

Low-calorie Thermogenic Beverage and Exercise Improves Composition and Lipid Profile in Overweight and Obese Women

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Abstract

The purpose of this study was to evaluate the combined effects of a 10-week exercise program with chronic ingestion of a thermogenic energy drink on body composition, cardiovascular fitness, strength, and safety in overweight and obese women. In a double-blind placebo-controlled approach overweight and obese women (n=27) were randomly assigned to groups that consumed identically tasting treatment beverages with exercise (EX-Act: n=6; EX-PL: n=9) or without exercise (NEX-Act: n=7; NEX-PL: n=5). All participants consumed one drink per day for 10 weeks; EX-Act and EX-PL participated in a 10-week endurance and resistance training program. Fifteen minutes prior to each workout, participants consumed their assigned drink; on non-training days the same beverage was consumed *ad libitum*. Changes in body composition were assessed using a four-compartment model. Changes in muscle mass (MM) were evaluated using a previously published equation based on DXA-derived appendicular lean-soft tissue. Cardiovascular fitness and upper- and lower-body strength were assessed prior to and following the 10-week intervention. Separate two-way repeated measures ANOVAs [treatment (EX-Act vs. EX-PL vs. NEX-Act vs. NEX-PL) x time (Pre vs. Post)] indicated a significant time x treatment interaction for muscle mass (p=0.026) and total cholesterol (p=0.047); a significant time x training interaction for VO₂peak (p=0.046), ventilatory threshold (VT, p=0.014), upper- and lower-body strength (p<0.05). Post hoc analyses revealed a significant difference between the EX- and NEX-groups for percent change in muscle mass (EX-Act: 6.8 ± 2.5%; EX-PL: 5.1 ± 2.4%; NEX-Act: 1.1 ± 3.2%; NEX-PL: 1.4 ± 1.3%) and VO₂peak (EX-Act: 13.4 ± 10.1%; EX-PL: 8.9 ± 6.9%; NEX-Act: 2.1 ± 6.6%; NEX-PL: 7.2 ± 5.4%), VT (EX-Act: 46.2 ± 23.3%; EX-PL: 15.0 ± 15.6%; NEX-Act: 6.6 ± 17.5%; NEX-PL: 10.3 ± 22.4%), upper- (EX-Act: 14.4 ± 10.1%; EX-PL: 20.9 ± 8.3%; NEX-Act: 2.0 ± 3.4%; NEX-PL: 2.7 ± 7.7%) and lower- (EX-Act: 33.3 ± 23.9%; EX-PL: 31.7 ± 23.94%; NEX-Act: 1.4 ± 4.1%; NEX-PL: 1.2 ± 3.0%) body strength. Clinical markers for hepatic and renal function revealed no adverse effects in response to the beverage consumption. Total cholesterol significantly decreased for the Act supplementing groups (EX-Act: -5.0 ± 4.7%; NEX-Act: -10.7 ± 15.4% vs. EX-PL: +3.0 ± 12.8%, NEX-PL: +0.3 ± 8.9%). The current data suggest that the ACSM exercise program guidelines provide an effective measure for improving cardiovascular fitness, strength and modifying body composition. Individual data demonstrate support for implementing a single serving thermogenic drink prior to exercise, to improve muscle mass, decrease fat mass and improve lipid profiles of overweight women, compared to exercise alone.

