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The Effect Of Ornithine Alpha-Ketoglutarate (Okg) On Healthy, Weight Trained Men

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ROBERT D. CHETLIN, RACHEL A. YEATER, IRMA H. ULLRICH, W. GUYTON HORNSBY, JR., ¹CARL J. MALANGA, AND RANDALL W. BRYNER. **The Effect Of Ornithine Alpha-Ketoglutarate (Okg) On Healthy, Weight Trained Men.** *JEPonline*, 3(4):37-47, 2000. The purposes of this study were to determine if OKG consumption (10 grams/day) improves strength, power and body composition in weight-trained men, and; evaluate OKG-effects on insulin and growth hormone blood concentrations, dietary intake, training intensity and volume. Eighteen resistance-trained men (age range 18-35) participated in a six-week double-blind study. Subjects were randomly assigned to an experimental (n=8) or placebo (n=10) group and were subsequently tested in 1-RM squat, 1-RM bench press, Wingate test, vertical jump, and hydrostatic weighing. After a 12-hour fast, subjects received 75g carbohydrate drinks and either OKG (10 grams) or placebo. Blood samples were obtained at baseline, 30, 60, and 90 minutes and analyzed for growth hormone, insulin and glucose. Subjects recorded their diet and training. Training volumes were similar between groups at study start and conclusion. Baseline dietary data was similar between groups except OKG-group consumed more carbohydrates (329±77g vs. 250±68g, p<0.05). Macronutrient consumption, however, was not different between groups during the experiment. Performance variables were not different between groups during the course of the study. The OKG group had a greater percentage increase in bench press strength (114±9kg vs. 123±2kg, 6.6% increase) versus controls (117±2kg vs. 118±2kg, 1.5 % increase), p<0.05. Strength gains in the squat were not different between groups. Acute training variables (i.e. sets, repetitions, exercise number) declined in both groups, while training intensity increased. Total training volume was not different between groups. No differences were noted between groups in mean levels of insulin or growth hormone after six weeks following OKG challenge. Conclusion: OKG did not alter insulin or growth hormone blood concentrations after six weeks in experienced weight-trained men. OKG does not result in increased training intensity, training volume, or muscle mass in free-living men. OKG effects on strength are unclear since bench press performance improved but squat performance did not.

Key Terms: ergogenic aid, resistance training, strength, insulin

INTRODUCTION

Ornithine alpha-ketoglutarate (OKG), a nutritional supplement, has gained a great deal of attention in both the scientific and athletic communities for its anabolic and anti-catabolic properties. Supplement manufacturers and distributors have described OKG as an ergogenic aid similar to the anabolic-androgenic steroids. OKG is an ionic salt that contains two molecules of ornithine and one molecule of alpha-ketoglutarate. Ornithine, an amino acid, is required for the normal functioning of the urea cycle, where ammonia is trapped to form urea. Alpha-ketoglutarate is the carbon skeleton of the amino acid glutamate. This amino acid analogue is an

intermediate in the citrate (Kreb's) cycle and plays an essential role in a variety of transamination reactions (1). OKG has demonstrated marked anabolic and anti-catabolic effects in healthy persons and individuals that have sustained trauma (2-4). The compound stimulates the release of insulin and growth hormone while raising levels of amino acids and their metabolites, presumably making them available for protein synthesis. Concurrently, OKG reduces the catabolic markers of protein degradation (5-6). Although OKG's mechanism of action is poorly understood, it is believed that the anabolic actions of insulin and growth hormone contribute to the supplement's influence on protein metabolism (5-6).

OKG has been used to treat burn and traumatic injury, surgical trauma, hepatic dysfunction, and acute and chronic malnutrition. The supplement was effective at doses of 10 grams per day or more (2-4). Previous research has shown that OKG administration results in the synthesis of many compounds which inhibit protein catabolism or stimulate protein synthesis. These include glutamate, glutamine, proline, arginine, polyamines and specific keto acids (2-4). Although glutamate has little direct effect on protein metabolism, all amination and transamination reactions involving the formation of glutamate from alpha-ketoglutarate result in nitrogen utilization rather than nitrogen loss via ureagenesis and excretion. Such "nitrogen economy" promotes the positive nitrogen balance crucial to protein anabolism and is believed to be the mechanism of OKG's nitrogen-sparing effect (7). OKG has been and is currently being used as an ergogenic nutritional supplement in those individuals pursuing enhancement of muscle strength and function. Such individuals are typically males experienced in resistance training who are highly motivated to improve muscle mass and strength, but are not utilizing an externally controlled training regimen. It is not known whether OKG has sufficient anabolic effect to result in an increase in training intensity or volume in these subjects. To our knowledge, no scientific studies have been done assessing the anabolic effectiveness of OKG on weight-trained athletes. Therefore, the purposes of this study were: 1) to determine if ornithine alpha-ketoglutarate (OKG), taken as a nutritional supplement by weight-trained subjects, promotes increases in muscular size, strength and power; 2) to determine if OKG increases insulin and growth hormone blood concentrations or changes dietary intake patterns, and; 3) to determine if daily OKG ingestion facilitates a change in training volume in free-living males experienced in resistance training and motivated to improve strength performance.

