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Research Article

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A Multi-Ingredient Nutritional Supplement (MINS) Increases Fat Oxidation and Augments Metabolic Rate

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Abstract

The study investigated the impact of a multi-ingredient nutritional supplement (MINS) on resting metabolic rate and energy expenditure. The supplement contained a combination of factors that are normally administered in isolation (32 g protein, 8.4 g CHO, 1.7 g fibre, 105 mg caffeine and 21 mg green tea extract with 10.5 mg catechins, per 50 g serving. 18 subjects participated in the study (10 males, 8 females), mean age 21.8 yrs. Following overnight fasting, subjects ingested either MINS or an isocaloric maltodextrin placebo. Resting oxygen uptake was determined by gas analysis measuring VCO_2 produced and VO_2 consumed. 7 days later, the protocol was repeated using a randomised two-treatment crossover design so each individual subject's response to both placebo and supplement was assessed. Results showed mean resting Respiratory Exchange Ratios were 0.77 ± 0.03 after supplementation, compared with 0.93 ± 0.03 after placebo ($P<0.05$), indicating a shift in contribution of fat to metabolism from 24 ± 2.5% (Control) to 79 ± 1.9% (MINS). Mean resting metabolic rate was found to be 3.69 ml per $kg.min^{-1}$ O_2 after supplementation, compared with 3.45 ml per $kg.min^{-1}$ O_2 after placebo. Whilst this difference is not statistically significant, it impacts on the absolute amount of fat metabolised at rest, increasing from 0.3 $kcal.min^{-1}$ (Control) to 1.0 $kcal.min^{-1}$ (MINS) ($P<0.05$). These findings may have significant implications for individuals involved in weight loss or weight management programmes.

Keywords

Obesity; RER; RMR; Fat oxidation

Abbreviations

Multi-ingredient nutritional supplement (MINS); Respiratory Exchange Ratio (RER); Resting Metabolic Rate (RMR); Free Fatty Acids (FFA)

Background

Three major factors modulate body weight: metabolic factors, diet, and physical activity, each influenced by genetic traits [1]. Despite recent advances in these areas, the prevalence of obesity in Westernised societies has increased. Indeed in western cultures, excess adipose mass, or obesity, has reached epidemic proportions, resulting in metabolic syndrome or syndrome X, typified by type 2 diabetes, cardiovascular disease, hypertension, and hyperlipidemia [2]. In order for weight loss to be achieved energy expenditure must exceed energy intake. Energy expenditure takes the form of physical activity, basal metabolism/resting energy expenditure and the thermic effect of food [1,3]. The relative contribution of each component to daily energy expenditure is variable, the smallest coming from thermic effect of food, which accounts for approximately 10% of the total. Resting energy expenditure, which generally represents about 60% of daily energy expenditure, depends largely on body mass, especially fat-free mass, which is more metabolically active than fat tissue [4]. Energy expenditure through physical activity refers to all voluntary movement associated with skeletal muscle tissues.

Oxidation of free fatty acids (FFA) can provide much of the energy for prolonged submaximal exercise [5] and is an effective method for utilising excess energy stores. During a long bout of exercise, plasma FFA concentration increases [5] with a concomitant decline in the respiratory exchange ratio (RER), indicating that a greater proportion of the energy is being supplied by oxidation of FFA [5]. An adaptation that characterises the trained state is a greater reliance on FFA oxidation during submaximal exercise, with a sparing of carbohydrate, as reflected in a lower RER [6]. In resting/fasting conditions, skeletal muscle in lean, healthy individuals relies on lipid oxidation for the majority of resting energy production on the basis of regional indirect calorimetry across the forearm [6]. Since, a relatively high respiratory quotient, has been suggested as a metabolic index that can predict weight gain [7] and is supported by the Baltimore Longitudinal Study [8] that showed a higher resting respiratory quotient correlated with greater weight gain it suggests that a relatively low respiratory quotient may be a predictor of subsequent weight loss. This therefore may be achieved by increasing energy expenditure by prolonged submaximal exercise or increasing the reliance of lipid oxidation during basal/resting conditions.

