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Original Research

Fat accumulation in the tongue is associated with male gender, abnormal upper airway patency and whole-body adiposity

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ABSTRACT

Objective. To examine associations between tongue adiposity with upper airway measures, whole-body adiposity and gender. We hypothesized that increased tongue adiposity is higher in males and positively associated with abnormal upper airway measures and whole-body adiposity.

Methods. We studied subjects who underwent whole-body positron emission tomography/computed tomography to obtain tongue attenuation (TA) values and cross-sectional area, pharyngeal length (PL) and mandibular plane to hyoid distance (MPH), as well as abdominal circumference, abdominal subcutaneous and visceral (VAT) adipose tissue areas, neck circumference (NC) and neck adipose tissue area. Metabolic syndrome was determined from available clinical and laboratory data.

Results. We identified 206 patients (104 females, 102 males) with mean age 56 ± 17 years and mean body mass index (BMI) 28 ± 6 kg/m^2 (range 16–47 kg/m^2). Males had lower TA values ($P = 0.0002$) and higher upper airway measures ($P < 0.0001$) independent of age and BMI ($P < 0.001$). In all subjects, TA was negatively associated with upper airway measures ($P < 0.001$). TA was negatively associated with body composition parameters (all $P < 0.0001$), most notably with VAT ($r = -0.53$) and NC ($r = -0.47$). TA values were lower in subjects with metabolic syndrome ($P < 0.0001$).

Conclusion. Increased tongue adiposity is influenced by gender and is associated with abnormal upper airway patency and body composition parameters.

Abbreviations: TA, tongue attenuation; PL, pharyngeal length; MPH, mandibular plane to hyoid distance; VAT, visceral adipose tissue area; SAT, subcutaneous adipose tissue area; NC, neck circumference; NAT, neck adipose tissue area; BMI, body mass index.

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1. Introduction

Obesity and male gender are significant risk factors for obstructive sleep apnea (OSA) [1,2], however the mechanisms involved are not completely understood. Prior studies have shown that obesity may lead to upper airway soft tissue enlargement by fat infiltration of the tongue, soft palate and lateral pharyngeal walls [3–5]. The tongue plays an important role in upper airway patency and increased tongue size and adiposity have been associated with higher risk for OSA [4,6] (Fig. 1). Importantly, overweight and obese men have significantly higher intermuscular adipose tissue depots in the neck, as well as higher neck circumference [7]. Taken together, these factors may play important roles in a differential risk for OSA between genders.

Abnormal body fat composition parameters such as body mass index (BMI), neck and waist circumference have shown positive associations with upper airway collapsibility measured using the passive pharyngeal critical closing pressure (Pcrit) technique [6]. Further, Pcrit was associated to airway parameters affecting hyoid position such as mandibular plane to hyoid distance (MPH), tongue length, tongue volume, and pharyngeal length, which are affected by tongue adiposity and size [6]. Preliminary evidence suggests that tongue adiposity may parallel ectopic fat accumulation elsewhere, with positive associations between abdominal subcutaneous (SAT) and visceral (VAT) adipose tissue and tongue fat being present among obese subjects [4]. Although evidence suggests links of (a) tongue adiposity with upper airway patency, and (b) tongue adiposity with whole-body adiposity, prior studies have not addressed these findings in a unified cohort of both genders with varied BMI and detailed whole-body composition assessments, including abdominal and neck fat content.

The purpose of this study was to characterize tongue attenuation values as a measure of tongue fat content, upper airway measures and whole-body adiposity using computed tomography (CT) in a cohort with a broad BMI range of both genders. We examined associations between tongue attenuation values, upper airway measures and body composition parameters, and investigated differences between genders and BMI categories. We hypothesized that increased tongue attenuation values reveal higher tongue fat content in males and are positively associated with abnormal upper airway measures and whole-body adiposity.

2. Materials and Methods

This study was approved by the institutional review board of Partners Health Care and complied with Health Insurance Portability and Accountability Act guidelines, with exemption status for individual informed consent. We performed a retrospective search for consecutive whole-body 18F-fluorodeoxy-glucose (FDG) positron emission tomography and computed tomography (PET/CT) studies obtained in adults (≥18 years old) at our institution. Inclusion criteria comprised (a) fasting glucose measured immediately before PET/CT, (b) FDG-PET/CT performed for benign etiologies or no malignancy at the time of imaging, (c) no FDG-avid lesions to suggest malignancy, and (d) availability of clinical/laboratory data to determine presence of metabolic syndrome. Use of antihypertensive, type 2 diabetes medications, and lipid-lowering agents was recorded. Subjects with a history of neck cancer, radiation therapy, and/or surgery were excluded. Blood pressure and serum lipids obtained beyond 12 months relative to imaging date were not collected. Subjects were

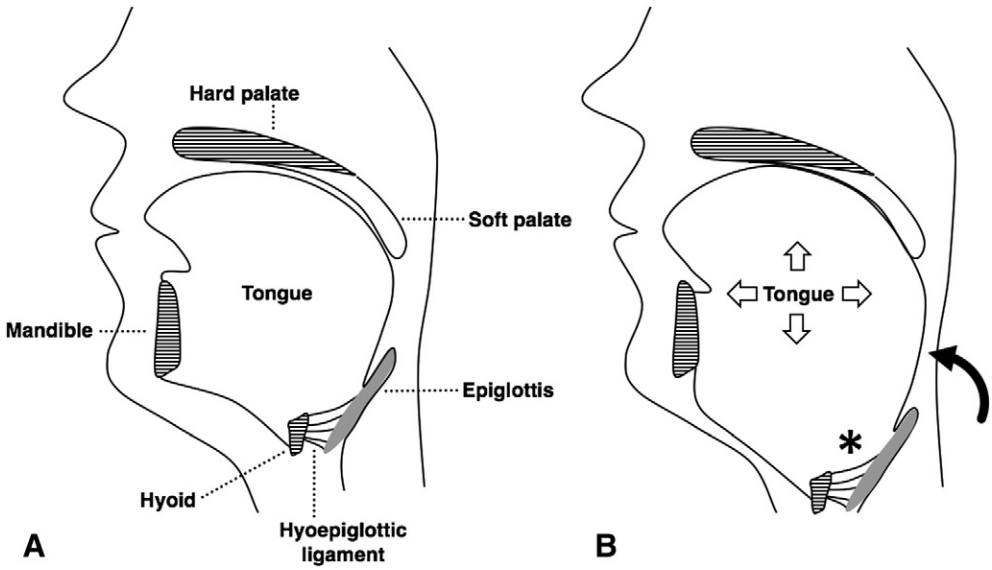

Fig. 1 – (A) The pharynx extends from the soft palate to the base of the epiglottis. The hyoid bone sits at the tongue base and is anchored by muscles and ligaments but does not articulate with other bones. (B) In obesity, tongue enlargement due to fat infiltration narrows the upper airway and displaces the hyoid caudally. The epiglottis follows the hyoid due to their connection via the hypoepiglottic ligament. Caudal displacement of the hyoid and epiglottis (*) leads to an increase in pharyngeal length (curved arrow). A longer pharynx is more collapsible, which predisposes to obstructive sleep apnea.