. Although one-way ANOVA did not identify significant differences among pre-supplementation values for these variables, these data were analyzed by analysis of covariance (ANCOVA) using Day 0 values as a covariate in order to verify that differences observed from the repeated measures ANOVA were not due to differences among groups in pre supplementation values. Data were considered significant when the probability for Type I error was 0.05 or less. Data are presented as unadjusted means ± standard deviations (SD).

RESULTS

Side Effects

Post-study questionnaires administered in a double-blinded manner revealed that subjects tolerated the supplementation protocol well with no reports of gastrointestinal distress and/or medical problems/symptoms. In addition, there was no evidence of an increased incidence of muscle injury and/or cramping noted by the athletic training staff during spring football practice.

Nutritional Intake

No significant differences were observed among groups in pre-supplementation mean estimated energy intake (**NS** 29.0±12; **P** 38.1±11; **MRx** 38.0±7; **P-I** 36.3±12; **P-II** 38.2±14 kcal/kg/d, *p=0.68)*, carbohydrate intake (**NS** 3.8±1.8; **P** 5.0±1.6; **MRx** 4.9±0.9; **P-I** 5.2±2.3; **P-II** 4.9±2.2 g/kg/day, *p=0.74)*, fat intake (**NS** 1.1±0.4; **P** 1.4±0.5; **MRx** 1.4±0.4; **P-I** 1.1±0.4; **P-II** 1.4±0.5 g/kg/day, *p=0.39)*, or protein intake (**NS** 1.2±0.6; **P** 1.6±0.4; **MRx** 1.6±0.4; **P-I** 1.4±0.5; **P-II** 1.6±0.6 g/kg/day, *p=0.44)*. Supplementation did not significantly alter mean energy intake (**NS** -3.8±9; **P** 4.1±11; **MRx** 2.9±9; **P-I** -0.8±7; **P-II** -2.8±7 kcal/kg/d,

p=0.27) or fat intake (**NS** -0.1±0.2; **P** -0.1±0.6; **MRx** -0.1±0.3; **P-I** 0.1±0.3; **P-II** -0.2±0.3 g/kg/day, *p=0.59)* from pre supplementation values. However, mean carbohydrate intake in the P group was significantly increased (**NS** -0.6±1.4; **P** 1.2±1.3; **MRx** -0.2±1.4; **P-I** -0.9±1.5; **P-II** -0.7±1.3 g/kg/day, *p=0.004)* while mean protein intake in the MRx, P-I and P-II groups was significantly increased (**NS** -0.2±0.5; **P** -0.2±0.5; **MRx** 0.9±0.5; **P-I** 0.5±0.3; **P-II** 0.4±0.3 g/kg/day, *p=0.001)*.

Table 2. Body weight and BIA determined body water data for the non-supplemented (NS), carbohydrate placebo (P), Met-Rx (MRx), Phosphagain (P-I), and Phosphagain 2 (P-II) groups.

Variable	*Group*	*Day 0*	*Day 35*	*Day 84*		
					Factor	p
Body weight (kg)					Group	0.81
					Time	0.02
					Group x Time	0.006
	NS	106.1±19.1 ¶‡^£	104.5±18.0 ¶‡^	104.3±18.0 ¶‡^		
	P	96.7±19.2 †£	97.3±18.2 †^£	97.5±18.0 †^£		
	MRx	96.3±17.1 †^£	96.4±17.7 †^£	97.0±17.5 †^£		
	P-I	98.7±18.3 †‡£	100.6±18.9 †¶‡£ø	101.2±18.0 ¶‡†^£ø		
	P-II	100.8±22.1 †¶‡^	103.4±21.9 ¶‡^ø	103.2±21.2 ¶‡^ø		
Total Body Water (%)					Group	0.07
					Time	0.94
					Group x Time	0.90
	NS	60.3±3.0	61.1±1.9	60.3±2.3		
	P	62.6±2.4	63.3±2.4	63.0±2.9		
	MRx	63.4±1.7	63.3±2.1	63.2±2.4		
	P-I	62.0±2.6†	63.0±2.4	62.1±2.7		
	P-II	61.6±2.9†	62.5±3.2	61.3±2.9		

Data are unadjusted group means±SD. † p <0.05 from NS, ¶ p <0.05 from P, ‡ p <0.05 from MRx, ^ p <0.05 from P-I, £ p <0.05 from P-II, ø p <0.05 from Pre(day 0)

