

The Change of Voice during Puberty in Choir Singers Measured with Phonetograms and Compared to Androgen Status together with Other Phenomena of Puberty

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1. Introduction

The purpose of our work is to get better laryngophysiological understanding and possibilities to predict the time when choir boys lose the high frequencies of voice, so that they no longer can be used as sopranos or altos in a boys' choir. Two questions arise:

1. Which parameters will enlighten the changes in the best way.
2. How are the normal limits defined in relation to extreme variants and pathological divergences.

These relations have been discussed by Weiss (1950). Already Flatau and Gutzmann (1908) made a study on the voice of schoolchildren. Hartlieb (1957) concentrated on the tone range of youngsters. Sturzeberger, Wagner, Becker, Rauhut and Seidner (1982) examined in an up to date study singing formants and phonetograms in adults, but we have found no study where our earlier work on comparing the strictly biological endocrine factors to voice phenomena could be elucidated (Pedersen, Kitzing, Krabbe and Heramb, 1982). Krabbe, Christiansen, Robro and Transbol (1979) have compared pubertal hormone changes to bone growth and mineralisation. The steroid hormones were examined in elder Danish children by Pedersen, Bennett, Nielsen and Svenstrup (1983). A survey of endocrinology in puberty was given by Tanner (1981).

Our study is here concentrated on understanding the connection between phonetograms and androgen status. Many other parameters have been measured and those are included that elucidate the phenomena mentioned.

2. Material and Method

48 boys from 8-19 years in the Copenhagen Boys' Choir were included in the research programme. The selection was randomized with an equal number of subjects in each class. The children are taken into the music school on the third level with the help of the criteria musicality and good voice qualities.

Blood examination for androgen status together with somatic examination were carried out on the same day. The phonetograms were made after Seidner and Schutte (1981) and areas were estimated. Some other parameters

are shown, e.g. testis volume, fundamental frequency with electroglottograph in a reading situation after Kitzing (1979) and the lowest frequency in the phonetogram. The measuring of androgens was carried out at the hormone Dpt. of Statens Seruminstitut. The logarithmic transformations of the observations of all parameters were required to obtain a normal distribution. Data were investigated by one-way analysis of variance and the correlation coefficients were calculated comparing all parameters. The age distribution is described in a set-up alike to the earlier mentioned study of Danish children. The yearly changes in percent of the values were calculated by linear regression on the logarithmically transformed data.

3. Results

The characteristic phonetograms at different ages are shown in Figs. 1-4. The pubertal changes for an individual certainly are not linear as the mean values suggest. The computed scattergrams for serum testosterone illustrated our problem. The regression line is straight even if the material is divided in two averaged groups there is no big difference in the gradient. In Table I we therefore described the results in groups, but we have calculated the change per year in percent of each factor for the androgenstatus as well as the testis volume and voice function on the basis of all results. The testis volume has a growth rate of 36% per year compared to a fall of fundamental frequency of 11% per year. Many nuances have to be explored, but we found that the parameters are correlated significantly to height, weight, and pubic hair ($p < 0.01$).

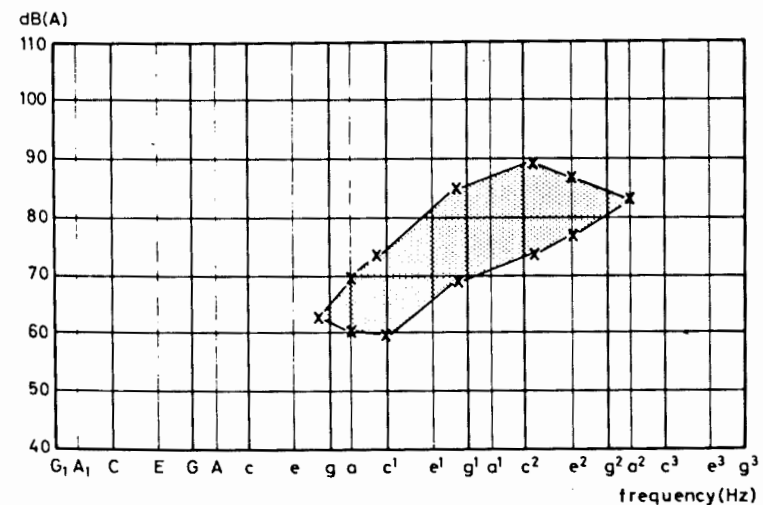


Figure 1. The characteristic phonetograms at 9.25 years when the boys start at the third school class level.