METHODS AND PROCEDURES

Subjects

Twenty men, 18-35 years of age, who weight trained for a minimum of one year using a resistance exercise regimen of six or more training hours per week, participated in the study. By self-report, subjects were taking no medications, nor had they used any International Olympic Committee (IOC) banned substance within the preceding six months (8). Subjects were asked not to consume other nutritional supplements during the study. Eligibility for the study was determined by questionnaire. HDL cholesterol was measured and subjects were excluded if levels were below 35 mg/dL, suggesting unreported anabolic-androgenic steroid use (9-11).

Study groups

Subjects were randomly assigned to either an OKG group (N=10) or to a placebo group (N=10). Each subject was instructed to ingest either 10 grams of OKG capsules daily or 10 grams of placebo capsules daily, depending upon group assignment, with both the subjects and primary investigator blinded to which supplement was given. Each subject received his allotment of OKG or placebo in six weekly portions. Subjects consumed OKG or placebo with a 75g-carbohydrate drink approximately 90 minutes prior to training, or upon awakening. On non-training days, the supplement was taken before or with breakfast. If the subject forgot to take his daily allotment of OKG or placebo at the appropriate time, he took the supplement later that day. Subjects were instructed not to double the intake the next day if it had been forgotten completely.

Training records

Prior to enrollment, the study was explained in detail to each prospective subject. Informed consent was obtained. Subjects were given a health history, a training/athletic history questionnaire and were instructed how to complete training records. To collect baseline data, subjects were asked to fill out a training record for the week prior to the study. All participants turned in weekly training records throughout the six weeks of the investigation. In addition, the training record allowed the volunteers to monitor changes in their rest, injuries and work/school schedule. Subjects continued their normal training regimens over the six-week period, but were specifically encouraged to increase the resistance anytime they “felt good” or “felt strong”.

Diet records

All subjects were instructed how to complete a diet record before the study began using plastic models depicting portion sizes of various foods and beverages. To determine baseline characteristics, participants were asked to record all food and drink consumption for the week prior to the beginning of the investigation. Subjects were asked not to change their diets during the six-week course of the study and subjects were instructed to record all food and drink intake and to estimate the respective portion sizes. Subjects were required to consume a daily minimum amount of protein equivalent to 0.8 g/kg body weight. Each participant submitted his diet record on a weekly basis. The diet record, as well as the training record, had to be submitted on a weekly basis in order for each individual to continue receiving supplement. Diet records were analyzed using Nutritionist IV software.

Testing procedures

Pre-testing took place over the course of two days with 48 hours between testing days. Subjects were asked to refrain from all training activities during the testing period. The first day of testing consisted of the resting metabolic rate determination, vertical jump test, skinfolds and circumferences and Wingate test. The second day of testing consisted of hydrostatic weighing, 1-RM squat and 1-RM bench press. Subjects were permitted to consume food and water *ad libitum* when appropriate during the pre-testing phase. Post-testing was identical to pre-testing and took place six weeks afterwards.

Carbohydrate tolerance test and resting metabolic rate determination (RMR)

Carbohydrate tolerance test and RMR were measured after a 12-hour fast and 24-hours post-exercise. An indwelling catheter was inserted into an arm vein after which each subject rested quietly in a reclining position for 30 minutes in a low light, temperature-controlled room. An expired air sample was collected at 28 and 29 minutes and was used for determination of resting metabolic rate. Blood was drawn at 0 (baseline) minutes and at 30, 60, and 90 minutes after supplement (10g OKG) and carbohydrate (75g) ingestion. Growth hormone, insulin and glucose were assayed on all samples. Growth hormone was measured with a double-antibody human growth hormone I-125 radioimmunoassay procedure (Diagnostic Products Corporation). Samples below the minimal detectable amount were assigned a score of zero. Insulin was measured with a Coat-A-Count Insulin I-125 Radioimmunoassay technique. Serum glucose was determined using a Sigma Glucose (Trinder) 500 assay.