Total Body Weight and Water. Table 2 presents mean changes in total body weight and body water for the NS, P, MRx, P-I and P-II groups. Repeated measures ANOVA revealed a significant interaction (*p=0.001*) among groups in total body weight. Post-hoc analysis revealed that total body weight was significantly increased in the P-I and P-II groups after 35-d and 84-d of training. In addition, gains in body weight in the P-I and P-II groups after 35 and 84 days of training, respectively, were significantly greater than changes observed in the NS group (**NS** -1.6 ±1.6, -1.9±2.0; **P** 0.6±2.1, 0.8±2.9; **MRx** 0.03±1.7, 0.7±2.0; **P-I** 1.9±2.6, 2.5±4.2; **P-II** 2.6±2.5, 2.4±2.7 kg). Since post-hoc analysis revealed differences among day 0 total body weight means, ANCOVA was performed on body weight data analysis using day 0 values as the covariate. ANCOVA analysis confirmed that the mean weight gain observed in the P-I and P-II groups was significantly greater (*p=0.001*) than the NS and MRx groups (**NS** -1.7±1.6; **P** 0.7±2.4; **MRx** 0.3±1.6; **P-I** 2.2±3.3; **P-II** 2.5±2.4 kg). No significant differences were observed among groups in changes in total body water expressed as a percentage of total body weight (**NS** 0.8±2.2, -0.1±1.8; **P** 0.7±1.9, 0.4±1.9; **MRx** -0.05±1.7, -0.12±1.8; **P-I** 1.0±1.4, 0.02±1.7; **P-II** 0.9±1.4, -0.3±1.2 %).

Body Composition

Table 3 presents DEXA determined body composition data obtained on days 0, 35 and 84 of training while Figures 1 to 4 present DEXA results expressed as mean changes in body composition values from days 0 to 35 and 0 to 84. A significant interaction (*p<0.001*) was observed among groups in scanned body mass. Post-hoc analysis revealed that scanned body mass was significantly increased from Day 0 values in the P-II group following 35 and 84 days of supplementation. Analysis of delta values revealed that changes in scanned mass in the P-I group were significantly greater (*p=0.001)* than

Table 3. DEXA body composition data for the non-supplemented (NS), carbohydrate placebo (P), Met-Rx (MRx), Phosphagain (P-I), and Phosphagain 2 (P-II) groups.

Variable	*Group*	*Day 0*	*Day 35*	*Day 84*		
					Factor	p
Scanned Mass (kg)					Group	0.77
					Time	0.001
					Group x Time	0.001
	NS	99.3±18.1 ¶‡^£	98.3±17.7 ¶‡^	97.6±17.6 ¶‡^		
	P	89.7±18.3 †^£	90.5±17.2 †^£	90.5±17.0 †^£		
	MRx	89.5±16.7 †^£	89.7±16.8 †^£	90.1±16.5 †^£		
	P-I	92.5±17.9 ¶‡†	94.2±18.2 ¶‡†£	94.1±17.1 ¶‡†£		
	P-II	93.5±21.1 ¶‡†	96.6±21.0 ¶‡^ø	96.4±20.4 ¶‡^ø		
Soft Tissue Lean Mass (kg)					Group	0.86
					Time	0.001
					Group x Time	0.001
	NS	71.1±8.6£	71.8±9.4£	71.8±9.7£		
	P	71.4±8.8	72.6±8.2£	72.6±8.0£		
	MRx	72.0±9.4	72.6±9.4£	73.2±9.9£		
	P-I	73.2±9.3†	75.7±9.3 ¶‡†ø	75.2±8.9 ¶‡†ø		
	P-II	72.4±8.7†	75.8±8.2 ¶‡†ø	75.7±8.2 ¶‡†ø		
Fat Mass (kg)					Group	0.29
					Time	0.001
					Group x Time	0.001
	NS	25.1±11.1	23.4±11.5	22.6±11.1		
	P	15.2±11.1	14.8±10.8	14.8±10.9		
	MRx	14.1±9.9	13.9±10.2	13.6±10.1		
	P-I	16.1±10.7	15.3±10.4	15.7±9.9		
	P-II	17.8±13.3	17.4±13.4	17.2±13.1		
Bone Mass (g)					Group	0.61
					Time	0.06
					Group x Time	0.66
	NS	3,214±453	3,242±488	3,251±478		
	P	3,100±369	3,141±361	3,124±340		
	MRx	3,355±542	3,380±548	3,375±588		
	P-I	3,221±499	3,207±468	3,213±448		