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INTRODUCTION

Weight loss supplements are widely available and superfluously marketed, while lacking substantial efficacy and safety data. Many supplements are marketed as 'natural' and therefore relaying 'safety' again lacking supporting data. Furthermore, many weight loss supplements fail to recognize the combination of diet and exercise, as the effective way to losing weight. Many common 'natural' ingredients, such as caffeine, green tea, and ginseng, have made their way into weight loss supplements, as effective thermogenic and lipolytic ingredients. Specifically, it has previously been reported (1) that a commercially available, low-calorie thermogenic drink (Celsius®, Celsius, Inc., Delray Beach, FL) significantly increased resting energy expenditure (REE) and serum free fatty acids (FFA) in response to acute oral ingestion compared to a placebo. In addition, Roberts et al. (2) reported a decrease in percent body fat (%FAT), increased serum FFA and no significant differences in blood lipids or other metabolic safety indices after 28 days of chronic ingestion of the same energy drink versus placebo. Dalbo et al. (1) found that compared to placebo, Celsius® significantly increased REE (kcal/d) by approximately 10% after 120 minutes post-ingestion, with no change seen at 180 minutes. At 30, 60, 120 and 180 minutes post-ingestion, circulating FFA concentrations were also significantly elevated, compared to placebo. Concluding that this thermogenic drink may be an effective stimulus to promote weight loss and changes in body composition, independent of modifications in diet or exercise (1). Moreso, Lockwood et al. (3) demonstrated that when combined with exercise, consuming a thermogenic drink prior to exercise may safely improve body composition and strength and fitness in healthy men. Therefore, the purpose of this study was to evaluate the combined effects of a 10-week exercise program with chronic ingestion of a thermogenic energy drink on body composition, cardiovascular fitness, strength, and safety in overweight and obese women.

EXPERIMENTAL DESIGN

This study implemented a randomized, double-blind placebo-controlled design examining the combined effects of a 10-week pre-exercise intervention with a low-calorie energy and thermogenic beverage (Celsius®, Celsius, Inc. Delray Beach, FL) and five days per week of combined aerobic and resistance exercise. Participants were randomized into one of four groups: active energy drink + exercise (EX-Act), energy drink only (NEX-Act), placebo + exercise (EX-PL) or placebo only (NEX-PL), and consumed their respective drink one time per day, either alone or in combination with exercise. Participants consumed their respective drink *ad libitum* on the other two days per week. Body composition was assessed using a four-compartment model (4) at Baseline and after 12 weeks of exercise and supplementation. Cardiovascular and strength testing were conducted within 24 hours of baseline and post-testing, and blood safety measures were also assessed after a 12-h fast.

METHODS

| GROUP | Age (yrs) | Height (cm) | Body Mass (kg) | % BF (%) |
|---------|---------------|----------------|----------------|--------------|
| EX-Act | | | | |
| n=6 | 31.17 ± 8.23 | 164.22 ± 11.10 | 78.60 ± 9.54 | 39.59 ± 2.78 |
| EX-PL | | | | |
| n=9 | 23.56 ± 7.42 | 163.37 ± 4.64 | 73.06 ± 10.40 | 38.49 ± 3.40 |
| NEX-Act | | | | |
| n=7 | 27.86 ± 9.21 | 163.47 ± 4.31 | 68.62 ± 12.90 | 37.56 ± 2.56 |
| NEX-PL | | | | |
| n=5 | 28.40 ± 10.16 | 169.26 ± 13.12 | 79.25 ± 11.68 | 36.22 ± 1.52 |
| N=27 | 27.26 ± 8.60 | 164.67 ± 8.13 | 74.29 ± 11.33 | 38.07 ± 2.87 |

BODY COMPOSITION (4C-MODEL)

All body composition measurements were performed on the same day following a 12-hour fast (water intake was allowed up to one hour prior to testing). Hydration status was determined prior to all testing using specific gravity via handheld refractometry (Model CLX-1, precision = 0.001 ± 0.001 , VEE GEE Scientific, Inc., Kirkland, WA) to assure proper hydration from PRE (1.022 ± 0.007) to POST (1.021 ± 0.007) measurements. Fat mass (FM), percent body fat (%FAT) and fat-free mass (FFM) were estimated using the four-compartment (4-C) model described by Wang et al.(4)

$$FM \text{ (kg)} = 2.748(BV) - 0.699(TBW) + 1.129(Mo) - 2.051(BM)$$

$$\%FAT = (FM/BM) \times 100$$

$$FFM \text{ (kg)} = BM - FM$$

Where BV is total body volume, TBW is total body water, MO is total body bone mineral, and BM is body mass.

