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A 3-day high-fat/low-carbohydrate diet does not alter exercise-induced growth hormone response in healthy males

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ABSTRACT

Objective: The purpose of the present study was to examine the effects of 3 days isoenergetic high-fat/low-carbohydrate diet (HF-LC) relative to low-fat/high-carbohydrate diet (LF-HC) on the exercise-induced growth hormone (GH) response in healthy male subjects.

Design: Ten healthy young males participated in this study. Each subject consumed the HF-LC (18 ± 1% protein, 61 ± 2% fat, 21 ± 1% carbohydrate, 2720 kcal per day) for 3 consecutive days after consuming the LF-HC (18 ± 1% protein, 20 ± 1% fat, 62 ± 1% carbohydrate, 2755 kcal per day) for 3 consecutive days. After each dietary intervention period, the hormonal and metabolic responses to an acute exercise (30 min of continuous pedaling at 60% of $\dot{V}O_{2max}$) were compared. The intramyocellular lipid (IMCL) contents in the vastus lateralis, soleus, and tibialis anterior were evaluated by proton magnetic resonance spectroscopy.

Results: Serum GH concentrations increased significantly during the exercise after both the HF-LC and LF-HC periods ($P < 0.05$). However, the exercise-induced GH response was not significantly different between the two periods. Fat utilization and lipolytic responses during the exercise were enhanced significantly after the HF-LC period compared with the LF-HC period. IMCL content did not differ significantly in any portion of muscle after the dietary interventions.

Conclusions: We could not show that short-term HF-LC consumption changed significantly exercise-induced GH response or IMCL content in healthy young males.

1. Introduction

Exercise is well known to be a powerful physiological stimulus for growth hormone (GH) secretion [1–5] and a single bout of exercise can evoke dramatic increase in GH concentration [6]. Additionally, increased GH concentration enhances acute lipolysis [7–9], and 24-h energy expenditure and fat oxidation in healthy adults [10]. Therefore, an elevated GH concentration with exercise is thought to play a role in preventing obesity.

Diet composition prior to exercise affects exercise-induced GH response. Consuming a high-fat meal 45 min before exercise markedly attenuates exercise-induced GH response [11,12] due to increasing somatostatin concentration, which inhibits GH secretion [11,13]. Meanwhile the influence of short-term (several days) fat loading on exercise-induced GH response has not been fully investigated. To our knowledge, only one study [14] investigated the effects of short-term high-fat intake on exercise-induced GH response. The above study [14] reported that short-term (1.5 days) consumption of high-carbohydrate diet plus fat supplementation did not alter exercise-induced GH response compared with high-carbohydrate diet alone. The absence of change in exercise-induced GH response was likely due to the lack of change in free fatty acid (FFA) concentration, because systemic FFA elevation suppressed GH secretion [15–18]. However, the influence of several days of high-fat/low-carbohydrate diet consumption on exercise-induced GH response is still questionable, because the previous study [14] utilized high-carbohydrate diet (high-fat/high-carbohydrate diet), which results in impaired high-fat induced FFA elevation by stimulating insulin secretion. Currently, we need to confirm that whether exercise-

Abbreviations: HF-LC, high-fat/low-carbohydrate diet; LF-HC, low-fat/high-carbohydrate diet; GH, growth hormone; $\dot{V}O_{2max}$, maximal oxygen uptake; IMCL, intramyocellular lipid; FFA, free fatty acid; BMI, body mass index; SE, standard error; BDHQ, brief type self-administered diet history questionnaire; $\dot{V}O_2$, oxygen uptake; HR, heart rate; VL, vastus lateralis; SOL, soleus; TA, tibialis anterior; MR, magnetic resonance; HDL, high density lipoprotein; LDL, low density lipoprotein; TG, triglycerides; IGF-I, insulin like growth factor I; IL-6, interleukin-6; CVs, coefficient of variation; $\dot{V}CO_2$, carbon dioxide production; RER, respiratory exchange ratio; RPE, rating of perceived exertion; ANOVA, analysis of variance; AUC, area under the curve; HOMA-IR, the homeostatic model assessment of insulin resistance.

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induced GH response is maintained when the subjects consume high-fat/low-carbohydrate diet.

GH secretion is inversely associated with whole body or visceral fat mass [19]. In fact, obese people with marked abdominal fat have impaired spontaneous [20,21] and exercise-induced GH responses [5,22,23] compared with normal-weight people. Interestingly, some studies have suggested that fat accumulated in the non-adipose tissue (e.g., muscle and liver) depot also attenuates GH secretion. In previous studies, peak GH concentration following GH releasing hormone and arginine administration has been shown to be inversely correlated with the intramyocellular lipid (IMCL) content [24,25]. Furthermore, the accumulation of IMCL is caused by increasing dietary fat. Short-term (2–7 days) high-fat/low-carbohydrate diet (HF-LC) increases IMCL by 36–76% compared with isoenergetic low-fat/high-carbohydrate diet (LF-HC) [26–29]. Therefore, we hypothesized that exercise-induced GH response would be impaired by several days of HF-LC consumption in young healthy adults. Thus, the present study was designed to compare changes in exercise-induced GH response and IMCL content between 3 successive days of HF-LC and LF-HC in healthy young males. This experimental approach mimics realistic situation, as a temporal increase in fat intake for several days (e.g., increased fat consumption during the weekend) occurs frequently in modern life.