Vertical jump test

The vertical jump test was used to measure explosive anaerobic power generated by the legs. Each subject stood sideways to a wall with a measuring device attached to the wall surface. The fingertips of each subject's dominant hand were dusted with magnesium-carbonate chalk. With feet flat on the floor, each subject extended his dominant arm in a maximal superior position, marking the wall with his chalked hand. The subject leapt

vertically, touching the wall with extended chalked hand at the apex of his jump. The distance between the two chalked points was the vertical jump value. The best of three trials was used for analysis.

Skinfolds and circumferential measurement, hydrostatic weighing

Each subject's body weight was recorded, and body composition was assessed by the hydrostatic weighing technique. Skinfold measurements were taken with John Bull calipers at the following sites: biceps, triceps, subscapula, suprailiac, chest and abdomen. Circumferential measurements were taken at the arm, forearm, chest, waist, hip, thigh and calf. Hydrostatic weighing was determined using the method of Warner (12). Residual volume was determined using the oxygen dilution technique (13).

Wingate power test

The Wingate test was used to measure each subject's peak anaerobic power and mean power output. Subjects rode an adjustable Monark bicycle ergometer with toe clips. They warmed-up at a comfortable speed with zero resistance for approximately 30 seconds. Resistance was added equivalent to 9% of the subject's body weight and each subject pedaled as fast as he could for 30 seconds.

One-repetition maximum squat

Before testing, subjects were permitted to familiarize themselves with the lifting area, barbell, weights and squat rack. Subjects warmed up in their usual manner. The barbell was placed in the squat rack at a height most comfortable for the subject. Subjects positioned the bar across a muscular ridge formed by retracting the scapulae and elevating the posterior deltoids and trapezius muscles. The subject unracked the weight by standing erect and backed away 2-3 steps from the rack. The subject lowered his body in a deep knee bend until the anterior aspect of the thighs near the inguinal crease reached a position approximately parallel with the floor. The subject then returned, without hesitation, to the original standing position with knees locked out. The principal investigator demonstrated for each athlete what was considered an admissible lift prior to testing and determined if each lift was acceptable. Subjects were requested to start with a weight they could normally handle for five repetitions. After each successful attempt, the weight on the barbell was increased in reasonable increments chosen by the subject. Each athlete was allowed up to five minutes rest between attempts. The one-repetition maximum (1-RM) squat test was concluded once the subject could no longer complete one repetition and the highest previous successful attempt was counted as the 1-RM. If the subject successfully finished any attempt, but failed to meet the criteria for a valid attempt, another attempt at the same weight was permitted. Subjects could use some or all of the following equipment in addition to their normal training attire while performing the 1-RM tests, provided the same equipment was used for all trials: lifting belt, knee wraps, wrist wraps, one-piece lifting suit, magnesium-carbonate chalk, ammonia capsules (smelling salts).

One-repetition maximum bench press

Before testing, subjects were permitted the same familiarization and warm-up procedures observed with the 1-RM squat test. Subjects were requested to begin with a weight that they could normally handle for five repetitions. Each subject began the test by reclining on the bench with head, shoulders and buttocks firmly secured against the bench and feet on the floor. Each subject removed the barbell from the rack, or received a "lift-off" from one of the spotters. The bar was then positioned at arm's length with elbows locked. The subject lowered the bar to the pectoral area under control, touched the bar to the chest and pressed the weight to arm's length in one continuous motion until the elbows locked while keeping the head, shoulders and buttocks against the bench and feet on the floor or platform. The subjects were not permitted to bounce the weight off the chest in order to complete the lift. Similar procedures were used as noted in the 1-RM squat.

Exercise protocol

After pre-testing, subjects continued their normal training regimen for six weeks. Subjects were allowed to perform additional sets with or without additional weight if they desired. Training volume of weight lifted (i.e. sets x reps x weight used) and total lifting time per session were recorded.

Data analysis

Pre-test data were analyzed for group differences using an independent t-test. Variables measured weekly and the multiple sample hormone data were analyzed with two-way repeated measures analysis of variance. Variables measured one time during the pre-test and post-test were analyzed with an analysis of covariance using the baseline value as the covariate. Total aggregate lifting volume for six weeks was calculated for each group and analyzed with an independent t-test.