Dual-energy X-ray absorptiometry (DXA) (software version 10.50.086, Lunar Prodigy Advanced, Madison, WI) was used to estimate total bone mineral content and total body muscle mass (MM). Bone mineral content (BMC) was converted to Mo using the following equation: $Mo = \text{total body BMC} \times 1.0436$. In addition, the sum of lean soft tissue for both arms and legs (ALST), as measured by CXA, was used to estimate MM from the validated equation of Kim et al.(5). $MM = (1.13 \times ALST) - (0.02 \times \text{age}) + [0.61 \times \text{sex} (m = 0, f = 1)] + 0.97$.

Body volume (BD) was assessed from HW with correction for residual volume (RV). Residual volume was determined with the subject in a seated position using the oxygen dilution method of Wilmore (6) via a metabolic cart with residual volume software (True One 2400®, Parvo-Medics, Inc. Provo, UT.). Underwater weight was measured to the nearest 0.025kg in a submersion tank in which a PVC swing seat was suspended from a calibrated Chatillon® 15-kg scale (Model # 1315DD-H, Largo, FL.). Previous test retest measurements of eleven men and women measured 24-48 hours apart for HW produced a SEM of 0.

A deuterium oxide (D₂O) tracer was used as the criterion method to estimate TBW. Prior to D₂O ingestion, urine samples were collected from all subjects. After voiding the bladder completely, subjects ingested ≈ 11 grams of D₂O along with a 100 ml rinse of deionized water. After a four hour equilibration period restricting defecation, urination and food and water ingestions, subjects were instructed to provide a post-urine sample. Within 30 minutes of collection, all urine samples were pipette into cryogenic vials and stored at -80°C for later analysis . All urine-diluted samples were measured in triplicate at an independent laboratory (Metabolic Solutions, Inc., Nashua, NH) using an isotope-ratio mass spectrometer, and the isotope abundances in the urine were calculated as previously reported by Wong et al. (7) TBW was then calculated from the dilution of isotopic water and corrected for the exchange of deuterium with non-aqueous tissue (7). Reliability measurements from 11 men and women for D₂O in one urine sample measured in triplicate resulted in a SEM value of 0.33L.

BODY COMPOSITION CALCULATION

Body fat was estimated using the four-compartment model (4C) of Wang et al. (4) using the following equation:

$$FM \text{ (kg)} = 2.748(BV) - 0.699(TBW) + 1.129(Mo) - 2.051(BM)$$

$$\%FAT = (FM/BM) \times 100$$

$$FFM \text{ (kg)} = BM - FM$$

Where BV is total body volume, TBW is total body water, MO is total body bone mineral, and BM is body mass.

CARDIOVASCULAR TESTING

Described by Rossiter et al. (8), using a Corival 906900 (Lode B.V. Medical Technology, Groningen, The Netherlands) upright cycle ergometer participants were instructed to pedal at a cadence of 60-80 RPMs, with resistance beginning at 20 Watts (W) and increasing in 20W/min (1W/3sec) until volitional fatigue or until participants could no longer maintain >50 RPMs, despite strong verbal encouragement. Respiratory gases were monitored and continuously analyzed with open-circuit spirometry to calculate minute ventilation (V_E), oxygen consumption rate (VO₂), carbon dioxide expiration rate (VCO₂), ventilatory threshold (VT) and respiratory exchange ratio (RER) using a metabolic cart and manufacturer's software (True One 2400®, Parvo-Medics, Inc., Provo, UT). The data were averaged over 15-second intervals, with the highest 15-second VO₂ value recorded as the peak oxygen uptake (VO_{2peak}). Prior to testing, flow rate, O₂ and CO₂ analyzers were calibrated following the manufacturer's recommendations.

