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1. Introduction

Advanced measures for voice analysis in patients are now-a-days not evidence based for clinical use, in randomized clinical trials as a basis for medical treatment. A number of reviews were made on voice disorders where no RCT was found (2-3). Evidence in voice research has been discussed by our group at several conferences (4-9). The problem has to some extent been the lack of normal voice function values that can be used for medical treatment (effect of allergy, infections of the upper airways as well as reflux, emotional and environmental voice disorders. Therefore we have established a normal frame of measurement references in a Danish material. In the clinical situation diagnosis of voice disorders will vary, depending on the apparatuses, and also on the cooperation between different experts. 1. Medical doctors 2. Voice pathologists 3. Engineers 4. Phoniatrists

2. Materials

18 healthy amateur female singers and 12 healthy amateur male singers between 20 and 40 years of age were analysed. At their inclusion a phonogram was made which means that they could reproduce a given tone. Normal values for phonograms are the appearance of the averaged phonograms in adults are given among others in the regime of F-J Electronics (13).

3. Methods

The following measurements were carried out in the duration of two days:

A. Multi-Dimensional-Voice-Program (MDVP) (10) by the firms Key Electromics and Laryngograph (11) including sustained tones and reading of a standard sentence: "the blue spot is on the key again, and the story: the north and the sun, respectively. Mean fundamental frequency, frequency and intensity variation percent were measured. For the firm Key Electromics also harmonics to noise ratio and degree of voicelessness, and for the firm Laryngograph, also glottal closed phase (Ox%), and cohesion factor (irregularity%). Long term average spectrograms (LTAS) measurements were made with Laryngograph equipment. The calculations were made on Key Electromics equipment.

B. Phonotograms (by the firm Voice Profile) (12) - including calculations of the lowest tone, the highest tone, maximal dynamics and calculation of area of voicing in semitones times decibels (dB(A)).

C. Acoustic measurements for sustained tones and consonant/vowels (Aerophone II by F J Electronics, Denmark) (13): lung volume, peak flow, mean flow rate and more updated new parameters. High speed films by the firm Wolf, Germany (14), which include many quantitative measurements, quantitatively of the opening phase between the vocal cords in front, middle and rear and an area opening calculation in % between the vocal cords. Standard deviations were made. Multivariate pair wise correlations were made and significance probabilities more than 0.5 were included. One way analysis of power (dB) was made by gender with summary of fit. A model of polynomial fit degree=5 was used for bit variety of power (dB) by frequency (Hz) for sustained tones. For reading of a text and polynomial fit degree=6 was used for bit variety of power (dB) by frequency (Hz). The statistics were made in a frequency area from 0-11,000 Hz and in 3-sub groups of frequency of 200-800 Hz, 2300-2700 Hz and 9,500-11,000 Hz. (SAS institute program, JMP 7) (15)

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4. Results

The clients had normal video stroboscopies and the measurements, as analysed with statistics from the SAS Institute will be used as normal values in our clinic further on. Some results (n = 10) were already presented earlier by invitation at the XIIIth Congress of the International Rhinology Society, (round table on coughing and voice disorders in rhinitis and asthma, the role of allergy and medication, Venice 2007) (16).

Table 1 shows the mean flow rate, vital capacity and peak flow in table 1a, compared with jitter and shimmer as well as electroglottographical closed phase (Ox%) on sustained tones, a comparison was made to frequency and intensity variation and Ox% in reading of a standard text in table 1b in this defined normal material, corresponding to a normal upper airway mucosa and anatomy, including a normal larynx by video stroboscopy and high speed films, of the vocal cords, the song, recesses of the larynx, backward region including the arytenoid cartilages and opening to the oesophagus (16).

Table 1a: Mean flow rate, vital capacity, peak flow, jitter, shimmer, and Ox% on sustained tones.

No significant difference was found for fundamental frequency, frequency and intensity variation in reading and for a sustained tone for the firms Key Electromics and Laryngograph. The use of the term jitter and shimmer in reading of a standard text should be probably in the future be replaced by frequency and intensity variation in percent. The Harmonics to Noise Ratio and degree of voicelessness measured with the Key Electromics program are shown for these normal persons in table 1c.

Table 1b: Key Electromics to Noise Ratio and Degree of voicelessness. Table 1c: Degree of voicelessness, Irregularity% (cohesion factor), and Degree of voicelessness (Ox%).

The cohesion factors or irregularity percents for all measures versus the ones were two resemble each other are presented. A division is made for reading of a standard text (the north win and the sun) and a sustained tone for 4 seconds. The phonation times are also presented. LTAS results are presented in table 1d, showing significant different results of harmonics between males and females. The difference is presented especially at the areas 200-800 Hz, 2300-2700 and 9500-11000 Hz in table 1d:

a. The sustained tones of both males and females are presented in polynomial fit degree=5 areas are marked from 200-800, 2300-2700 and also 9500-11000. With one way analysis of power by gender, a difference is found between resonance power, better for males at the area 200-800 Hz (40 vs 34 dB). At the area between 2300-2700 (23 vs 20 dB) the resonance power is also better for men. But at 9500-11000 Hz there is a slightly better result for females. Measurements from 9500-11000 Hz based on a polynomial fit degree=5 of sustained tones.