RESULTS

Subject characteristics

Subject activity classification, taken from the training/athletic history questionnaire, revealed that the OKG group consisted of one powerlifter, two bodybuilders, three competitive athletes and two health fitness enthusiasts. The placebo group consisted of one powerlifter, one body builder, three competitive athletes and five health fitness enthusiasts. Two subjects in the OKG group dropped out of the study during the fifth week of the experimental period for unknown reasons. Subject characteristics, training history, baseline training, and dietary information can be found in table 1. An independent t-test found that pre-study descriptive, training and dietary data were not different between the groups, except that daily carbohydrate intake was significantly higher ($p < 0.05$) in the OKG group at baseline. There was no difference, however, in carbohydrate, or any other nutrient or total caloric consumption, between groups during six weeks of treatment.

Table 1. Subject Characteristics: Descriptive Data and Baseline Training and Dietary Information (M \pm SE)

	<i>OKG (n=8)</i>	<i>Placebo (n=10)</i>
<i>Age (yrs)</i>	22.5 \pm 1.8	23.8 \pm 1.2
<i>Height (cm)</i>	176.3 \pm 3.5	180.1 \pm 1.4
<i>Weight (kg)</i>	83.3 \pm 3.8	84.5 \pm 2.9
<i>Age Started Training (yrs)</i>	13.9 \pm 0.7	16.7 \pm 1.4
<i>Years Training</i>	8.0 \pm 2.2	7.6 \pm 1.5
<i>Training Days (/week)</i>	4.9 \pm 0.4	5.5 \pm 0.2
<i>Training Hours (/week)</i>	8.2 \pm 0.8	7.6 \pm 0.5
<i>Repetitions (/week)</i>	734 \pm 117	676 \pm 85
<i>Sets (/week)</i>	73 \pm 7	71 \pm 5
<i>Volume^a (kg/week)</i>	58,367 \pm 15,466	38,382 \pm 4,065
<i>Kcals (/week)</i>	2,524 \pm 150	2,202 \pm 81
<i>Protein (g/week)</i>	127 \pm 22	121 \pm 13
<i>Protein Ratio^b (/week)</i>	1.5 \pm 0.2	1.5 \pm 0.2
<i>CHO (g/week)</i>	329 \pm 27 *	250 \pm 21
<i>Fat (g/week)</i>	70 \pm 11	75 \pm 6

^a reps x sets x wt. used; ^b g/kg bwt/day; * $p < 0.05$

Performance Testing

Performance test data is shown in table 2. Analysis of covariance, with the pre-test value as covariate, demonstrated no differences between the groups for power data. There was a significant increase ($p < 0.05$) in

the adjusted means for bench press strength in the OKG group compared to placebo control (figure 1). There was no difference between the groups in squat strength.

Table 2. Performance Test Data (M±SE)

	<i>OKG (n=8)</i>		<i>Placebo (n=10)</i>	
	Pre	Post #	Pre	Post #
<i>Resting Heart Rate (beats/min)</i>	71 ± 3	67 ± 2	69 ± 3	68 ± 2
<i>Resting Systolic BP (mm Hg)</i>	123 ± 3	126 ± 3	125 ± 5	127 ± 3
<i>Resting Diastolic BP (mm Hg)</i>	74 ± 3	80 ± 4	80 ± 3	73 ± 4
<i>Mean Power a (W)</i>	482 ± 51	460 ± 52	437 ± 40	471 ± 46
<i>Fatigue Rate a (%)</i>	33.6 ± 4.8	37.3 ± 3.7	30.2 ± 3.1	43.1 ± 3.3
<i>Squat (kg)</i>	153 ± 18	158 ± 3	149 ± 14	159 ± 3
<i>Bench Press (kg)</i>	114 ± 9	123 ± 2 *	117 ± 12	118 ± 2