EXERCISE PROTOCOL

The exercise program was designed using the American College of Sports Medicine (ACSM) recommended guidelines for apparently healthy adults; all participants

were supervised by a certified trainer. Progressive endurance training, on cycle ergometers, was performed three days per week (Table 2). Resistance training was performed two days per week, providing at least 24 hours recovery between sessions. Participants completed nine isotonic exercises incorporating both single-joint and multi-joint exercises. Each exercise was performed once per session, with participants completing 8-12 repetitions per exercise, until volitional fatigue. Weight was increased when participants performed >10 repetitions, at the same resistance, during two consecutive lifting sessions.

| Table 2 | | |
|--------------------------|-----------------------|-------------|
| Week | Duration (min) | %HRR |
| 1 | 15 – 20 | 40 – 50 |
| 2 | 20 -25 | 40 – 50 |
| 3 | 25 – 30 | 50 -60 |
| 4 | 25 – 30 | 50 -60 |
| 5 | 25 – 30 | 60 – 70 |
| 6 | 25 – 30 | 60 – 70 |
| 7 | 25 – 30 | 60 – 70 |
| 8 | 30 – 35 | 60 – 70 |
| 9 | 30 – 35 | 60 – 70 |
| 10 | 30 – 35 | 60 – 70 |
| HRR = Heart rate reserve | | |

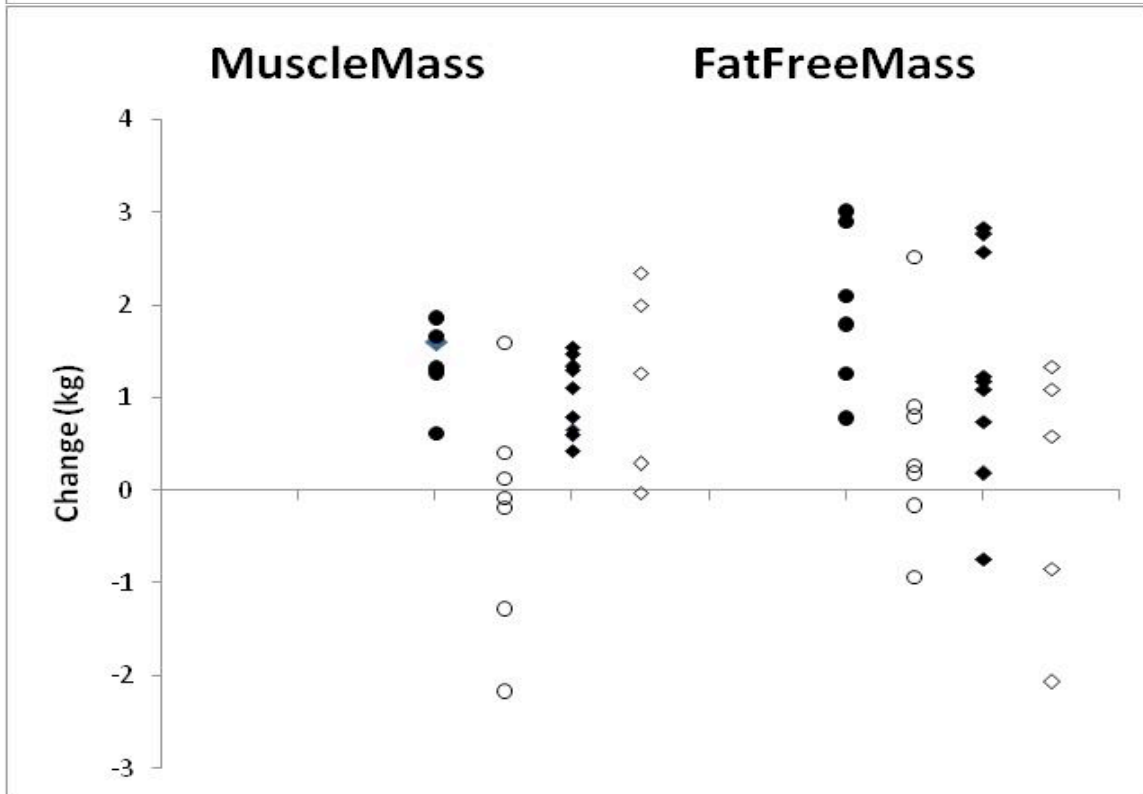
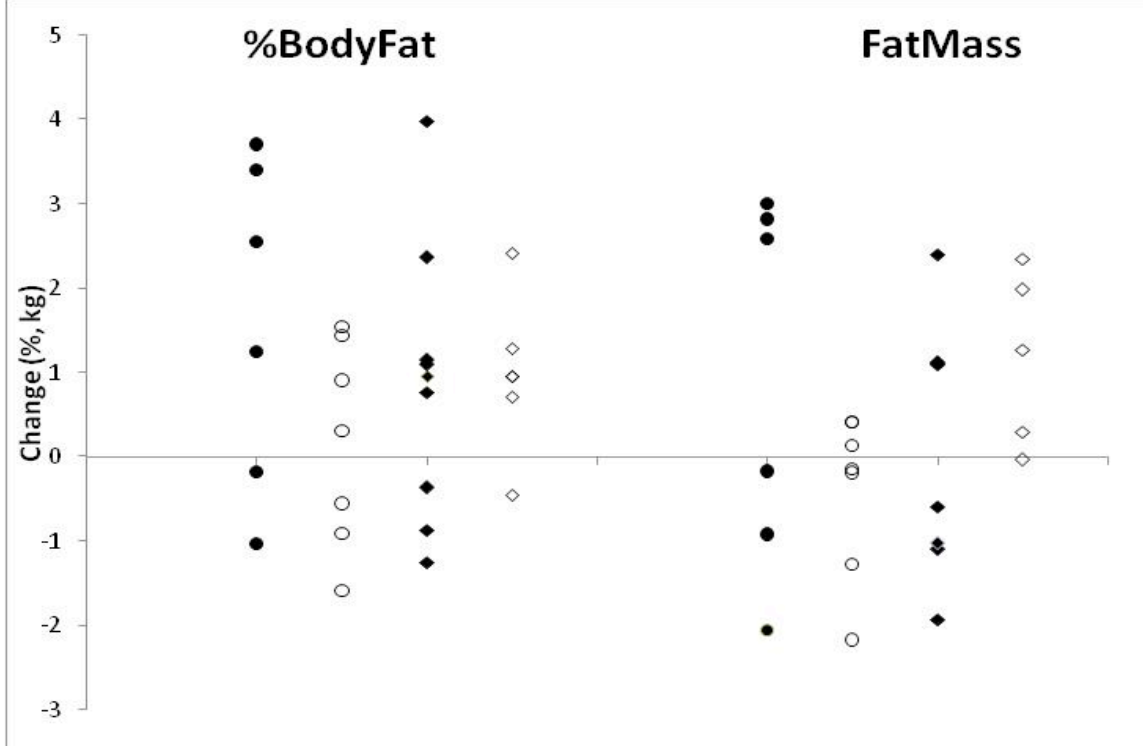
THERMOGENIC DRINK PROTOCOL

