Associations of Sex Hormones and Anthropometry with the Speaking Voice Profile in the Adult General Population

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Summary: Objective. There is evidence that sexual hormone concentrations and anthropometric factors influence the human voice. The goal of this study was to investigate to what extent body mass index (BMI), body height, body weight, breast-to-abdomen-ratio, testosterone, estradiol, dehydroepiandrosterone-sulfate (DHEA-S), follicle-stimulating hormone, and luteinizing hormone are associated with the sound pressure level and the fundamental frequency of the speaking voice in a cross-sectional approach among adults in the general population.

Methods. Speaking voice profiles with four different intensity levels, hormone concentrations, and anthropometric parameters were assessed for 2,381 individuals aged 40–79 years, who were randomly sampled from the population of a large city in Germany. Multivariate analysis was performed, adjusting for age and stratified by sex.

Results. Taller body height was associated with lower frequencies. Higher body weight was associated with lower frequencies and higher sound pressure levels. The ratio of chest to abdominal circumference was associated with the sound pressure levels in males and females: participants with larger breast-to-abdomen-ratio were found to have higher sound pressure levels. Among the sexual hormones, higher concentrations of DHEA-S were associated with lower fundamental frequencies of the voice while using the normal speaking voice. In addition, bioavailable testosterone was associated with the sound pressure level of the normal speaking voice in men and the softest speaking voice in women.

Conclusion. Our findings suggest that BMI, body height, body weight, breast-to-abdomen-ratio, bioavailable testosterone, and DHEA-S are associated with the speaking voice in adults. No associations between testosterone and the frequency of the speaking voice were found.

Key Words: Body height–BMI–Voice range profile–DHEA-S–Testosterone.

INTRODUCTION

Voice range profiles permit fast and easy assessment of two basic characteristics of the voice: the fundamental frequency and the sound pressure level.[1–3] In clinical practice, this type of examination can help to characterize impairments in vocal performance. Voice range profiles can be measured while singing or while speaking at different prespecified conditions. In the past, singing voice profiles have attracted more attention than speaking voice profiles. Accordingly, the scientific literature on the latter is less comprehensive. Investigations of the speaking voice of a larger sample from the general population are comparably rare.

Sex hormones and speaking voice

Hormonal factors have an influence on the voice. Previous studies suggested that androgens lower the male voice during mutation by one octave while progesterone, estrogen, and testosterone lower the frequency of the voice in women by one-third.[4,5] In adult men, it has been shown that high levels of salivary testosterone are correlated with a low voice pitch,[6–8] while Gugatschka et al demonstrated that androgens have no effect on the elderly male voice.[9] In men with increasing age, endochondral ossification of the larynx could be observed, which can lead to an increase in fundamental frequency.[10] Receptors for progesterone, estrogens, and androgens could be found in the male and female larynx, with significant differences in the number of different subunits.[11,12] The vocal frequency can be lowered by the therapeutic application of high doses of testosterone.[13] A review of the medical literature revealed that the most frequently reported complaints of the premenstrual syndrome was the loss of high notes of the singing voice.[14] It has been shown that multivitamins and estradiol replacement therapy improve these symptoms.[5] During pregnancy, the concentration of progesterone and estrogen is associated with an elevation in phonation threshold pressure.[15] Decreased estrogen was furthermore found to increase the fundamental frequency of the male voice.[9] Vocal changes in postmenopausal women could be reversed by hormone therapy.[16]

Anthropometric parameters and the speaking voice

It has been shown that body height is associated with the speaking frequency, with taller individuals having a lower frequency of the speaking voice.[7,17] While Acurio et al found that excessive body weight was associated with a significant elevation in fundamental frequency value after vocal loading,[18] other authors were not able to show a correlation between body mass index (BMI) or body weight and any of the parameters of the voice.[19–22] Larger chest circumferences were associated with a decrease in fundamental frequency.[23]

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We have recently described how age, sex, socioeconomic status, and smoking are associated with the speaking voice obtained within the framework of a large population-based epidemiological study (Leipzig Research Centre for Civilization Diseases [LIFE]-Adult-Study).[24] Using data from this study, the aim of the present work was to investigate associations between BMI, breast-to-abdomen ratio, body height, body weight, testosterone, luteinizing hormone (LH), follicle-stimulating hormone (FSH), estradiol, dehydroepiandrosterone-sulfate (DHEA-S), and the speaking voice.