the NS group following 35 and 84 days of training. In addition, the gains in scanned mass in the P-II group were significantly greater than the NS, P, and MRx groups following 35-d and 84-d of training (**NS** -1.0 ±1.2, -1.7±1.6; **P** 0.8±2.4, 0.8±2.9; **MRx** 0.3±1.6, 0.6±1.8; **P-I** 1.7±2.1, 1.6±3.6; **P-II** 3.1±2.6, 2.9±2.7 kg for days 35 and 84, respectively). Since post-hoc analysis revealed significant differences among day 0 scanned mass, ANCOVA was performed using day 0 values as the covariate. ANCOVA analysis confirmed that mean changes in scanned mass in the P-I group was significantly greater (*p=0.001*) than the NS group and changes observed in the P-II group were significantly greater than the NS, MRx, and P groups (**NS** -1.4±1.3; **P** 0.8±2.5; **MRx** 0.4±1.5; **P-I** 1.7±2.7; **P-II** 3.0±2.5 kg).

Repeated measures ANOVA also revealed a significant interaction (*p=0.001)* in STLM values. Post-hoc analysis revealed that STLM was significantly increased in the P-I and P-II groups following 35 and 84-d of training. Analysis of delta values revealed that mean gains in STLM observed in the P-I and P-II groups were significantly greater than changes in the NS, P, and MRx groups following 35 days of training. However, following 84-d of training, gains in STLM in the P-I group were only significantly greater (*p=0.001*)

Table 3, cont'd.

	P-II	3,339±475	3,398±476	3,418±476	
Body Fat (%)				Group	0.10
				Time	0.001
				Group x Time	0.11
	NS	24.5±7.0	23.0±7.4	22.4±7.4	
	P	15.5±8.7	15.0±8.6	15.1±8.7	
	MRx	14.7±7.9	14.4±8.0.	14.1±8.1	
	P-I	16.2±8.4	15.0±7.9	15.5±7.8	
	P-II	17.2±9.3	16.2±9.2	16.2±9.0	

Data are unadjusted group means±SD. † p <0.05 from NS, ¶ p <0.05 from P, ‡ p <0.05 from MRx, ^ p <0.05 from P-I, £ p <0.05 from P-II, ø p <0.05 from Pre(day 0)

than the NS group while gains observed in the P-II group were significantly greater than the NS, P, MRx, and P-I groups (**NS** 0.7 ±1.8, 0.7±1.8; **P** 1.2±1.6, 1.1±1.6; **MRx** 0.5±1.2, 1.1±1.5; **P-I** 2.5±1.3, 2.1±1.9; **P-II** 3.5±1.9, 3.4±1.9 kg for days 35 and 84, respectively). ANCOVA confirmed that mean changes in STLM in the P-I group were significantly greater (*p=0.001*) than the NS and MRx groups while mean changes in the P-II group were significantly greater than the NS, P, and MRx groups (**NS** 0.7±1.3; **P** 1.2±1.6; **MRx** 0.8±1.2; **P-I** 2.3±1.4; **P-II** 3.4±1.8 kg). No significant differences were observed among groups in DEXA determined bone mass (*p=0.66)*. There was some evidence that fat mass (*p=0.07*) and percent body fat (*p=0.11*) decreased to a greater degree in the NS group.

Strength

Table 4 presents results for the 1 RM bench press test and 70% of 1RM bench press repetition tests performed on day 0, 35, and 84 of training. ANOVA for repeated measures revealed no significant interactions in 1RM bench press (*p=0.10*), the number of repetitions performed at 70% of 1 RM (*p=0.34*), or total lifting volume (*p=0.49*). However, mean change analysis revealed that gains in 1 RM bench press in the MRx, P-I and P-II groups were significantly greater (*p=0.04*) than gains observed in the NS group (**NS** 2.0±9; **P** 7.6±7; **MRx** 9.8±6; **P-I** 10.3±5; **P-II** 10.0±8 kg). No significant differences were observed among supplemented groups.

