Auditory perception of voice qualities and speaking fundamental frequency in Mulibrey-nanism and in some other children with growth failure

Vuorenkoski, V. and Tjernlund, P. and Perheentupa, J.

journal: STL-QPSR
volume: 13
number: 2-3
year: 1972
pages: 064-074

http://www.speech.kth.se/qpsr
IV. MEDICAL APPLICATIONS

A. AUDITORY PERCEPTION OF VOICE QUALITIES AND SPEAKING FUNDAMENTAL FREQUENCY IN MULIBREY-NANISM AND IN SOME OTHER CHILDREN WITH GROWTH FAILURE

V. Vuorenkoski*, P. Tjernlund**, and J. Perheentupa***

Summary
Auditory and instrumental analysis of the voice of 20 children with different types of growth failure revealed various kinds of abnormalities. The fundamental frequency was found to be higher than normal, with no correlation to age. In the auditory judging of voice qualities, several voices were regarded abnormal, the sex of the subjects was not correctly identified, and the age was estimated younger than the chronological age. Various articulatory and phonatory disorders were observed in the material. The clinical significance of voice analysis in children with growth failure is discussed.

There is a multiplicity of causes of growth retardation in children. Some of them affect postnatal growth only. Of these, the normal variants of hereditary small stature and hereditary slow growth and maturation are the most common; especially the coincidence of these two features appears as marked stunting of the child. The well known deficiency states of thyroid and growth hormone must be recognized and effectively treated as early as possible. Children with growth failure which is already apparent at birth are as common but less well classified. Various aberrations of genes or chromosomes cause such prenatal dwarfism. In other instances a known or unknown external harmful influence of a temporary nature gives rise to permanent damage to the growth of tissues in utero. New methods are needed to characterize the various aspects of growth failure for classification purposes.

Mulibrey-nanism is a recently described prenatal dwarfism(4) which is inherited by an autosomal recessive gene. One of the characteristics of this condition was reported to be a peculiar type of high-pitched voice; this observation initiated a systematic study of a possible correlation

* Dept. of Speech Communication, KTH and Dept. of Pediatrics, Keskipohjänmaa Central Hospital, Kokkola, Finland.
*** Children’s Hospital, University of Helsinki, Finland.
between early voice deviations and growth retardation. A collection of tape recordings of different types of nanism was started in 1970 at the Children's Hospital, University of Helsinki.

Primary observations had suggested the occurrence of different types of abnormalities and peculiarities in the voices of these patients:

1. Many patients with growth failure seem to have some kind of voice deviation already at an early age;
2. A relatively high fundamental frequency (F0) is a general feature;
3. Some specific voice qualities may make it possible to differentiate certain types of nanism (e.g., Mulibrey) from others;
4. Some patients may have individual voice qualities on the basis of which we can make a personal identification during infancy.

Method and material

Voice recordings from 20 patients representing different types of growth failure were included in this study. Fifteen had prenatal nanism (cases 1-15); five had postnatal nanism (cases 16-20), two of these familial short stature with delayed growth and maturation (cases 19-20). Their chronological age varied between 3.9 and 13.2 years at the time the voice recording was made. There were 11 boys and 9 girls. For the clinical data, see Table IV-A-I.

The voice sample used was the same for each subject, a short sentence of command in Finnish "Tulkaa hiihtämään!" [tulk:a:hiiht:am:a:n] (in English: "Come to ski!"). Figs. IV-A-1 and IV-A-2 show sound spectrograms of this sentence, recorded from cases 18, 19, 1, 10, 8, and 6. The different vowels and consonants are roughly segmented but these spectrograms are shown only as a guide for preliminary orientation. A detailed study of the physical analysis of the articulatory features will be presented in a forthcoming study. The children were asked to say the sentence in a loud voice to imagined friends in the room close by.

The recorded voice samples were studied both by instrumental and by auditory analysis. The results of the F0 analysis are presented in this paper from the instrumental analysis. The F0 and the subsequent calculations were analyzed from each sample using an automatic computerized method. This method has been described in detail elsewhere (5). In short, the fundamental is isolated using a low pass filter. The zero crossings are detected and converted to a pulse train. These pulses are the input
Fig. IV-A-1a - c. "tulkaa hiihtämään" recorded from cases 18, 19, and 1.