adjusted post-test means; * p<.05

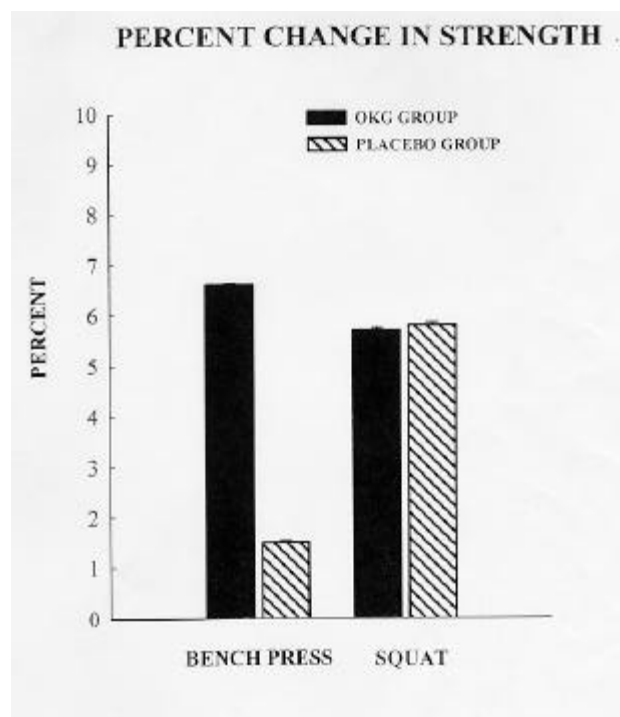


Figure 1: Percent change in bench press strength was greater (p<.05) in the OKG group versus controls from pre-test to post-test. Percent change in squat strength was not different between groups.