DISCUSSION

Results from the present study indicate that: 1.) supplementing the diet with P-I and P-II during the first 5-wks of off-season football resistance/agility training resulted in significantly greater gains in the scanned total lean mass in comparison to the NS, P, and/or MRx groups; 2.) the changes in STLM during phase II of training were minimal; and, 3.) gains in 1 RM bench press strength in the P, MRx, P-I and P-II groups were significantly greater than gains observed in the NS groups. These findings suggest that dietary supplementation during off-season football training may affect lean tissue accretion in varying degrees depending on the specific nutritional formulation ingested and the type of training employed. While the etiology of these findings remain to be determined, results indicate that P-I and P-II supplementation during training may be effective in promoting lean tissue accretion during off-season college football training. The following discussion provides greater insight into the alterations in body composition and strength observed.

Body Composition

There are several interesting findings observed in the present study regarding body composition changes during training. First, the gains in STLM and total body weight observed were not associated with significant increases in fat mass. In this regard, Forbes and associates (9) reported that an average of 0.5 kg of FFM is gained or lost with each 1kg change in total body mass during training. Since 4 to 8 weeks of resistance training typically promotes a 0.5 to 1.0 kg increase in FFM (10), one would expect that the hypertrophic resistance/agility phase of training would increase body mass with proportional increases in STLM and fat mass. In the present

Table 4. Strength data for the non-supplemented (NS), carbohydrate placebo (P), Met-Rx (MRx), Phosphagain (P-I), and Phosphagain 2 (P-II) groups.

Variable	*Group*	*Day 0*	*Day 35*	*Day 84*	Factor	p
1 RM Bench Press (kg)					Group	0.49
					Time	0.001
					Group x Time	0.10
	NS	136.4±23	141.6±24	135.2±16		
	P	125.9±25	134.9±27	132.1±23		
	MRx	129.9±25	139.5±25	139.9±23		
	P-I	138.7±21	150.5±21	147.5±21		
	P-II	136.9±24	148.8±22	145.0±18		
Repetitions (70% 1 RM)					Group	0.59
					Time	0.001
					Group x Time	0.34
	NS	14.8±3.5	11.9± 3.5	13.2±2.9		
	P	12.5±2.2	11.6± 1.7	12.8±2.7		
	MRx	14.8±4.0	11.7±4.2	12.8±2.6		
	P-I	14.6±3.6	13.1± 2.8	13.9±2.9		
	P-II	13.2±3.1	12.4± 2.3	14.2±2.7		
Lifting Volume (kg)					Group	0.29
					Time	0.04
					Group x Time	0.49
	NS	1,410±427	1,140± 299	1,334±256		
	P	1,110±337	1,106± 312	1,186±362		
	MRx	1,349±434	1,174±509	1,253±293		
	P-I	1,409±390	1,356± 223	1,412±301		
	P-II	1,282±387	1,285± 281	1,411±338		

Data are unadjusted group means±SD

study, subjects in the NS group lost -1.0±1.2 kg of scanned body mass during Phase I of training. Consequently, based on previous findings, it would be expected that STLM and fat mass would have decreased. However, while fat mass decreased (-1.8±1.8 kg), STLM increased (0.7±1.8 kg) resulting in 1.6±1.7 % reduction in body fat percent. During Phase II of training, overall gains in STLM mass were maintained (0.7±1.8 kg) while scanned mass (-1.7±1.6 kg), fat mass (-2.5±1.6 kg) and body fat percent (-2.2±1.6 %) continued to decrease from pre-supplementation levels. These findings suggest that athletes undergoing off-season football training may be able to increase STLM and lose fat mass despite losses in total body weight. Moreover, positive body composition alterations (i.e, gains in STLM and loss in fat mass) can be achieved during off-season football training without nutritional intervention.

One of the theoretical goals of nutritional supplementation during training is to promote greater gains in FFM during hypertrophic training phases and/or serve to maintain FFM during intense training periods. General nutritional recommendations for promoting weight gain/lean tissue accretion during training include increasing caloric intake by 500 - 1,000 kcal/day through eating 5 to 6 well-balance meals/day and/or supplementing the diet with carbohydrate and/or nutrient fortified carbohydrate/protein powders in order to increase caloric intake. Studies which have evaluated the effects of increasing caloric intake on body composition indicate that this nutritional strategy is effective in increasing total body mass (1,11). However, only 30-50% of the mass gain is typically fat free mass (1,11). For athletes, gaining fat mass may not be a desirable alteration in body composition. Consequently, researchers have been looking for nutritional strategies to promote lean tissue accretion during training without excessive gains in fat mass.

