Nutrition, Metabolism & Cardiovascular Diseases (2008) **18**, 256–262

ELSEVIER

Nutrition, Metabolism & Cardiovascular Diseases

www.elsevier.com/locate/nmcd

Low serum testosterone in men is inversely associated with non-fasting serum triglycerides: The Tromsø study

Ingvild Agledahl [a,*], Paal-André Skjærpe [a], John-Bjarne Hansen [b], Johan Svartberg [a]

[a] *Department of Medicine, University Hospital of North Norway, 9038 Tromsø, Norway*
[b] *Center for Atherothrombotic Research in Tromsø (CART), Institute of Clinical Medicine, University of Tromsø, 9037 Tromsø, Norway*

Received 22 September 2006; received in revised form 12 January 2007; accepted 30 January 2007

KEYWORDS
Triglycerides;
HDL cholesterol;
Testosterone;
SHBG;
BMI;
Lifestyle factors;
Postprandial hyperlipemia

Abstract *Objective:* To study the relationships between endogenous testosterone, sex hormone-binding globulin (SHBG) and serum lipids in non-fasting men.
Methods: We performed a cross-sectional study in 1274 men without known cardiovascular disease who participated in a population-based study, the 1994/1995 Tromsø study. Anthropometric characteristics were measured and questionnaires regarding lifestyle and medical history were completed. Non-fasting blood samples were drawn between 08.00 and 16.00 h, and total testosterone, SHBG, triglycerides (TG), total cholesterol (TC) and high-density lipoprotein (HDL) were analyzed.
Results: In stratified analyses based on sampling time, a linear increase in serum TG levels was found in men with total testosterone levels below the 50th percentile during the day (p for trend $= 0.004$). In contrast, serum triglycerides did not change during the day in men with testosterone levels above the 50th percentile. In regression analyses, total testosterone and SHBG were inversely and independently associated with TG ($p < 0.001$ and $p < 0.001$ respectively), and positively and independently associated with HDL ($p = 0.005$ and $p < 0.001$, respectively). Men with an unfavorable lipid profile (HDL <0.90 and TG >1.8) had significantly lower levels of total testosterone and SHBG ($p = 0.004$ and $p < 0.001$, respectively) in age and BMI adjusted analyses, compared to men with a normal lipid profile.

* Corresponding author. Institute of Clinical Medicine, University of Tromsø, 9037 Tromsø, Norway. Tel.: +47 95 85 41 35; fax: +47 77 64 43 78.
E-mail addresses: ingvild.agledahl@fagmed.uit.no (I. Agledahl), johan.svartberg@unn.no (J. Svartberg).

0939-4753/$ - see front matter
doi:10.1016/j.numecd.2007.01.014

Conclusions: Low serum total testosterone was associated with a linear increase in serum TG during the day, and was independently associated with an unfavorable lipid profile. Our findings may indicate that low total testosterone is associated with impaired TG metabolism in men.

Introduction

Postprandial lipemia is a physiological phenomenon occurring several times a day after the ingestion of a meal. Atherosclerosis has been described as, at least in part, a postprandial disease caused by accumulation of triglyceride-rich dietary lipoproteins (TRL) in the vascular wall, due to impaired metabolism and thereby prolonged exposure of the vascular wall to TRL [1]. Both peak levels and the magnitude of postprandial triglyceridemia are associated with cardiovascular disease (CVD) [2]. Men have a less favorable lipid profile and a higher risk for CVD [3] than women. To what extent this gender difference is due to differences in sex hormones is debated. Rising total testosterone levels during puberty in young men are associated with a rise in triglycerides (TG) [4] and a fall in high density lipoprotein (HDL) cholesterol [5] which is a strong and independent risk factor for CVD [6]. Most, but not all, cross-sectional studies in fasting men have shown a negative association between endogenous total testosterone and TG [7] and a positive association between endogenous total testosterone and HDL cholesterol [8,9].

Despite the fact that most of our lives are spent in a postprandial state, between the consumption of regular meals, plasma lipids, and triglycerides in particular, are generally measured in a fasting state. Thus, we investigated the relationship between total testosterone and non-fasting TG levels in 1274 men who participated in the fourth Tromsø study.

Methods

The participants of the study were men recruited from the fourth survey of the Tromsø Study (1994/1995), a population based health study, previously described in more detail [10]. In a representative subgroup of 1605 men, aged 25—84 years, non-fasting blood samples were drawn between 08.00 and 16.00 h. Serum HDL cholesterol was measured after the precipitation of low density lipoprotein (LDL) with heparin and manganese chloride. Serum total cholesterol and triglyceride levels were analyzed by enzymatic colorimetric methods with commercial kits (CHOD-PAP for cholesterol and GPO-PAP for triglycerides, Boeringer-Mannheim, Mannheim, Germany). Serum samples for the analyses of sex hormones were stored at −70 °C, until they were first thawed in 2001. Determination of total testosterone, and sex hormone-binding globulin (SHBG) was performed on Immulite 2000 (Diagnostic Product Corp., Los Angeles, CA, USA). The intra- and inter-assay coefficients of variation (CV) for the analyses were between 5 and 10%. Free testosterone values were calculated from total testosterone and SHBG using a fixed albumin according to Vermeulen et al. [11]. All analyses were performed at the Department of Clinical Chemistry, University Hospital of North Norway. Height and weight were measured in subjects wearing light clothing without shoes. Body mass index (BMI) (kg/m^2) was calculated.

Self-administered questionnaires that included information about smoking habits, physical activity, alcohol and coffee consumption and medical history were completed and checked by trained nurses. A physical activity score was calculated from the questionnaires by adding the hours of easy and vigorous physical activity, with the hours of vigorous activity receiving double weight. The alcohol intake of beer, wine and hard liquor consumed during a 2-week period was also scored, assuming an equal amount of alcohol in one glass of each type.

Of the 1605 men randomly selected for sex hormone analyses 1563 men had complete sex hormone values. Two hundred and sixty-seven men reporting CVD (angina, myocardial infarction or stroke) were excluded as they may have made life-style interventions possibly affecting lipid levels. An additional 22 men were excluded because they either used lipid-lowering drugs or did not have complete lipid values, leaving 1274 men to participate in this study. The Regional Ethics Committee approved the study, and all participants gave written informed consent.

Statistical analyses

Normal distribution was evaluated with determination of skewness, and total and HDL cholesterol and the sex hormones were considered normally