MATERIALS AND METHODS

Study population

The present investigation was performed as part of a large population-based cohort study (LIFE-Adult-Study), which is conducted in Leipzig, a major city in Germany with 550,000 inhabitants. In November 2014, the baseline examination of 10,000 randomly selected adult inhabitants (aged 18–79 years) was completed. The LIFE-Adult-Study is part of LIFE, a large research initiative at the University of Leipzig. A major objective of LIFE is to investigate disease prevalences, early onset markers, genetic predispositions, and the role of lifestyle factors for the development of major civilization diseases. Further details of the objectives and the design of the LIFE-Adult-Study are described elsewhere.[25] As part of the baseline examination program, a subsample of 2,510 participants underwent measurement of voice range profiles. Of these, 129 individuals were excluded from the present analysis due to missing (n = 128) or implausible (n = 1) data. Thus, a total of 2,381 participants were eligible for data analysis. Participants who suffered from a common cold or other acute voice disorders, who had undergone surgery of the larynx, or who had known voice problems were not eligible for voice assessment. A questionnaire was used to identify participants with these mentioned conditions prior to the voice assessment.

Voice range profile

For the recording of voice range profiles, the DiVAS voice diagnostics software (XION GmbH, Berlin, Germany) was used. It was run on a Windows-based PC (Microsoft, Redmond, USA), utilizing the self-calibrating microphone headset provided by the software manufacturer. A standardized voice range measurement protocol as recommended by the Union of European Phoniatricians by Schutte and Seidner was maintained.[26] A constant distance of 30 cm between the mouth of the participant and the microphone was kept.

For the speaking voice range profile, every subject was requested to count as softly as possible from 21 to 30, then to count again from 21 to 30 using the normal speaking voice (fundamental frequency), following classroom voice and the shouting voice to record the speaking voice at four different volumes. The recordings were started after reaching 23 but before reaching 24. In addition to the speaking voice range profile, a singing voice range profile of every subject was also measured.

Feasibility studies were performed prior to the main study to assure interexaminer reliability. All measurements were performed by trained technical staff based on written standard operating procedures. Experienced voice specialists from the Department of Phoniatrics and Audiology conducted regular quality control audits every 3 months.

Anthropometric data assessment

Anthropometric measurements were performed using a laser-based 3D-bodyscanner (Vitus Smart XXL with software ScanWorX 2.9.9b; Human Solutions GmbH, Kaiserslautern, Germany). This technique provides an optical resolution of 3 mm vertically and 1 mm horizontally, with 27 measurement points per square centimeter body surface. From the raw scanning data, the ScanWorX software (Human Solutions GmbH) is able to determine more than 140 anthropometric measures. For the purpose of the present analysis, the ratio of the chest circumference (measured directly under the breast) to the belly circumference was used as measure of interest (breast-to-abdomen ratio).

Classical anthropometric measurements were also performed. Body weight was determined with an electronic scale (SECA 701; seca GmbH & Co. KG, Hamburg, Germany) with a precision of 0.01 kg, and body height was measured by means of a stadiometer (SECA 240; seca GmbH & Co. KG). The BMI was determined from these two measurements.

Laboratory measurements

Blood samples were drawn to measure the concentrations of the following sex hormones: LH, FSH, estradiol, testosterone, and DHEA-S. DHEA-S is the sulfate ester of DHEA, which is a precursor hormone of estrogens as well as androgens, synthesized in the adrenal gland. The measurements were performed by the fully mechanized electrochemiluminescence system Cobas (Roche, Germany) in the Institute of Laboratory Medicine, Clinical Chemistry and Molecular Diagnostics of the University of Leipzig, which is a certified laboratory. Bioavailable testosterone concentrations were calculated using the formula developed by Vermeulen,[27] taking into consideration the concentration of sexual hormone-binding globulin (SHBG), albumin, and testosterone and calculating the concentration of testosterone not bound to SHBG. SHBG and albumin were likewise measured by the Cobas system. Intra-assay as well as interassay coefficients of variation of all methods were below 6%.

Statistical analysis

Descriptive statistics were employed using absolute and relative frequencies, mean and standard deviation, median and interquartile range, and 95% confidential intervals. Multivariable linear regression models were used to investigate associations between voice profile parameters (dependent variables) and body height, body weight, BMI, breast-to-abdomen ratio, DHEA-S, FSH, LH, bioavailable testosterone, and estradiol (independent variables). All regression models were adjusted for age and calculated separately for men and women. We considered P values <0.05 as statistically significant. Statistical analyses were conducted using IBM SPSS Statistics for Windows Version 22.0 (IBM Corp., Armonk, New York).