In the present study, dietary supplementation of P, MRx, P-I, and P-II did not significantly increase total energy intake. However,

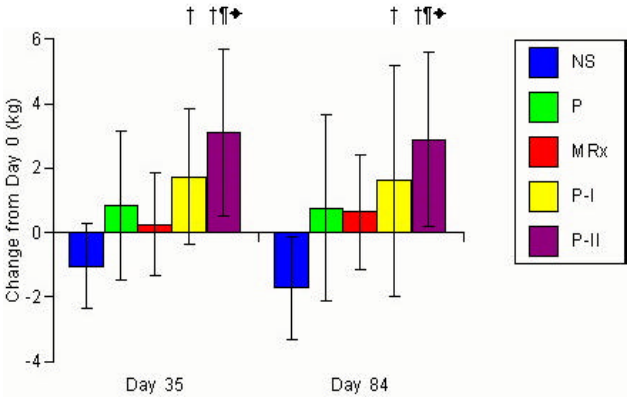

Figure 1. Changes in DEXA determined scanned body mass for the non-supplemented (NS), carbohydrate placebo (P), Met-Rx (MRx), Phosphagain (P-I), and Phosphagain 2 (P-II) groups after 35-d and 84-d of supplementation. Data are means and ± SD. † represents p<0.05 difference from the non-supplemented group. ¶ represents p<0.05 difference from placebo group. + represents p<0.05 difference from MRx group.

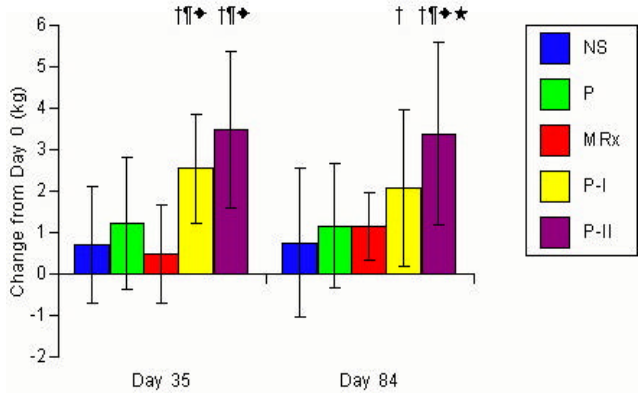

Figure 2. Changes in DEXA determined soft tissue/lean mass (STLM) for the non-supplemented (NS), carbohydrate placebo (P), Met-Rx (MRx), Phosphagain (P-I), and Phosphagain 2 (P-II) groups after 35-d and 84-d of supplementation. Data are means and ± SD. † represents p<0.05 difference from the non-supplemented group. ¶ represents p<0.05 difference from placebo group. represents p<0.05 difference from MRx group. represents p<0.05 difference from P-I group.

carbohydrate intake was increased in the P group while protein intake was increased in the MRx, P-I and P-II groups. These findings suggests that the supplementation strategies employed were effective in altering macro- and/or micro-nutrient intake but that the athletes' altered dietary patterns to essentially maintain total energy intake. Whether this was due to the supplements altering appetite and/or normal dietary adaptations to training is unclear. Nevertheless, it is clear that if the nutritional supplementation strategies employed promoted greater gains in lean tissue accretion during training than observed in the NS group, gains in STLM could not simply be attributed to increased caloric intake but rather alterations in macro- and/or micro-nutrient intake.

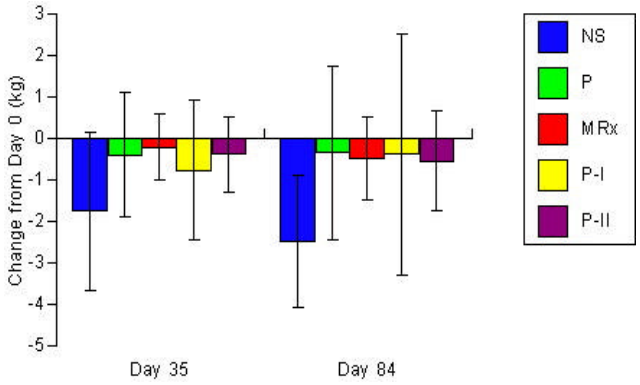

Figure 3. Changes in DEXA determined fat mass for the non-supplemented (NS), carbohydrate placebo (P), Met-Rx (MRx), Phosphagain (P-I), and Phosphagain 2 (P-II) groups after 35-d and 84-d of supplementation. Data are means and ± SD.