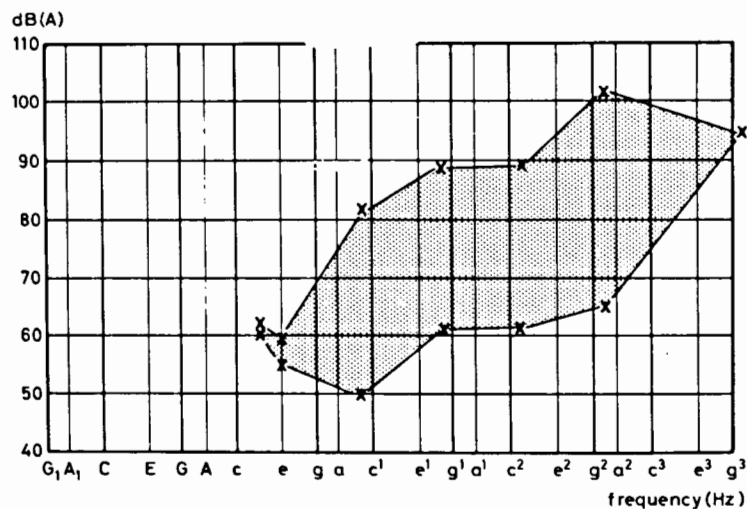


Figure 2. The characteristic phonotograms at 11.9 years when the singing quality is at its height.

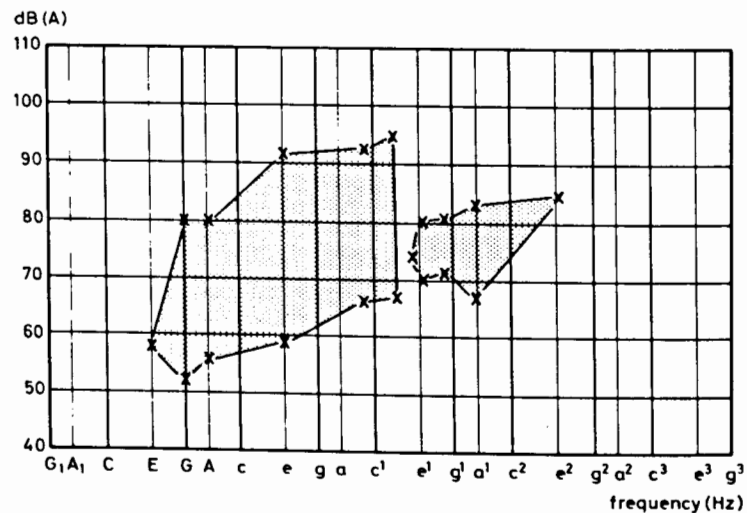


Figure 3. The characteristic phonotograms at 14.2 years when the boys can no longer sing properly.

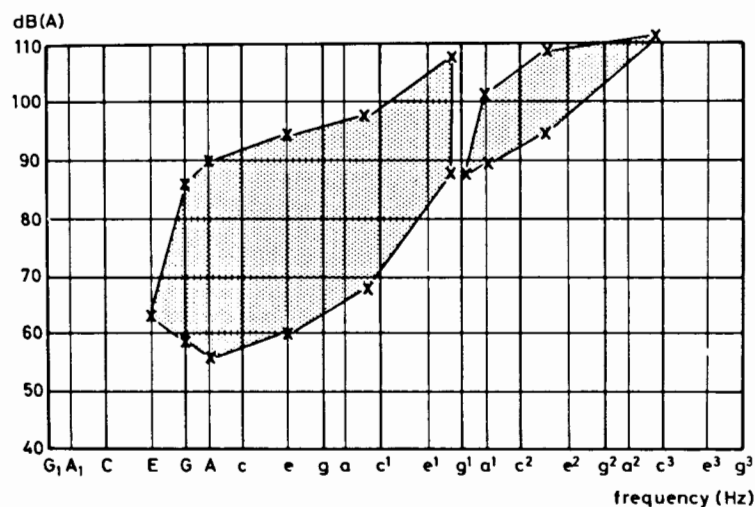


Figure 4. The characteristic phonotograms at 18.2 years when the young man sings again with a good voice.

Table I. Geometric means of androgen status, testis function and voice

Age	(years)	8.7-12.9	13.0-15.9	16.0-19.5	pr yr % change
No of boys		19	15	14	
Serum testosterone	(nmol/l)	0.54	10.5	18.9	68
Dihydrotestosterone	(nmol/l)	0.18	1.21	1.57	37
Free testosterone	(nmol/l)	0.007	0.14	0.33	77
Sexual hormone Binding globulin	(nmol/l)	134	66	45	-16
Delta 4 androstene Dione	(nmol/l)	0.59	1.7	2.5	24
Dehydro epi andro Sterone sulfate	(nmol/l)	1400	4100	5900	25
Testis volume	(ml)	2.3	13	20	36
Fundamental frequency	(Hz)	273	184	125	-11
Voice range	(semitones)	3.7	4.8	5.0	3.9
Phonotogram area	(cm ²)	19	28	34	9.2
Lowest biological tone	(Hz)	158	104	72	-12

4. Conclusion

A significant correlation between androgens, fundamental frequency voice range phonotogram area and lower border frequency in the phonotogram was found. We can therefore state that the hormone changes are related to the fundamental frequency and probably at least in our material to the lower border of the biological tone range and the phonotogram area with the same

significance. We therefore have to continue our studies to encircle prognostic data for losing height of voice in puberty. Problems with differentiation of falsetto in the upper part of the phonetogram must be discussed. The limits can possibly be defined with singing formants which were found in some children (Seidner and Pedersen, 1983). In the material given, our results on the musical talents of the children are not discussed in detail. With a perception test we have tried to find the limits of the tone range usable in a choir situation and mark them in the phonetograms.

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