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ARTICLE

Marked differences of fat taste sensitivity between obese and lean subjects

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Gado Dramane, Samuel Gnanka and Virgile Ahyi

Full Length Research Paper

Marked differences of fat taste sensitivity between obese and lean subjects

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Obesity is a risk factor for several diseases such as diabetes and cardiovascular complications. It is established that there is a difference of taste perception between lean and obese subjects. We used alternative forced-choice method to evaluate linoleic acid (LA) sensitivity in 58 West African subjects. LA sensitivity is inversely correlated with the body mass index and the waist circumference, and obesity biomarkers are higher as body mass index (BMI) increase. Our work suggests differences of fat taste sensitivity between BMI categories. Moreover, waist circumference was positively correlated with reduced fat taste sensitivity.

Keys words: Obesity, body mass index (BMI), fatty acid sensitivity.

INTRODUCTION

The deep technical and economic changes of the 20th Century have deeply modified our lifestyle and consequently, our eating behavior. For the first time since the dawn of civilization, much of the world's population has not been able to find their food. Lipids account for about 40% of the calories ingested in the modern diet, whereas the nutritional recommendations for daily lipid intake are 5 to 10% lesser. The prolonged lipid overeating, associated with a qualitative imbalance, is thought to contribute to an increase in the prevalence of obesity and the emergence of diseases of plethora (atherosclerosis, type-2 diabetes, hypertension, cancer, etc.) (Barry et al., 2009). The overconsumption of dietary lipids is associated with an attraction to it. The attraction for dietary lipids has been reported in various species (Takeda et al., 2000; Tsuruta et al., 1999). However, the

molecular mechanisms responsible for this attraction for fatty foods remain unclear. Oro-intestinal tract plays a major role in nutrient bioavailability and eating behavior (El-Yassimi et al., 2008; Schwartz, 2011).

As recently reported for carbohydrates (Margolskee et al., 2007), detection of dietary lipids along the oro-intestinal tract might take place through a common specific lipid-sensing system. In fact, lipid-binding proteins (LBP) are expressed in both oral cavity and small intestine and, consequently, might play such a function. Long chain fatty acids have been shown to be detected in oral cavity via a fatty acid transporter (CD36) (Tsuruta et al., 1999), GPR40 or GPR120 proteins (Cartoni et al., 2010), or by simple diffusion of fatty acids across plasma membrane (Hamilton, 1964). Consistently to this assumption, recent data have reported that the

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scavenger receptor CD36 is expressed on tongue papillae and plays a significant role in the oro-sensory perception of dietary lipids (El-Yassimi et al., 2008; Gaillard et al., 2008). Linoleic acid (LA) is an essential long chain fatty acid used as a representative chemosensory stimulus for fat perception in the oral cavity (Laugerette et al., 2005).

In our study we compare the sensitivity for LA in obese and lean subjects. The sensitivity of LA is compared to the body mass index (BMI) and the abdomen measurement. We also looked at the blood lipids status in our subjects.

MATERIALS AND METHODS

Subjects

58 subjects (median age: 25 years; age range: 18 to 32; median body mass index (BMI): 23; BMI range: 18 to 35) participated in the study. Only healthy men and women were included. All subjects were unrestrained eaters, were free from gastrointestinal or other disease including diabetes, were nonsmokers, nondrinkers and were not taking any medication known to affect appetite or oral sensitivity. The national guidelines for the use and the care of patients in epidemiologic studies were followed.

Data records

Anthropometric measurements taken from patients are weight, height to calculate body mass index (weight in kilograms divided by the square of the height in meters, kg/m^2), and the measure of waist circumference to estimate abdominal obesity. The weight in kilograms was measured for shoeless patients and wearing minimal clothing with a trade balance. Height was measured using a device comprising a centimeter tape. The tape was used to measure waist circumference, just below the last rib and on the top of the hip bone. The blood samples (approximately 8 ml) were taken in EDTA coated bottles and simple bottles from patients with their consent, by a practitioner in medical conditions.

