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Original article

Macronutrient and alcohol intake is associated with intermuscular adipose tissue in a randomly selected group of younger and older men and women

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SUMMARY

Background: Alcohol and macronutrient intake have been found to be related to general and central body fat distribution. Intermuscular adipose tissue (IMAT) is a small ectopic fat depot located within the muscle bundles. IMAT is important for muscle function, mobility and energy homeostasis and also associated with cardiovascular- and diabetes-related risk factors.
Aim: To test the hypothesis that macronutrient and alcohol intake is associated with IMAT.
Methods: 50 men and 50 women, randomly selected from the general population formed height- and weight-representative age groups of 50 younger (27–31 years) and 50 older (57–61 years) subjects. A dietary questionnaire was used to estimate habitual intake of foods and beverages. Body composition including IMAT was measured with computed tomography.
Results: Energy percent (E%) carbohydrates were negatively associated with IMAT in men (β: −0.6234, $P < 0.05$) and in younger subjects (β: −0.792, $P < 0.05$). E% alcohol was positively associated with IMAT in women (β: 2.3663, $P < 0.01$) and in older subjects (β: 1.232, $P < 0.01$). In younger individuals, E% protein was positively associated with IMAT (β: 1.840, $P < 0.05$). Centralized and general body fat distributions were positively associated with IMAT. S- (serum) cholesterol was positively associated with IMAT in men (β: 0.05177, $P < 0.01$) and younger individuals (β: 0.06701, $P < 0.01$).
Conclusions: These cross-sectional analyses showed associations between measures of body fat distribution and IMAT as well as associations between macronutrient- and alcohol intake and IMAT. Since IMAT is situated within the energy demanding striated muscles, our data could suggest that changes in dietary energy intake and macronutrient distribution may induce changes in IMAT in both normal weight and obese subjects.

1. Introduction

Anatomical distribution of white adipose tissue reflects the development and progression of metabolic disease. The majority of fat is found in the subcutaneous and visceral adipose tissue depots and it is well established that the visceral depot is more strongly associated to metabolic disorders than the subcutaneous depot, for review see Refs. [1,2]. However, in pathological states, lipids can also accumulate within non-adipose tissues (ectopic fat), thereby impairing the functionality of organs such as the liver, skeletal muscle, and pancreas.

The intermuscular adipose tissue (IMAT) is an ectopic fat depot located between skeletal muscle bundles and may affect muscle force production, mobility as well as metabolic status [3–5]. IMAT is increased in older subjects [6,7] and in young sedentary individuals [8] and there is a strong linear relationship between IMAT and total amount of adipose tissue [3]. It has also been shown that IMAT is independently associated with cardiovascular risk factors

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such as glucose and total cholesterol [9,10] and that a greater amount of IMAT can be found in individuals with type 2 diabetes or insulin resistance [3,10,11], or with the metabolic syndrome [12].

The amount of IMAT can be affected by lifestyle interventions. An increase in IMAT was seen after decreased physical activity in young adults [8]. In other studies, a decrease in size of the IMAT depot could be seen after an increase in physical activity [5,13] and after weight loss among overweight and obese older [14–16], and younger [17] adults. In an intervention study on carbohydrate restriction in overweight or obese women with polycystic ovarian syndrome, IMAT decreased significantly over 8 weeks in the carbohydrate-reduced diet group compared to standard intake of carbohydrates [18]. Thus, IMAT can be altered by changeable lifestyle factors such as energy restriction and increased physical activity.

Alcohol contains more energy per gram (7 kcal/g) than carbohydrate and protein (4 kcal/g, each) and somewhat less energy than fat (9 kcal/g). Alcohol may contribute to fat mass, through decreased oxidation of fat and carbohydrates when alcohol is consumed and oxidized [19]. Alcohol intake has found to be related to both general and central adiposity [20], but the relation to IMAT is, to our knowledge, not known. Thus, it is unclear whether total energy intake, macronutrients and alcohol intake are associated with the size of the IMAT depot under weight-stable conditions. Therefore, the primary aim of this cross-sectional study was to identify nutritional predictors for IMAT in terms of energy- and macronutrient- as well as alcohol intake in younger and older men and women. The secondary aim was to study the association between IMAT and anthropometric measures, total adipose tissue and metabolic variables related to the metabolic syndrome.