If these nutritional strategies are effective in promoting lean tissue accretion during training, one would expect that subjects supplementing their diet with carbohydrate (P group) would promote significantly greater gains in STLM in comparison to athletes training while maintaining normal dietary practices (NS group). Further, supplementing the diet with fortified carbohydrate/protein powders containing nutrients purported to promote lean tissue accretion (i.e., MRx, P-I and P-II groups) would promote greater gains in STLM than the NS and P groups. Interestingly, increasing dietary availability of carbohydrate (P group) and

protein (MRx group) during training did not result in significantly greater gains in STLM in comparison to the NS group. However, there was evidence that P-I and P-II supplementation during training promoted greater gains in STLM in comparison to the NS, P, and MRx groups.

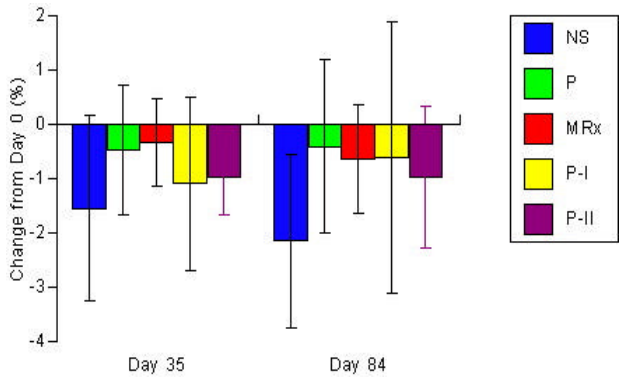

Figure 4. Changes in DEXA determined % body fat for the non-supplemented (NS), carbohydrate placebo (P), Met-Rx (MRx), Phosphagain (P-I), and Phosphagain 2 (P-II) groups after 35-d and 84-d of supplementation. Data are means and ± SD.

While the etiology of the greater increases in STLM observed in the P-I and P-II are unclear, there are several points that should be noted. First, gains in STLM observed during the hypertrophic resistance-training phase in the NS (0.7±1.4 kg), P (1.2±1.6 kg), and MRx (0.5±1.2 kg) groups were typical of gains previously reported in response to 4 to 8 weeks of resistance-training (10). Second, no significant differences were observed among these groups in gains in STLM. These findings suggest that supplementing the diet with carbohydrate and the popular vitamin and mineral fortified carbohydrate/ protein meal replacement powder Met-Rx did not promote significantly greater gains in STLM during training than subjects maintaining normal dietary practices. Third, gains in STLM in the P-I group following Phase I of training (2.5±1.3 kg) were 1.1 to 4 times greater than the gains observed in the NS, P, and MRx groups. Furthermore, the overall gains in STLM in the P-I group (2.1±1.9 kg) were 0.9 to 2 times greater than the NS (0.7±1.8 kg), P (1.1±1.6 kg), and MRx (1.1±1.5 kg) groups following 84 days of training. These gains could not be explained by a disproportionate increase in total body water, greater caloric intake, or differences among groups in training energy expenditure. Moreover, fat mass was slightly decreased throughout the training period (-0.4±2.9 kg). Consequently, P-I supplementation during training was effective in promoting greater gains in STLM without gains in fat mass.

While it is unclear which individual or combination of nutrients was responsible for the gains in STLM observed, the theoretically active nutrients include creatine monohydrate, taurine, yeast-derived RNA, and L-glutamine. Creatine supplementation (20 g/d for 5 to 28 days) has been reported to increase intramuscular total creatine content (12-18) and increase body mass and/or fat free mass (1,8,12,19-28) possibly due to fluid retention (13,29) and/or enhanced skeletal muscle protein synthesis (27,30). Studies indicate that long-term supplementation (> 7-d) of creatine alone (8,12,19,20,21,25,26,27), creatine with glucose (8,24,25), and creatine with carbohydrate/protein powders (1) promote significantly greater gains in body mass and/or fat free mass in comparison to placebo controls. The amino acid taurine is the second most abundant free amino acid in human skeletal muscle, compartmentalized primarily in type I muscle fibers (31). There is evidence from animal studies that taurine may potentiate the actions of insulin (32,33). Nucleotides (liberated from RNA) serve as precursors in nucleic acid synthesis, participate in energy transfer reactions, and function as coenzymes (34). Finally, glutamine has been reported to be important in modulating cellular hydration/volume (35) and regulating protein synthesis in skeletal muscle (36,37). While additional study is necessary to examine the potential additive and/or synergistic interactions that nutrients contained in the P-I formulation

may have on lean tissue accretion, present data support our initial findings (1) that this nutritional formulation may serve as an effective means of promoting lean tissue accretion during resistance-training.