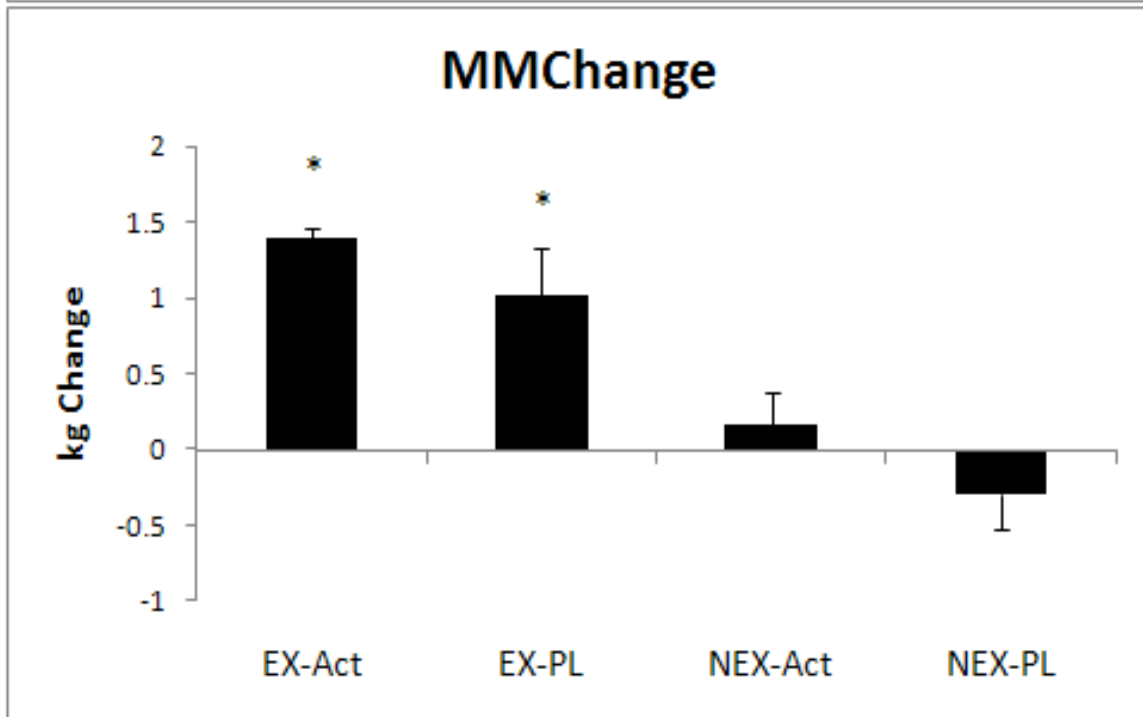
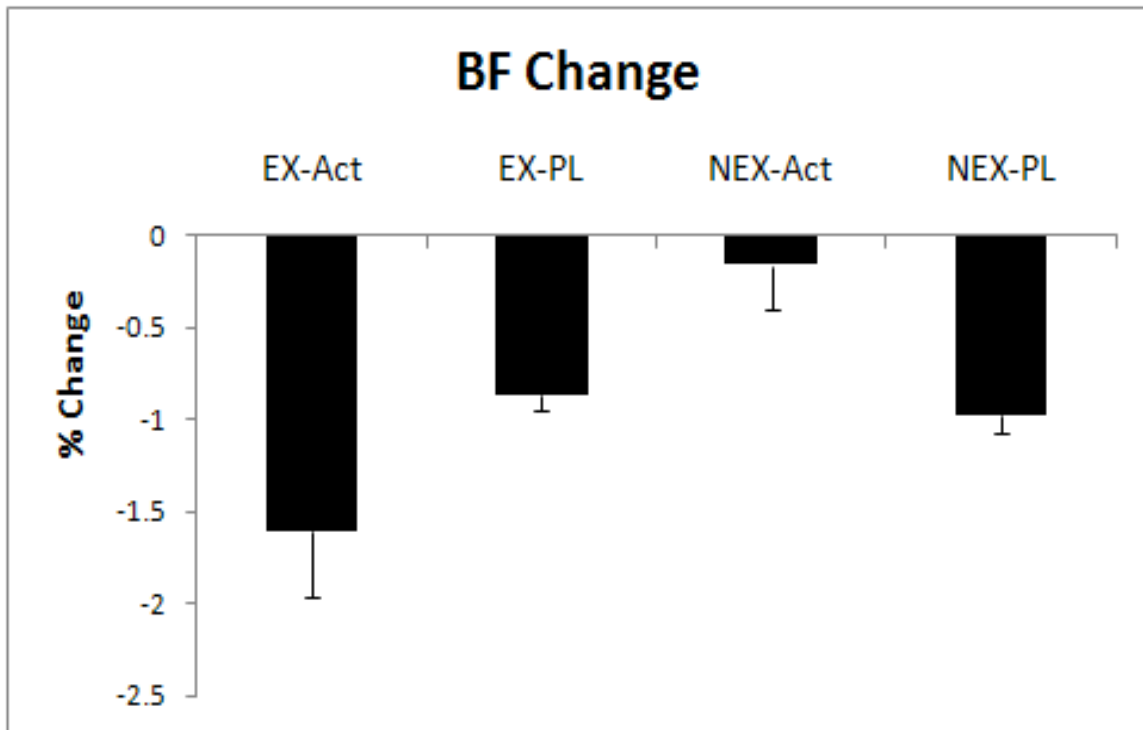
All participants were instructed to consume one drink per day, for a total of 70 consecutive days (10 weeks). During exercise days, participants reported to the training facility and consumed one drink prior to exercise; initiating exercise 15 minutes after consumption. On non-exercise days, time of day for consuming the beverage was left to the subject's discretion. Figure 1 provides the supplement facts panel for the beverage (Celsius®, Celsius Inc., Delray Beach, FL) consumed by participants in CEX. Participants in PLX consumed an identically canned and labeled placebo beverage that yielded an identical supplement facts profile, minus the "Celsius® Thermogenic Blend" (taurine, guarana seed extract, green tea leaf extract standardized to 10% EGCG, caffeine as caffeine anhydrous, glucuronolactone and ginger root extract).