Study outline

Each subject was studied on three occasions separated by at fewer 30 min, in randomized order. The dietary lipids detection threshold was determined using linoleic acid (LA; Sigma-Aldrich, St Louis, MO) at various concentrations (0.018, 0.18, 0.37, 0.75, 1.5, 3, 6 and 12 mmol/L). The alternative forced-choice method (AFC) (Stewart et al., 2011) was used. According to the AFC method, subjects tasted three solutions, one by one, where two solutions contained the control substance (gum arabic, 0.01%; the food Alchemists, France) and the third solution contained LA. Gum arabic is used to mimic the texture of edible oils and allow the emulsion. The sensitivity threshold will be evaluated using a score from 0 to 10 by asking the question if subjects see a "taste of fat" among the proposed solutions. The subjects were not allowed to drink the solution but they should spit after a brief stint (gargle a few seconds) in the mouth. When subjects failed to detect a difference of "taste", they tasted a preparation of higher lipid concentration until they can detect the presence of "oil taste" to record the detection threshold. Results were compared between lean and obese subjects using the BMI and the waist circumference.

Study protocol: blood lipids status determination

Serum separated from the blood sample of each subject collected into plain bottles was assayed for low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c) and triglycerides (Biolabo Scientific Instruments SA, Châtel-St-Denis Switzerland), using the glycerol phosphate oxidase-peroxidase method, end point. Briefly, serum triglycerides are hydrolyzed to glycerol and free fatty acids by lipase. In the presence of ATP and glycerol kinase (GK), the glycerol is phosphorylated to glycerol-3-phosphate (Glycerol-3-P), which is then oxidized by glycerol phosphate oxidase (GPO) to yield dihydrogen acetone phosphate and hydrogen peroxide (HO). The hydrogen peroxide oxidizes a chromogen under the influence of enzyme peroxidases (POD) to form a red quinoneimine dye. The intensity of red colored complex is measured at 505 nm.

Statistics

Results are expressed as mean \pm standard error of mean (SEM). The correlation between groups was evaluated with XLSTAT (Addinsoft, France). We first checked that the data for each group were normally distributed. We then carried out two-tailed Student's *t*-test or Pearson correlation.

RESULTS

Dietary lipids sensitivity is inversely correlated with the body mass index and the waist circumference

To explore whether the orosensory of dietary lipids was related to BMI, we represented LA detection threshold by BMI classes and waist measures. We found that LA detection threshold increased as both BMI and the waist increase. Then lean subjects were highly sensitive (low detection threshold) and obese subjects were less sensitive to dietary lipids (Figure 1). Using analysis of variance, it was found that $F < F_{\text{critical}}$, so the hypothesis is accepted. *t*-Student was $1,10951\text{E}-16$ ($P < 0,005$). Dietary lipids sensitivity is inversely correlated with the body mass index and the waist size.

Blood lipids concentrations increase as BMI and waist circumference increase

To determine whether the glycaemia and the blood lipids are related to the BMI, comparison of the means values ($n = 58$) was done. It was found that the blood concentration of total cholesterol (ChoT), HDL, LDL, triglycerides and glucose (Glc) were higher as the BMI increased. It was also found that in the case of the concentration of blood lipids, the glucose and the waist circumference changed as a function of the BMI (Figures 2 and 3).