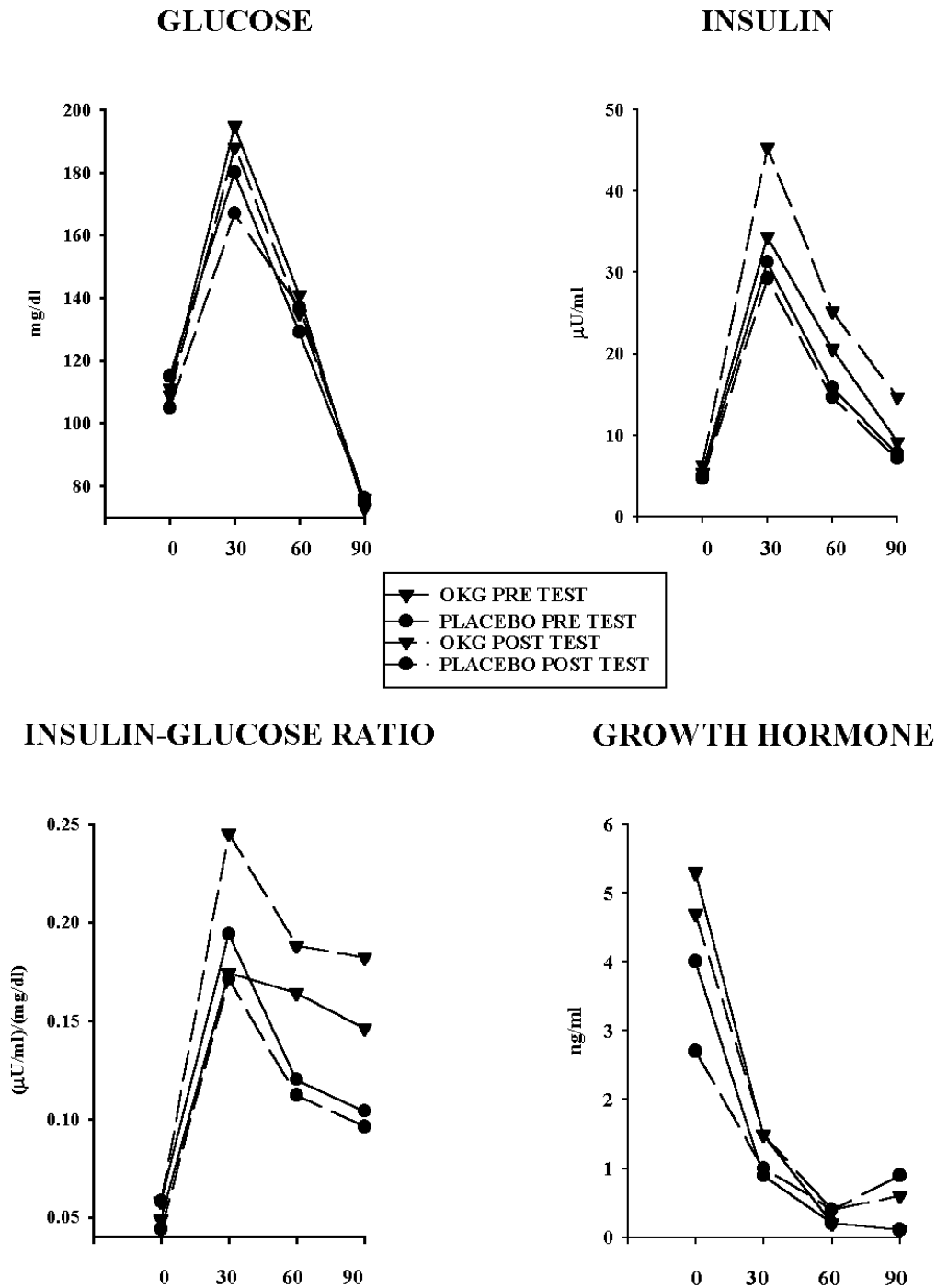


Figure 2

Glucose and growth hormone were not different between the groups for either pre-test or post-test. The insulin/glucose ratio did not differ within either group across tests. No interactions were observed for any blood variable.

Body composition and anthropometrics

Analysis of covariance utilizing the pre-test value as covariate revealed no differences between the groups on any hydrostatic weighing or anthropometric variable.

Hormone profiling

Two-way repeated measures analysis of variance found no main effect in growth hormone concentration, insulin concentration or the insulin/glucose ratio between the groups after six weeks of treatment (figure 2). Post-test growth hormone concentration ninety minutes after supplement and carbohydrate ingestion was significantly higher than pre-test values ($p < 0.05$) in both groups. Additionally, post-test insulin concentration sixty minutes after supplement and carbohydrate consumption tended to be higher than pre-test values ($p < 0.08$) in the experimental group versus control.

Weekly dietary and training information

There was no difference between the groups for any training variable at the commencement of the study. Of the dietary variables, only carbohydrate consumption was higher ($p < 0.05$) in the OKG group at baseline, but there was no difference in carbohydrate or any other nutrient intake during the course of the six-week investigation. The acute training variables of sets, repetitions and exercise number were significantly lower ($p < .01$) in week six of the experiment compared to week one in both groups. Total training volume (sets x repetitions x resistance used) was not different between groups at any time. There was no difference in training between the groups throughout the six-week experimental period.

DISCUSSION

This investigation was designed to simulate a free-living environment analogous to that in which nutritional supplements might normally be used and, therefore, no attempt was made to alter either the subjects' training or dietary practices. Review of training and dietary records in the groups confirmed that random assignment had successfully achieved similar groups. Mean age, height, weight, age at which subjects started training, number of training years, days and hours of training per week and total training volume did not differ between the groups. Both groups were characterized by similar baseline measurements in body composition, anthropometric values, maximal bench press and squat strength, vertical jump and Wingate test. Of dietary variables initially assessed, only daily carbohydrate intake differed (higher in the OKG group) significantly, but there was no difference in carbohydrate consumption between the groups during the actual six-week experimental period. Therefore, the nutrient intake patterns of both groups were similar throughout the course of the investigation.

Significant changes were observed in several training variables for both groups during the six-week study. Mean number of exercises performed, sets and repetitions declined in both groups from week one of the investigation to week six. Total lifting volume (i.e. sets x repetitions x resistance used) was not different between groups during the study indicating that OKG did not affect this variable. The increased lifting intensity observed in both groups typifies a training "periodization" strategy where sets and repetitions decrease but the amount of weight lifted (i.e. the weight on the barbell) for each exercise increases, thus producing either no change or modest differences in the total lifting volume (14). This type of regimen prevents over-training and optimizes peak strength performance by producing physiological and neurological adjustments to the increased stress of elevated training intensity. Periodization is based on the General Adaptation Syndrome model, first proposed by Canadian endocrinologist Hans Selye, and is intended to maximize strength and/or power (15). It is interesting to note that although the subjects were free to pursue whatever training strategy they desired, that overall, these participants selected this type of approach to optimize their strength gains. This phenomenon may