2. Methods

2.1. Subjects

Ten non-obese young males participated in this study. Their age, height, weight, and body mass index (BMI) were 22.6 ± 0.8 yrs., 169.1 ± 2.3 cm, 60.8 ± 1.9 kg, and 21.2 ± 0.5 kg/m^2 [mean ± standard error (SE)], respectively. All subjects were informed about the purpose of this study and the experimental procedures, and their written informed consent was obtained. This study was approved by the Ethics Committee for Human Experiments at Ritsumeikan University, Japan.

2.2. Experimental design

Before the dietary intervention, all subjects were examined for daily physical activity level, daily energy intake level, and $\dot{V}O_{2max}$ (maximal oxygen uptake). Then, each subject consumed the LF-HC for 3 consecutive days. After the LF-HC period, the subjects consumed the isocaloric HF-LC for 3 consecutive days (Fig. 1). The period of 3 consecutive days of consuming the HF-LC was selected in accordance with previous studies [28,29]. The subjects consumed same meals during each dietary intervention. All subjects were advised to maintain their daily physical activity at individual daily physical activity level ± 10% during the experimental period, which was monitored by an acceleration sensor (Actimarker, Panasonic Electric Works Co, Osaka, Japan).

After completing each dietary intervention, whole body and regional fat accumulation and hormonal and metabolic responses to acute exercise (30 min of continuous pedaling at 60% of $\dot{V}O_{2max}$) were determined.

2.3. Dietary intervention

All foods were provided and packed in weighed portions and labeled appropriately for each meal during the dietary intervention. The dietary intervention was started with 3 consecutive days of a LF-HC. During this period, the LF-HC (18 ± 1% protein, 20 ± 1% fat, 62 ± 1% carbohydrate, 2755 kcal per day) was provided three times per day. After completing the LF-HC intervention, the subjects consumed the HF-LC (18 ± 1% protein, 61 ± 2% fat, 21 ± 1% carbohydrate, 2720 kcal per day) for 3 consecutive days. Dietary calorie intake per day of each participant was calculated using the Dietary Reference Intakes for Japanese equation (basal metabolic rate [reference basal metabolic rate] × physical activity level [normal physical level, 1.75]) established in Dietary Reference Intakes for Japanese 2010 [30]. The energy and food contents of the diets were administered by registered dietitians. Regarding to the component ratio of the LF-HC and daily diet, there were not much differences. The component ratio of daily diet was analyzed using a brief-type self-administered diet history questionnaire (BDHQ) [31] by a registered dietitian.

2.4. Measurement of each parameter

2.4.1. Maximal oxygen uptake

$\dot{V}O_{2max}$ was assessed using a graded power test on a cycle ergometer (AEROBIKE 75XLIII, Combi Wellness Co., Tokyo, Japan). The test began at 70 W and load was increased progressively at 35 W increments every 2 min until exhaustion. The test was terminated when the subject failed to maintain the prescribed pedaling frequency of 70 rpm or reached their $\dot{V}O_2$ plateau. Respiratory gases were collected and analyzed using an automatic gas analyzer (AE300S, Minato Medical Science Co., Ltd., Tokyo, Japan). Data were averaged every 30 s. Heart rate (HR) was measured continuously using a wireless HR monitor (Polar RS400TM, Polar Electro Japan Co, Tokyo, Japan).

2.4.2. Whole body fat mass and IMCL content

Whole body fat mass was determined using the bio-impedance method (In Body 720, Biospace Co., Tokyo, Japan) after both dietary interventions.

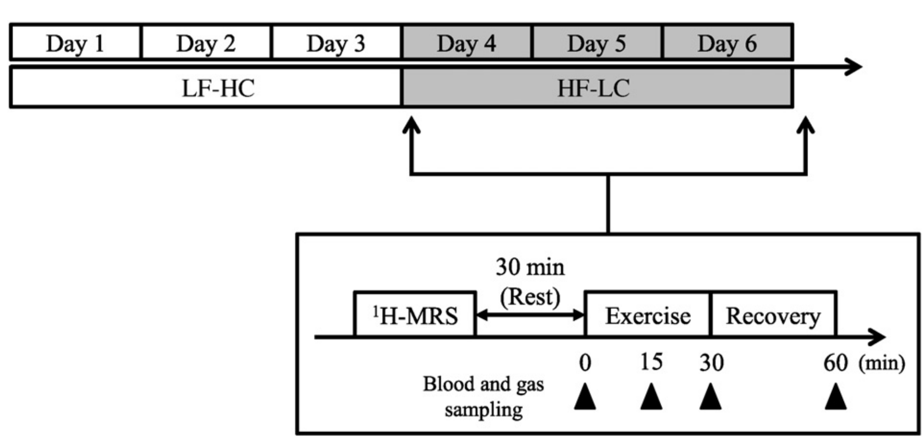

Fig. 1. Experimental design. All subjects consumed the normal-fat diet (20% protein, 20% fat, 60% carbohydrate) for 3 consecutive days followed by the high-fat diet (20% protein, 60% fat, 20% carbohydrate) for 3 consecutive days. After each dietary intervention, ^{1}H-MRS measurement and the exercise test (30 min of continuous pedaling at 60% of $\dot{V}O_{2max}$) were completed. LF-HC, low-fat/high-carbohydrate diet; HF-LC, high-fat/low-carbohydrate diet.