METABOLISM CLINICAL AND EXPERIMENTAL 63 (2014) 1257–1264

Available online at www.sciencedirect.com

Metabolism

www.metabolismjournal.com

Clinical Science

Effects of a eucaloric reduced-carbohydrate diet on body composition and fat distribution in women with PCOS☆

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ARTICLE INFO

Article history:
Received 7 February 2014
Accepted 12 July 2014

Keywords:
Macronutrient composition
Obesity
Intra-abdominal adipose tissue

ABSTRACT

Objective. To determine if consumption of a reduced-carbohydrate (CHO) diet would result in preferential loss of adipose tissue under eucaloric conditions, and whether changes in adiposity were associated with changes in postprandial insulin concentration.

Methods. In a crossover-diet intervention, 30 women with PCOS consumed a reduced-CHO diet (41:19:40% energy from CHO:protein:fat) for 8 weeks and a standard diet (55:18:27) for 8 weeks. Body composition by DXA and fat distribution by CT were assessed at baseline and following each diet phase. Insulin AUC was obtained from a solid meal test (SMT) during each diet phase.

Results. Participants lost 3.7% and 2.2% total fat following the reduced-CHO diet and STD diet, resp. ($p < 0.05$ for difference between diets). The reduced-CHO diet induced a decrease in subcutaneous-abdominal, intra-abdominal, and thigh-intermuscular adipose tissue (−7.1%, −4.6%, and −11.5%, resp.), and the STD diet induced a decrease in total lean mass. Loss of fat mass following the reduced CHO diet arm was associated with lower insulin AUC ($p < 0.05$) during the SMT.

Conclusions. In women with PCOS, consumption of a diet lower in CHO resulted in preferential loss of fat mass from metabolically harmful adipose depots, whereas a diet high in CHO appeared to promote repartitioning of lean mass to fat mass.

Abbreviations: PCOS, polycystic ovary syndrome; CHO, carbohydrate; NIH, National Institutes of Health; BMI, body mass index; STD, standard; DXA, dual energy x-ray absorptiometry; CT, computed tomography; NDSR, Nutrition Data System for Research; IAAT, intra-abdominal adipose tissue; SAAT, subcutaneous abdominal adipose tissue; IMAT, intermuscular adipose tissue; SAT, subcutaneous adipose tissue; PMAT, perimuscular adipose tissue; CRU, Clinical Research Unit; AUC, area-under-the-curve; CV, coefficient of variation

☆ Supported by: R01HD054960, UL1RR025777, P30DK56336, P60DK079626.

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http://dx.doi.org/10.1016/j.metabol.2014.07.007
0026-0495/

1. Introduction

Polycystic Ovary Syndrome (PCOS) is the most common endocrine disorder affecting nearly 8%–10% of premenopausal women [1]. Primary features of the syndrome include biochemical or clinical hyperandrogenism, ovulatory dysfunction and polycystic ovaries [2]. Other common features include insulin resistance, elevated circulating insulin, and metabolic dysfunction [3], which may be mechanistically linked to weight gain and obesity in this population [4,5]. In PCOS, elevated insulin may contribute to excess adiposity by limiting fat mobilization and oxidation, thus making weight maintenance and weight loss a significant challenge. Obesity, specifically abdominal or ectopic adiposity, may contribute to the severity of symptoms and progression of comorbidities associated with PCOS. Non-pharmacological interventions to limit adiposity in the PCOS population are needed.

A number of studies have demonstrated that weight loss and diet quality may contribute to improvement of symptoms associated with PCOS [6–9]. However, whether qualitative aspects of the diet affect weight or body composition and fat distribution independent of energy restriction among women with PCOS is unclear. Diets reduced in carbohydrate (CHO) with a low glycemic load may be more likely to lower postprandial glucose and the subsequent insulin secretory response when compared to diets higher in CHO content [10,11]. We previously reported a significant reduction in intra-abdominal adipose tissue among women in response to a diet reduced in CHO content during weight maintenance conditions, and a preferential loss of fat mass during weight loss conditions [12]. These findings suggest that a diet reduced in CHO may be an optimal dietary approach to reducing total and abdominal adiposity among women with PCOS, considering their prevailing hyperinsulinemia.