DISCUSSION

Obesity has reached epidemic proportions in the world,

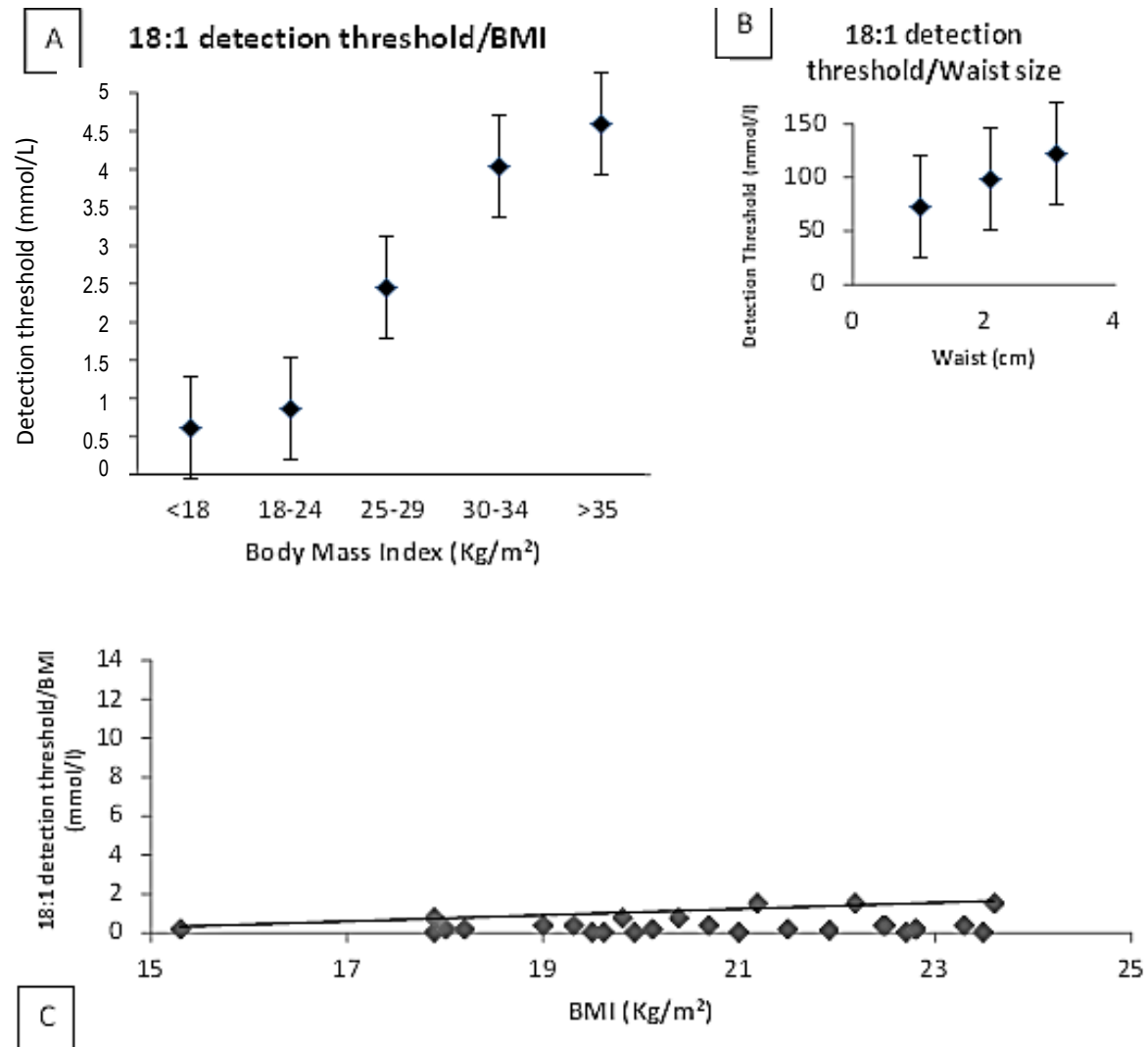


Figure 1. Comparison of the dietary lipid sensitivity in lean and obese subjects. (A) Changes of the LA sensitivity (Mean: 3.5463 ± 3.4 mmol/L) as a function of BMI (Mean: 23.892 ± 5.547 kg/m²), (B) Changes of the LA sensitivity (Mean: 3.5463 ± 3.4 mmol/L) as a function of waist circumference (77.875 ± 13.6 cm). C: Correlation between the BMI and LA detection threshold, determined by using alternative forced-choice method.

with over 1.6 billion adults being overweight and, at least, 500 million being clinically obese (World Health Organization, 2000). Obesity, particularly visceral obesity, is a risk factor for several diseases such as type 2 diabetes, cardiovascular complications, hypertension and some types of cancers (Xiao and Yang, 2012). Obesity generally occurs when the balance between energy intake and physical activity is disturbed. Dietary fat provide an important part of energy and the excessive intake contributes to weight gain and obesity. There are several factors which influence fat consumption, including energy density and palatability (Blundell and MacDiarmid, 1997). Besides, oral taste sensitivity to fatty acids may influence food ingestion and, consequently, regulate body weight.