Fourth, the primary difference between the P-I and P-II formulations was that P-II contained less carbohydrate (18 $g \cdot d^{-1}$) and had an additional 12 g/day of protein, 5.5 g/day of HPCE pure creatine monohydrate, 725 mg/day of yeast-derived RNA, 1.8 g/day of L-glutamine, 3.2 g/day of taurine, and 6.75 g/day of calcium α-ketoglutarate. Dietary availability of calcium has been reported to positively affect fat free mass (7). Moreover, if the theoretically active nutrients described above and/or calcium α-ketoglutarate affect lean tissue accretion, one would expect greater gains in STLM in the P-II supplemented group. Results revealed that the gains in STLM observed in the P-II supplemented group following Phase I of training (3.5±1.9 kg) were 2.9 to 7 times greater than observed in the NS, P, and MRx groups and non-significantly greater (40%) than the P-I group. Further, that gains in STLM in the P-II group following 84-d of supplementation (3.4±2.2 kg) were 3.1 to 4.9 times greater than the NS, P, and MRx groups and significantly greater (67%) than the P-I group. Once again, these gains could not be explained by disproportionate increases in total body water, greater caloric intake, and/or differences among groups in training energy expenditure. Moreover, they occurred despite a -0.6±1.2 kg decrease in fat mass. While it is unclear which nutrient or combination of nutrients may have promoted the additional gains in STLM, results suggest that this nutritional formulation may be particularly effective in promoting lean tissue accretion during training.

Strength

Resistance-training typically promotes gains in muscular strength through a combination of neural adaptations and muscle hypertrophy (10). Results of the present study indicate that mean gains in 1RM bench press in the MRx, P-I and P-II groups were significantly greater than gains observed in the NS group (NS 2.0±9; P 7.6±7; MRx 9.8±6; P-I 10.3±5; P-II 10.0±8 kg). However, no significant differences were observed among the P, MRx, P-I and P-II groups. These findings suggest that subjects supplementing their diet with MRx, P-I and P-II promoted greater gains in upper extremity strength than subjects maintaining normal dietary practices during training. Interestingly, P-I and P-II supplementation (which contain 20 and 25 g/day of creatine monohydrate, respectively) did not promote significantly greater gains in 1 RM strength in comparison to supplementing the diet with carbohydrate or MRx despite significant gains in STLM. These findings appear to contrast reports that creatine supplementation during training may increase gains in 1RM strength (8,17,20,21,22,23,25,26,38). Moreover, no significant differences were observed in the number of repetitions performed at 70% of 1RM or total lifting volume among groups. These findings contrast previous reports that supplementing the diet with creatine may increase muscular endurance (8,12,17,21,26,39). This may be due, in part, to the manner in which the 70% of 1RM tests were conducted. In this regard, subjects lifted 70% of their new 1RM following 35-d and 84-d rather than being retested on lifting 70% of their pre-supplementation 1RM. Consequently, muscle endurance at a given percentage of 1RM could be assessed while controlling for changes in 1RM strength. Nevertheless, results indicated that gains in 1RM strength in the MRx, P-I and P-II groups were significantly greater than gains in the NS group but that there were no differences in muscular endurance when lifting 70% of their new 1RM. Additional research should investigate the effects of ingesting creatine-containing supplements on alterations in strength during training.

SUMMARY

Results of this study indicate that subjects supplementing their diet with P-I and P-II during off-season college football training had significantly greater gains in STLM in comparison to subjects maintaining a normal diet or supplementing their diet with near isocaloric amounts of a carbohydrate placebo or a popular meal replacement powder. Furthermore, gains in 1RM strength in the MRx, P-I, and P-II supplemented groups were significantly greater than gains in the NS group. Gains in STLM and strength were primarily observed during phase I of resistance/agility training while these measurements were essentially maintained during phase II of training/spring football practice. These findings could not be explained by differences among groups in percentage of total body water, caloric intake, and/or differences in energy expenditure. While additional research is necessary to examine potential additive and/or synergistic interactions that nutrients contained in the P-I and P-II formulations may have on lean tissue accretion during resistance-training, results indicate that these nutritional formulations may serve as effective nutritional strategies in enhancing lean tissue accretion particularly during intense periods of resistance/agility training.

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