indicate that the volunteers were preparing for the post-test in the same manner that they would prepare for an athletic competition. Though both groups increased strength equally in the squat, the OKG group increased strength significantly more than controls in the bench press. Percent change scores indicated the OKG group increased bench press strength by 6.6% while the control group experienced a 1.5% gain in strength. If OKG is responsible for strength changes in bench press performance, it is somewhat puzzling why similar changes were not found in squat strength. One possible explanation is as follows. Most of the subjects routinely performed the bench press as part of their workout prior to the study, but not the squat exercise. Therefore, the squat exercise was a novel training task for these subjects. In an untrained muscle group, the first adaptation to resistance training is neurological, i.e. learning to increase muscle recruitment (16). In the first six weeks there might be nominal improvement due to changes in muscle, for example, protein synthesis or hypertrophy. The literature does not indicate that OKG would be effective in altering neurological capacity. Therefore, both groups would be expected to have similar improvements if adaptation were neurological and training exercises were the same, as in this study. Alternatively, in trained muscles like those used for the bench press in these subjects, one would expect improvement, if it occurred, to be predominately due to changes in muscle function rather than neurological changes. OKG may have produced changes in muscle function in these trained tissues (i.e. an increase in protein synthesis) which could have resulted in the 6.6% increase in strength gains seen in the treatment group.

Though there were no differences in growth hormone response between the groups after six weeks of treatment, both groups demonstrated a significant increase in growth hormone blood concentrations ninety minutes after supplement ingestion compared to baseline. Since a variety of factors may contribute to changes in growth hormone stimulation, including age, gender, dietary practices, diurnal and pulsatile variation, rest, lifestyle and exercise, it may be possible that one or more of these intervening influences may have contributed to the increased growth hormone concentration observed in the post-test (17-18). It should be noted, however, that the chronic responses of growth hormone to resistance training have not been extensively examined and it might prove problematic to implicate the participants' training habits as the primary cause of the increased growth hormone concentration observed in this study. Nonetheless, some have suggested that a resistance-training intensity threshold, associated with repeated changes in hydrogen ion concentration, may exist that contributes to increased chronic growth hormone release (17-18). Such intensity levels are an integral part of periodized routines designed to elicit improvements in maximal strength.

Insulin concentrations were not different between the groups, although the OKG group tended to have increased post-test insulin concentration sixty minutes after supplement ingestion versus controls. While insulin is known to have significant anabolic properties, hyperinsulinemia has also been implicated in promoting atherosclerosis. Glucose values were also assayed over the 90-minute pre-test and post-test blood draws and an insulin/glucose ratio was formulated for each group. Though some levels of plasma glucose appeared high at the 30-minute mark, no subject fit the criteria for impaired glucose tolerance or diabetes mellitus established by the American Diabetes Association (19). No differences for the insulin/glucose ratio were observed within the OKG group or placebo group from pre-test to post-test. Therefore, the subjects did not become less sensitive to insulin. Furthermore, increased blood pressure, a marker for insulin resistance, was not seen.

Several studies have reported that OKG increases insulin and growth hormone blood concentrations in healthy individuals (2-4). Our investigation did not confirm these previous findings. Some of the reasons we may not have seen these changes may be due to the confounding effects of other endogenous hormones, including cortisol, testosterone and the catecholamines. The role these hormones may play in altering insulin and growth hormone release in weight trained individuals chronically ingesting OKG has yet to be determined. Cortisol

and the catecholamines, for example, are counter-regulatory to insulin and persistent, elevated levels of these substances may interfere with normal insulin function. In addition, changes in serum cortisol, catecholamines, testosterone and growth hormone have all been observed with various weight training programs (20-22). While hormone responses may vary widely depending upon individual training, skill level, muscle groups utilized, exercise mode, exercise intensity and exercise volume (9,18,23), our subjects were similar in all of these training parameters. They did, however, increase their exercise intensity over the course of the six-week experiment. Although stress hormones were not measured in this study, one could speculate that the increased training intensity of the groups could have resulted in increased secretion of stress hormones that may have interfered with insulin secretion.

In summary, daily ingestion of ten grams of OKG with carbohydrates for six weeks did not change training intensity or volume compared to a placebo control group. OKG consumption did not alter insulin concentration, growth hormone concentration or dietary intake over six weeks versus controls. Additionally, six-week OKG supplementation in weight trained men did not improve power performance or squat strength above placebo. The OKG group did, however, significantly increase bench press strength over placebo.

CONCLUSIONS

OKG did not cause a change in training intensity or volume, or result in an increase in muscle mass. However, ten grams of OKG taken daily with carbohydrates for six weeks produced small changes in bench press performance, but not squat performance. Therefore, the effect of OKG on strength remains unclear. OKG did not alter blood concentrations of insulin or growth hormone at the time periods measured in this study. Further research is needed to determine whether OKG has an anabolic effect in healthy, free-living males void of traumatic injury.

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