2. Subjects

1200 persons in the city of Mölndal in western Sweden, randomly selected through a computerized program, received an invitation and a questionnaire including health-related questions including present height and weight. Forty-eight to 68% of the subjects (across sex and age groups) answered the questionnaire and were divided in height-quintiles. The subjects in each height-quintile were then divided in weight-quintiles. Each weight-quintile consisted of approximately seven subjects. The median person in each weight-quintile was included in a height- and weight representative sex and age group of 25 individuals. Thus, fifty men and 50 women, of non-Hispanic white origin, aged either 27–31 years or 57–61 years, were examined in the Mölndal Metabolic Study. The reason for the division of the subjects into groups with respect of age, height and weight was to study metabolic, cardiovascular and lifestyle factors in groups with a broad range of height and weight and body composition. There were no subjects with ages between the younger and older age groups included in the study.

3. Methods

The subjects were examined with respect to anthropometry and body composition, insulin sensitivity, biochemical variables and blood pressure, known cardiovascular risk factors as well as hormonal patterns. The subjects completed several questionnaires regarding general health and dietary intake. The examinations were performed at the Obesity Unit, Sahlgrenska University Hospital, Gothenburg, Sweden.

3.1. Anthropometry

Body weight (kg) was measured in underwear without shoes with 2 decimals accuracy and height (m) to the closest 0.5 cm when standing without shoes. Measures of waist- and hip circumferences (cm) were performed in supine position after a normal expiration according to Sjöström et al. [21].

3.2. Computed tomography (CT)

A 28-scan CT-technique in which the human body can be divided in 12 different regions has been developed at our institution [22]. Several of these regions can be further divided into smaller regions. Using this multi-compartment technique, body composition of an individual can be studied in detail. In the present study, the 28-scan-CT was used to measure total adipose tissue (total AT), visceral adipose tissue (VAT), subcutaneous AT (SAT), skeletal muscle and IMAT in each individual. The CT-technique measures areas and volumes that can be transformed into masses by densities of specific tissues.

3.3. Habitual food intake

The participants completed a semi-quantitative dietary questionnaire, on habitual food and beverage intake during the last three months [23,24]. The participants specified intake frequencies from standardized portions of different foods and photographs of portion sizes of cooked meals. Alcohol intake was specified as different alcoholic beverages in standardized portions and frequencies. The questionnaire that was used included 50 questions and has been developed within the SOS- (Swedish Obese Subjects) study. The questionnaire has been validated against a 4-days food registration, 24-h energy expenditure in chamber for indirect calorimetry and excreation of urinary nitrogen [23,24].

3.4. Ethics

All participants received oral and written information about the study and each participant signed an informed consent form before entering the study. The ethics committee, University of Gothenburg, approved the study.

4. Statistical analysis

Statistical analyses were performed separately in men and women as well as in younger and older subjects. Differences between age groups and between men and women were analyzed using one-way ANOVA. The IMAT-values were log 10-transformed in order to normalize distributions. General linear models were used to analyze the relationship between IMAT and anthropometry, biochemical variables and energy-, macronutrient- and alcohol intake. Analyses were adjusted for sex, age, BMI and skeletal muscle mass when appropriate. Data were analyzed using JMP version 10.0.2 (SAS institute, Cary NC).

5. Results

In both sexes, older subjects had higher mean BMI, total AT, VAT and IMAT compared with younger subjects (Table 1). SAT was higher in older compared with younger women, only. Older men had approximately 1.7 times more IMAT than the younger men. Older women had 2.3 times more IMAT compared with the younger women. Both older men and women had higher systolic and diastolic blood pressure compared with their younger counterparts (Table 1). Older women had significantly higher S-triglycerides, S-cholesterol, B-glucose and S-insulin compared with younger women. In men, S-cholesterol was significantly higher in older compared with younger subjects (Table 1).

Older compared to younger men reported significantly lower energy intake (2400 ± 540 vs. 2796 ± 748 kcal, $P < 0.05$) (Table 2).