It has been recently shown that there is a difference in the taste perception between lean and obese subjects. Indeed, the threshold for oro-gustatory perception of dietary lipids, like oleic acid, is reduced in obese subjects as compared to age-matched non-obese ones (Blundell and MacDiarmid, 1997). Stewart et al. (2011) classified obese subjects as hypo- or hyper- sensitive to oleic acid taste detection and concluded that hyposensitive subjects consumed significantly more energy (fat, saturated fat, fatty foods) and had greater body mass index (BMI). The hyposensitive subjects were less perceptive of small changes in the fat contents compared to hypersensitive subjects (Pepino et al., 2012). These findings are consistent with our results. We reported that lean subjects are highly sensitive (low detection threshold) and obese

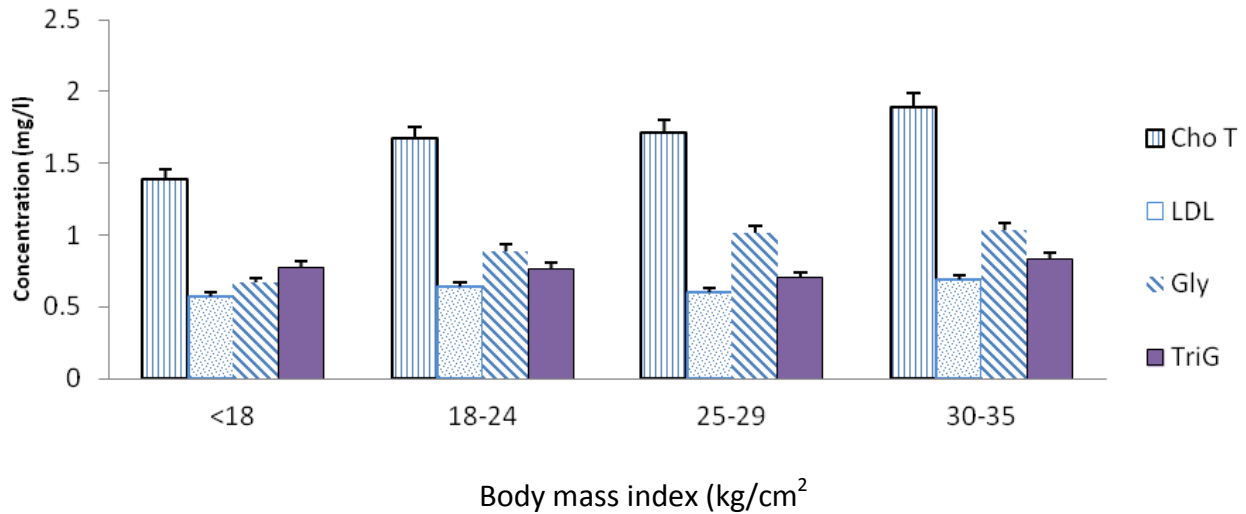


Figure 2. Change of the concentration of blood lipids and glucose as function of the BMI.

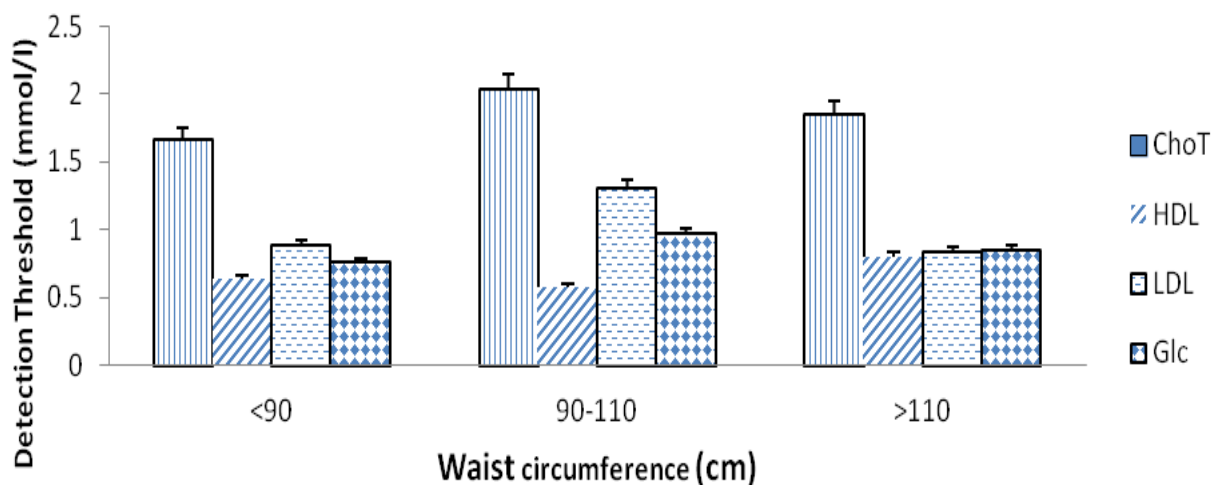


Figure 3. Change of the concentration of blood lipids and glucose as a function of the waist circumference.

subjects are less sensitive to dietary lipids.