| Supplement Facts | | |
|--|----------------|------|
| Serving Size 12 fl. oz | | |
| Servings per Container 1 | | |
| Amount per serving | | %DV† |
| Calories | 10 | |
| Total Carbohydrates | 1g | <1% |
| Sugar | 0g | |
| Vitamin C (ascorbic acid) | 60mg | 100% |
| Riboflavin | 1.7mg | 100% |
| Niacin (as niacinamide) | 20mg | 100% |
| Vitamin B6 (as pyridoxine hydrochloride) | 2mg | 100% |
| Vitamin B12 (as cyanocobalamin) | 6mcg | 100% |
| Biotin | 300mcg | 100% |
| Pantothenic Acid (as calcium d-pantothenate) | 10mg | 100% |
| Calcium (as calcium carbonate) | 50mg | 5% |
| Chromium (chelate) | 50mcg | 41% |
| Sodium | 6mg | <1% |
| MetaPlus™ | 1,810mg | |
| Taurine | | ** |
| Guarana extract (seed) | | ** |
| Green Tea leaf extract (leaf) standardized to 10% EGCG | | ** |
| Caffeine (as caffeine anhydrous) | | ** |
| Glucuronolactone | | ** |
| Ginger extract (root) | | ** |
| †Percent Daily Values are based on a 2,000 calorie diet. | | |
| **Daily Value (DV) not established. | | |
| Other Ingredients: Filtered Water, Natural Colors, Natural Flavors, Citric Acid, Sucralose | | |
| Contains: 200 mg total caffeine per serving | | |