The objective of the present study was to determine if, in women with PCOS, consumption of a diet moderately reduced in CHO would reduce total and regional adipose tissue during weight maintenance conditions, and whether changes in adiposity would be associated with lower postprandial insulin concentrations.

2. Material and methods

2.1. Participants

Thirty women with PCOS defined using the NIH 1990 criteria were recruited. The diagnostic criteria included i) hyperandrogenism and/or hyperandrogenemia, (ii) oligo-ovulation, and (iii) the exclusion of other existing disorders such as Cushing's syndrome, hyperprolactinemia, or congenital (non-classic) adrenal hyperplasia. Specific inclusion and exclusion criteria have been described elsewhere [13]. In brief, exclusion criteria included structured exercise >2 h per week, pregnancy, current breastfeeding, use of medication that could affect body composition or glucose metabolism (including oral contraceptives, cholesterol medications, and blood pressure medications), current use of tobacco, use of illegal drugs in last 6 months, major food allergies or food dislikes, and a medical history that contra-indicated inclusion in the study. Participants had a BMI under 45 kg/m^2 and were weight stable 6-months prior to enrolling in the study. Prior to enrollment in the study, participants were informed of the protocol and engaged in oral and written consent. The protocol for this study was approved by the Institutional Review Board for Human Use at UAB, and all participants signed informed consent prior to initiation of testing.

2.2. Protocol

The study design was a crossover dietary intervention. Participants consumed a reduced-CHO diet for 8 weeks and a standard (STD) diet for 8-weeks separated by a 4-week washout period. Participants completed a 4-day food record (3 weekdays, 1 weekend day) for assessment of typical nutrient intake prior to beginning the dietary intervention, and again following the 4-week washout period. Diet order (reduced-CHO first then STD diet, or STD diet first then reduced-CHO diet) was assigned using a randomization scheme following baseline testing. Dual-energy X-ray absorptiometry (DXA) and computed tomography (CT) scans were acquired for all participants at baseline of each diet arm and following completion of each diet arm. A solid meal test (SMT) to determine glucose and insulin response to the study meal was performed at the 4-week midpoint of each diet arm. Sample size calculations were based on our previous data from a weight maintenance study in a population of obese men and women [12]. In this study, we detected a decrease in IAAT of 11.0 ± 9.7 cm^2 after 8 weeks of consumption of a eucaloric reduced-CHO diet. Assuming a change of 11.0 ± 9.7 cm^2, a two-sided paired t-test, and a significance alpha level of 0.05, we would have over 80% power to detect a significant change in IAAT with 17 participants per diet group. In the present study, we enrolled 30 women to allow for attrition; 23 completed both arms of the intervention, and 27 completed the reduced-CHO arm.

2.3. Diets

All food was provided to the participants for each 8-week diet arm by the UAB Clinical Research Unit (CRU) Metabolic Kitchen. For the duration of the study, participants reported to the CRU several times each week to be weighed and to collect food for off-site consumption. Participants were blinded to diet order, and either first consumed a reduced-CHO diet (41% CHO, 19% protein, and 40% fat) for 8-weeks or the STD (55% CHO, 18% protein, and 27% fat) diet for 8-weeks. The glycemic index of the reduced-CHO diet was ~50 and that of the STD diet was ~60. Details of the two diets were previously reported [13]. Intervention diet menus were designed using Nutrition Data System for Research (NDSR) software versions 2009 and 2011 (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). Examples of meals provided from each diet are shown in Table 1. Total energy requirements were determined by using each individual's measured resting energy expenditure from indirect calorimetry with an activity factor of 1.35. Participants were asked to maintain their baseline level of physical activity throughout the study period.