The mechanism of oro-gustative perception of lipids is as follows: Long chain fatty acids (LCFA) released from triglycerides (TG) by lingual lipase bind to the fatty acid transporter (CD36) which acts as a lipid receptor in taste receptor cells. The recognition of LCFA by FAT/CD36 induces an increase in intracellular free calcium concentration, an event known to generate the release of neurotransmitters by taste receptor cells. Lipid taste signal is then transmitted by the gustatory nerves, chorda tympani nerve (VII) and glossopharyngeal nerve (IX) to gustatory area of the nucleus of the solitary tract (NST) in the brainstem (Dramane et al., 2012).

Many works have shown that rodents and humans display an attraction for lipid-rich foods through well

known mechanisms (Pepino et al., 2012; Gaillard et al., 2008). Nevertheless, it remains to explain if the dietary fat preference is triggered by obesity and/or induces obesity. Chevrot et al. (2013) brought the first demonstration that the gustatory pathway involved in the detection of dietary lipids is altered in diet-induced obese mouse. Obese mice were unable to properly detect low concentrations of oil (0.02%). Furthermore, the reduced fat taste preference might be due to low expression of FAT/CD36. In high fat diet-maintained obese rats, there is a lower expression of CD36 in gustatory papillae as compared to normal animals (Zhang et al., 2011). In humans, a common single nucleotide polymorphism SNP (rs1761667) in the CD36 gene that reduces CD36 expression has been reported in obese subjects (Pepino et al., 2012). CD36

SNP A-allele, being present both in young lean and in obese children, is associated with high threshold for fatty acid taste sensitivity only in obese children (Sayed et al., 2015).

Numbers of observations suggest that obesity may strongly interfere with the orosensory system responsible for the detection of free long-chain fatty acids in humans (Chevrot et al., 2014). All of these studies have been conducted on Caucasian populations and they must be confirmed in other population where the eating habits are thought to be different.

The present report brings the first demonstration in this region of the world (West Africa) that blood lipids and glucose are generally higher concentrated in increased BMI/Waist circumference of the subjects. The alterations in the insulin levels, during obesity, might have an impact on CD36 expression. The determination of glucose levels could shed light on whether the obese subjects are developing insulin resistance, an early factor responsible for the onset of type 2 diabetes.

Lahfa et al. (1995) have shown that increased hepatic mass was positively correlated with weight gain in obese *Psammomys obesus* (sand rat). It has been shown that obesity in these animals is characterized by peripheral and hepatic insulin resistance (Koceir et al., 2003). Since unnecessary high caloric diet eating contributes to weight increase and insulin resistance, it is possible that fat ingestion might be altered in the obese state (Bray et al., 2004). Besides, obese subjects have been reported to exhibit a higher preference for fatty foods than lean subjects (Mela, 2001). Abdoul-Azize et al. (2013) have shown that in animal models, oral fatty acid sensitivity is determinant for fat consumption and body weight regulation.

Conclusion

Since the increasing incidence of obesity is one of the most important health problems of the world, clarifying the mechanisms of oro-gustatory detection of dietary fat is critical for the prevention and treatment of obesity. From the present study on subjects from West Africa it was thought that obesity only concerns societies with a high standard of living. But our results revealed that the relation between dietary fat perception and/or consumption is similar to Western people. It was established here that the gradual increase of the orosensory detection threshold of lipids leads to a progressive enhancement of the BMI or waist circumference. Furthermore, the markers of obesity are sensibly enhanced as the BMI. This work suggests differences of fat taste sensitivity between BMI categories. The results supports that of Tucker et al. (2014) which led to the same conclusion under conditions of repeated testing where thresholds declined for the lean and overweight but remained stable in the obese. Thus, the lean and

overweight had lower limits of detection for LA. Increased dietary fat intake was associated with decrease in the taste sensitivity.

Conflict of interests

Authors have none to declare.

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