Not recommended for people that are caffeine sensitive, children under 12, or women pregnant or nursing.

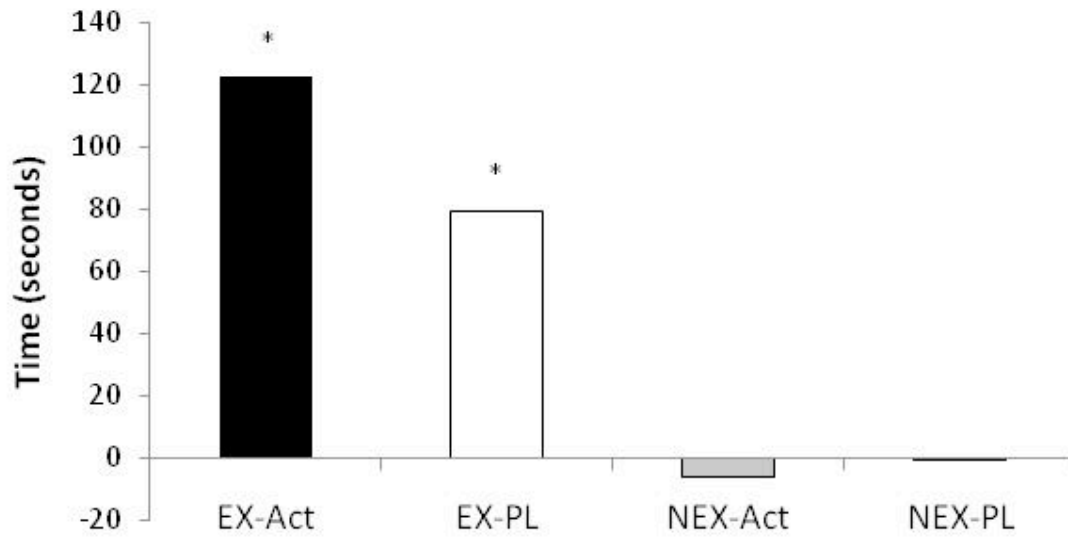
RESULTS





Using a two-way repeated measures ANOVA, significant time*treatment interactions resulted for muscle mass ($p < 0.05$). 100% of the subjects in the Act supplementing group increased Muscle mass, while 45% of the EX-PL group and 20% of the individuals in the NEX-PL group increased in muscle mass. Although the decrease in %BF was not significant, 50% of the Ex-Act group saw a decrease (MD 1.8%), 22% in the Ex-PL, 20% in the NEX-PL and no one in the NEX-Act.

Change in VO₂TTE



| Changes in fasting lipid concentrations from PRE to POST | | | | |
|--|--|---------|----------------|-----------------|
| | | | PRE | POST |
| Total Cholesterol (mg/dL) | | | | |
| | | EX-Act | 211.33 ± 30.22 | 200.33 ± 27.37* |
| | | EX-PL | 161.67 ± 26.50 | 165.56 ± 26.69 |
| | | NEX-Act | 199.57 ± 65.38 | 173.14 ± 41.59 |
| | | NEX-PL | 170.40 ± 31.61 | 170.20 ± 31.23 |
| HDL (mg/dL) | | | | |
| | | EX-Act | 52.33 ± 9.04 | 52.83 ± 7.17 |
| | | EX-PL | 54.11 ± 8.96 | 54.89 ± 10.45 |
| | | NEX-Act | 55.29 ± 6.97 | 51.86 ± 8.40 |
| | | NEX-PL | 51.80 ± 15.83 | 57.20 ± 20.56 |
| LDL (mg/dL) | | | | |
| | | EX-Act | 137.50 ± 30.85 | 120.33 ± 24.31* |
| | | EX-PL | 92.56 ± 22.69 | 93.00 ± 19.67 |
| | | NEX-Act | 125.57 ± 61.15 | 102.43 ± 37.48* |
| | | NEX-PL | 101.20 ± 30.04 | 95.40 ± 31.00 |
| VLDL (mg/dL) | | | | |
| | | EX-Act | 21.50 ± 5.13 | 27.17 ± 7.25 |
| | | EX-PL | 15.00 ± 5.20 | 17.67 ± 4.64 |
| | | NEX-Act | 18.71 ± 6.26 | 18.86 ± 7.80 |
| | | NEX-PL | 17.40 ± 5.68 | 17.60 ± 7.20 |
| Triglycerides (mg/dL) | | | | |
| | | EX-Act | 108.00 ± 24.80 | 135.83 ± 35.49* |
| | | EX-PL | 74.44 ± 26.17 | 87.67 ± 22.27 |
| | | NEX-Act | 94.14 ± 31.21 | 95.14 ± 38.19 |
| | | NEX-PL | 86.40 ± 29.10 | 88.20 ± 35.07 |

Strength and cardiovascular improvements were significantly ($p < 0.05$) augmented in both training groups. However, a significant time*treatment interaction resulted for time to exhaustion during the VO_{2peak} ($p = 0.046$)

Safety data suggest this thermogenic drink as an effective method for lowering TC and LDL (main effect for treatment).

CONCLUSIONS

The current data suggest that the ACSM exercise program guidelines provide an effective measure for improving cardiovascular fitness, strength and modifying body composition. Individual data demonstrate support for implementing a single serving thermogenic drink prior to exercise, to improve muscle mass, decrease fat mass and improve lipid profiles of overweight women, compared to exercise alone. Additionally, our data suggest that consuming a single serving of Celsius® prior to working out may enhance the positive adaptations of chronic exercise on body composition and cardiorespiratory fitness and endurance performance in previously sedentary overweight women.

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