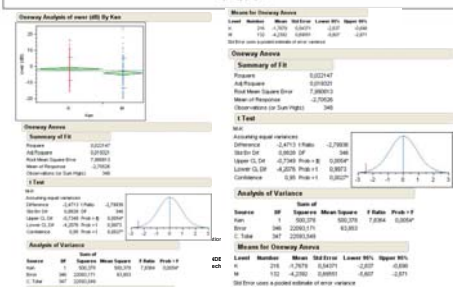
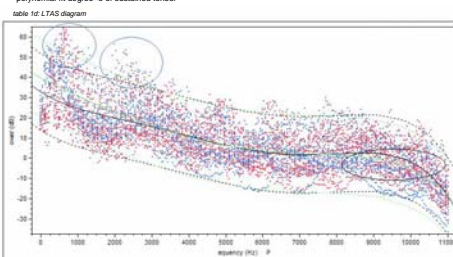
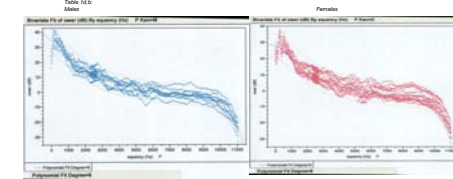
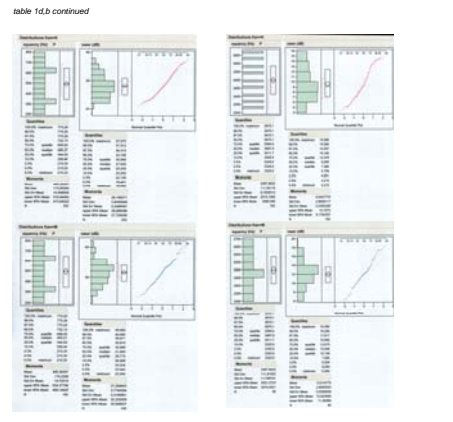


Table 1d,b: The text (north win and the sun) of both males and females are presented in polynomial fit degree=6. The normal distributions at 200-800 Hz and 2300-2700 Hz are presented and the one way analysis of power (dB) by gender showed that the males had a larger resonance than the females (31 vs 28 dB) at 200-800.



Results continued



In table 2 the calculated results are presented for phonograms of the lowest-, highest tones, the maximal dynamic area and the total area in semitones times decibels for males and females. In table 3 an attempt has been made to select some of the most important new air flow parameters.

Table 2: 30 normal amateur singers. Table 3: 30 normal amateur singers. Table 4: 30 normal amateur singers. Table 5: 30 normal amateur singers.

In table 6 the open quotients of the high-speed films are presented, in front, centre and rear as well as the area calculation of the general open phase %.

A multivariate statistics made with SAS institution showed many interesting connections in table 5.

Table 5: Statistical connections between parameters. Table 6: Open quotients of high-speed films.

The clinical value of the results, document the voicing as a wind instrument with most significant connections to the Aerophone II measurements.

5. Discussion

Normal materials of voice measurement vary of course with age. We have earlier measured the fundamental frequency and phonotograms at school age up to 18-19 years of age (17) compared with hormonal development and secondary sex characteristics. The same approach has been not yet been made with aging of voice. LTAS from 1-11,000 Hz have to be made in larger materials on sustained tone and in speech (reading7). Single plots give no information about the quality of the voice usable in pathology related e.g. to allergy, infections of the upper airways and reflux, except in extreme cases. The open quotient in high speed films is interesting, variations give information as a basis for treatment e.g. of posterior laryngitis as seen in laryngo-pharyngeal reflux, development of voice and various technical problems related to the closure in front, centre and rear part of the vocal cords. We have presented statistical significant relations especially to airflow related parameters. We have not sorted out the standard deviations after mutual dependencies on Aerophone II. But the high significances for correlations indicate that these measurements must be used much more in the future. This is a promising cue to further understanding of the voice as a wind instrument. The documentation aspects of treating allergy, infection and reflux at the laryngeal level certainly have taken a step forward with video stroboscopy, combined with quantitative high speed films (18) and a significantly related frame of normality for physiological and acoustical measures.

6. Conclusion

The clinical usable tools: video stroboscopy and high speed films were evaluated in 30 amateur singers and the (normal) results were statistically compared with physiological and acoustical parameters measured at the same time. The result of all air flow must be used much more in the future since the significant values related to sound wave disorders. The aspect of air pressure measurement is also a promising for clinical trials of treatment effect of upper airway surgery. For high speed films the quantitative measurements must be further developed.