Thus, in the present study, the objective was to examine the impact of a dietary supplement on resting metabolic rate and energy expenditure. We hypothesised that the synergistic effects of the MINS compared with placebo would result in lower readings for RER indicating a greater shift in the contribution of fat metabolism and increased energy expenditure associated with higher resting metabolic rate.

Materials and Methods

Recruitment and ethics

Healthy adult subjects were recruited through advertisement. Exclusion criteria were signs or symptoms of chronic disease, or taking any medication known to affect metabolic rate. All subjects gave written informed consent to participate in the study and the study was approved by the University of Bedfordshire Ethics Committee. All measurements were conducted at the Sport and Exercise Science laboratory at the University of Bedfordshire.

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Participants

A total of 18 subjects participated in the study, 10 males and 8 females. Mean age was 21.8 ± 4.2 years (range 18-33 years). Mean body mass was 72.3 ± 5.4 kg prior to commencing the Control study and 72.0 ± 4.8 kg prior to commencing the MINS diet study.

MINS and placebo

Both MINS diet and placebo were supplied by Maximuscle Limited, Hemel Hempstead, UK and prepared in water according to the manufacturer's instructions: MINS contained 32 g protein, 8.4 g CHO, 1.7 g fibre, 105 mg caffeine and 21 mg green tea extract with 10.5 mg catechins, per 50 g serving and placebo consisted of isocaloric maltodextrin. Specific ingredients for MINS were Xylitol, Oligofructose (Inulin) conjugated linoleic acid (CLA), guar gum, vitamins (Ascorbic acid, D-alpha-tocopherol succinate, Nicotinic acid, Retinol Palmitate, Panthothenic Acid, Cholecalciferol, Pyridoxine hydrochloride, Thiamine hydrochloride, Riboflavin, Cyanocobalamin, Folic Acid, Biotin), guarana extract, caffeine, green tea extract, magnesium oxide, zinc gluconate, ferrous citrate, sweetener: sucralose, copper gluconate, manganese gluconate, potassium iodide, selenium enriched yeast. Subjects ingested either a 50g portion of the supplement or the placebo.

Protocol

The object of this study was to examine the synergistic effect of a dietary MINS diet (Maximuscle Limited, Hemel Hempstead, UK) on resting metabolic rate and energy expenditure. All subjects reported to the laboratory subsequent to an overnight fast between 7 am and 9 am. Subjects were weighed and resting oxygen uptake determined at 40-minute intervals over a 2-hour period prior to commencing the study.

Subjects ingested either a 50 g portion of the supplement, or an isocaloric maltodextrin placebo. Baseline measures of resting oxygen uptake, to determine metabolic rate were taken at 40-minute intervals over a 4-hour period. Expired air was collected using Douglas bags over a 15-minute period for determination of oxygen consumption and carbon dioxide production using a Servomex Gas Analyser (Cranlea, Birmingham, UK) and Harvard Gas Meter (Cranlea, Birmigham, UK). Respiratory exchange ratio (RER) was used to determine indirect calorimetric measure for energy expenditure. Throughout the experiment, subjects were asked to sit quietly in the laboratory in a controlled and quiet environment, and were continually supervised. The experiment was repeated on each subject, using randomised two-treatment crossover design so that each individual subject's response to both the placebo and supplement could be assessed. Transfer from supplement and placebo was staggered by 7-days to ensure complete removal of either product before retesting.

Indirect calorimetry: Flexible total collection system

Oxygen consumption and carbon dioxide production was measured and converted to energy expenditure using indirect calorimetry. The Douglas bag total collection system comprised a polyvinyl chloride bag of 100–150 litre capacity. The top of the bag was connected by tubing to a three-way valve Hans Rudolf Valves (Cranlea, Birmingham, UK) which may be rotated to seal the bag, admit atmospheric air or admit expired air via tubing attached to a respiratory valve. To use this approach, the three-way valve is first rotated to open the circuit to atmospheric air, the bag is rolled up to expel its contents and the three-way valve then rotated to seal the bag. The subject breathes through the mouthpiece and the three-way valve is rotated to allow the expired air to collect in the Douglas bag for 10–20 minutes. After the timed collection period, the three-way valve is turned to seal the bag. Several bags were used to prolong the total measurement period. After collection of the expired air, the volume of the expired air in the bag was measured using a Harvard mass flow meter (Cranlea, Birmingham, UK) and the samples analysed with a Servomex Gas Analyser (Cranlea, Birmingham, UK) to determine oxygen and carbon dioxide concentrations. Under optimal conditions the error of energy expenditure measurements undertaken with Douglas bags was 3%.

Mood state and satiety

Mood state was assessed using a profile of mood states (POMS) questionnaire. The questionnaire consisted of 65 adjectives that are rated by subjects on a 5-point scale. Six factors derived from this: tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia, vigour-activity and confusion-bewilderment. .

Appetite and hunger were assessed using visual analogue scale questionnaires. Snack food was provided during the study. Energy consumption from snack feeding was calculated from the mass of food, and calorific intake, consumed by subjects under each condition (MINS diet or placebo), using the snack food of their choice either chocolate 520 kcal/100 g or flapjacks 440 kcal/100 g. Additionally water was provided and fluid intake was recorded to assess the effect of supplementation on thirst.

Statistical analysis

Data were analysed using Microsoft Excel 2007, SPSS version 17.0 software and GraphPad Prism Version 5.0 software. Results are presented as the mean ± standard error of the mean (SEM). The test–retest reliability of the indirect calorimetry procedures was also determined ($r = 0.92$; sample $n = 4$). Statistical significance was determined using one-way analysis of variance with multiple post hoc analyses. Results were considered statistically significant when the P value was <0.05.

Results and Analysis

MINS increases utilisation of fat stores during rest

The RER is the ratio of the carbon dioxide produced to the amount of oxygen consumed. Metabolism of carbohydrate requires the utilisation of an amount of oxygen equal to the amount of carbon dioxide produced to give a higher RER, approaching or equal to 1.0. Because oxidation of fat requires a larger consumption of oxygen than the carbon dioxide produced, the RER during fat metabolism is lower approaching 0.7. The RER gives an indication of the percentage of the energy expenditure that is derived from fat oxidation relative to the percentage derived from carbohydrate oxidation.

Mean RER values after MINS supplementation 0.77 ± 0.03 were significantly ($P<0.05$) lower compared with 0.93 ± 0.03 after the Control intervention. This indicated a shift in metabolism from 24 ± 2.5% contribution to energy expenditure from fat for Control conditions to a 79 ± 1.9% contribution from fat after MINS supplementation (Table 1). These findings demonstrate a substantial > 3-fold increase in fat metabolism after consumption of the MINS diet.

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Table 1: Energy Expenditure and Fuel Utilisation.

Group	Mass (kg)	RMR/O_2 Consumption (ml. kg.min^{-1})	RER	Energy from fat (%)	Energy from CHO (%)	Energy Expenditure (kcal.min^{-1})	Fat (kcal.min^{-1})	CHO (kcal.min^{-1})
Control	72.3 ± 5.4	3.45 ± 0.31	0.93 ± 0.03	24 ± 2.5	76 ± 3.2	1.24	0.3	0.94
MINS	72 ± 4.8	3.69 ± 0.25	0.77* ± 0.03	79 ± 1.9*	21 ± 1.6*	1.26	1*	0.26*
P	NS	NS	<0.05	<0.05	<0.05	Ns	<0.05	<0.05

RER and relative absolute energy expenditure from fat and carbohydrate at rest. Baseline measures of resting oxygen uptake to determine RER and metabolic rate were taken at 40-minute intervals over a 4-hour period. Expired air was collected using Douglas bags over a 15-minute period for determination. RMR is expressed as a measure of VO_2.

Note: RER: Respiratory Exchange Ration; RMR: Resting Metabolic Rate; CHO: Carbohydrate; kcal: kilocalories; NS: Not Significant (P>0.05)

There was a trend, albeit non-significant (P>0.05), for resting metabolic rate to be higher after the consumption of MINS in comparison to Control (RMR 3.69 ml.kg.min^{-1} O_2 MINS; 3.45 ml.kg. min^{-1} O_2 Control). When combined with the significant shift in RER values, this increased the impact of the additional metabolism of fat after MINS supplementation resulting in significantly (P<0.05) higher percentage of fat being metabolised. This shift in fat metabolism equated to an increase of 0.3 kcal.min^{-1} (Control) to 1.0 kcal.min^{-1} (MINS) that was significant (P<0.05) (Table 1).

MINS does not affect mood or satiety

Mood state was assessed using a POMS questionnaire. Data (not shown) indicated no significant differences when comparing POMS data in either the Control or MINS conditions. Appetite and hunger were assessed using visual analogue scale questionnaires. Energy consumption from snack feeding was calculated from the weight of food, and calorific intake, consumed by subjects under each condition, using the snack food of their choice. Similarly, no significant differences were found in the weight of snack food or total number of calories consumed for either the MINS or Control conditions, indicating that MINS had no effect on satiety. There were no significant differences in the volume of fluid consumed under either condition, suggesting that the intervention with MINS had no effect on thirst.

Discussion

In the present study, we report in healthy subjects, an increase in fat metabolism after MINS supplementation when compared with Control diet (P<0.05). This was as a result of significantly lower (P <0.05) Respiratory Exchange Rates (RER) after MINS supplementation, in combination with a trend for a higher Resting Metabolic Rate (RMR) post-MINS. Most triacylglycerols are stored in adipose tissue (≈17 500 mmol in a lean adult man), but they are also present in skeletal muscle (≈ 300 mmol) and plasma (≈ 0.5 mmol). The total amount of energy stored as triacylglycerol (≈ 560 MJ) is > 60 times the amount stored as glycogen (≈ 9 MJ) [9]. These findings suggest that being able to utilise more fat stores for energy may be beneficial in reducing total body fat. However, it is difficult to hypothesise whether this would translate into weight loss, since this would require either an increase in energy expenditure or a decrease in energy intake. Although non-significant, an increase in RMR was observed with MINS supplementation suggesting higher levels of energy expenditure at rest compared with the control group.

Potential longer-term use of MINS greatly increases energy usage from fat stores

Weight gain develops only if energy intake, in the form of feeding, chronically exceeds total body expenditure – includes physical activity, basal metabolism, and adaptive thermogenesis. There was a trend for resting metabolic rate to be higher after the consumption of MINS when compared to the control trial (RMR 3.69 ml per kg.min^{-1} MINS vs 3.45 ml per kg.min^{-1} Control). When combined with the significant shift in RER values, this increases the impact of the additional metabolism of fat after MINS supplementation (i.e. there is a higher percentage of fat metabolised, albeit non-significantly, of higher total energy expenditure. Hence, in absolute terms, this change in fat metabolism equated to an increase of 0.3 kcal per minute (Control), to 1.0 kcal per minute (MINS). Whether the findings of elevated fat metabolism and decreased carbohydrate metabolism also exist during exercise is a further area requiring investigation. Should this be the case it could have implications for individuals involved in endurance and ultra-endurance exercise where glycogen sparing is beneficial for sustained performance.

A further topic for investigation is the determination of the specific ingredient(s) within the product that could have caused the increase in fat metabolism. Whilst in theory this could have been the caffeine content, the level of caffeine in the product suggests that, in isolation, this may not have been the case. Identification of the specific ingredient(s) though a series of controlled trials could help in either the development of new products, or enable the removal of certain ingredients in the existing product that may not be having any effect on metabolism, and hence contribute to a reduction in the cost of goods of the product.

Conclusions

The critical finding of this study was that significant increase in fat metabolism was reported after MINS supplementation. The data indicate that carbohydrate / glycogen stores are spared at rest, and this finding may have positive implications for individuals preparing for endurance activities.

Competing Interests

The authors have no professional relationship with companies or manufacturers who may benefit from the results of the present study. The authors' interpretation of the results does not constitute endorsement of the product. The study was partially funded by Maximuscle Limited. In accordance with the authors' declared independency, Maximuscle Limited was not at any point involved in study design, data sampling, data analysis or preparation of the written product.

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