Segments:  
1 = t  
2 = u  
3 = 1  
4 = k  
5 = a:  
6 = h  
7 = i:  
8 = h  
9 = t  
10 = m  
11 = m  
12 = z:  
13 = n  

Fig. IV-A-1a.
Fig. IV-A-1b.
to a computer. The computer measures the period time using the internal clock as reference. It calculates the instantaneous frequency and stores the results. This operation is made in real time with the computer working on line. The normalized frequency distribution is calculated and fed through a digital plotter together with the median value and the semi-interquartiles.

The possibility of auditory perception of abnormal and specific voice qualities was tested using a specially edited tape containing the 20 samples of "Tulkaa hiihtämäen" mixed in random order. The method of constructing this type of test tape has been described earlier \(^6\). A copy of the test tape can be obtained by request from the authors. The tape was played in several group tests to 56 adult judges with pediatric or acoustical training. The judges are presented in this study as one group (Table IV-A-I) and are also divided into three sub-groups (Table IV-A-II):

1. 16 pediatricians and nurses who knew at least some of the children, studied at the Children's Hospital, University of Helsinki;
2. 20 pediatricians and nurses with no experience in the care of the patients studied, from the Dept. of Pediatrics, Keskipohjanmaa Central Hospital, Kokkola, Finland;
3. 20 acousticians and students in acoustics and general phonetics having no experience with the voices of nanism-patients and a relatively poor knowledge of children's voices and Finnish, at the Dept. of Speech Communication, KTH, Stockholm.

The judges were informed that they were to hear "Tulkaa hiihtämäen" from 20 different children and that some of them had voice disorders caused by a growth failure. The tape was played twice; the first time the judges were asked to write on a special rating formula whether the voice belonged to a child with a growth retardation or not. When the tape was played the second time, the judges were asked to write the age and sex of the children. In addition, group I was asked to mark "Mulberry" if they could make this differential diagnosis.

Results

Results from the \( F_0 \) analysis and from the auditory perception test (all the 56 judges condensed into one group) are presented in Table IV-A-I. The \( F_0 \) (median) varied in this series between 300 Hz (case 10) and 431 Hz (case 2), the mean of all the median values being 356 Hz. The mean values for the semi-interquartiles were 293 and 400 Hz.
Fig. IV-A-2a - c. "tulkaa hiitämään" recorded from cases 10, 8, and 6.

Segments:
1 = t  4 = k  7 = i:  10 = m  13 = n
2 = u  5 = a:  8 = h  11 = m
3 = i  6 = h  9 = t  12 = m.

Fig. IV-A-2a.
As for the auditory judging of voice items as growth retarded, the total mean frequency was .52. The voices of 7 boys and one girl (see Table IV-A-1) were identified at a significant level as abnormal while the voices of 3 boys and 5 girls were regarded as normal, the judging being contradictory in the case of one boy and 3 girls. We can examine the influence of the age of the child on the estimation level in Fig. IV-A-3, which shows a correlation scatter diagram of the mean estimation as growth retarded by 56 judges and the chronological age of the 20 children; no correlation can be traced.

The judges estimated from the different voices .58 for boys and .42 for girls, which corresponds to the actual sex ratio (11 boys, 9 girls). The total mean for correct identifications was .68. Among the different voice items, the sex of 9 boys and 5 girls were well identified. One boy (case 8) was identified as a girl, and two girls (cases 10 and 14) were identified as boys. Judging of the sex was contradictory for one boy (case 3) and for two girls (cases 7 and 13). The sex identification frequency varied between .14 (case 10) and 1.00 (cases 18 and 20).

The total mean of all age estimations was 1.9 years less than the mean chronological age; this difference is highly significant. Of the different voice items, 5 boys and 4 girls were estimated to be younger than their chronological age at a significant level and no one was significantly estimated to be older than the chronological age. The deviation in age estimation varied between -8.0 years (case 6) and +1.3 years (case 2).

Taking into consideration all the three judgings together (diagnosis, sex, and age), cases 11, 15, 18, and 20 can be regarded as most normal. The most abnormal ones were cases 3, 8, 10, and 17.

If we examine the 6 Mulibrey cases separately we can see that only two of them, cases 4 and 6, have been judged to be normal. The sex of one Mulibrey patient (case 3) was not well identified. The age deviation is significant in only one of the cases (case 6) but is also the most remarkable one: 8 years.

It was of interest to compare the $F_0$ and the age. Fig. IV-A-4 shows a correlation scatter diagram of chronological age and $F_0$ - no correlation can be traced. Similar scatter diagram of bone age and $F_0$ did not
Fig. IV-A-3. Correlation scatter diagram of chronological age and mean estimations as growth retarded by 56 judges. $p > 0.05$. 
Fig. IV-A-4. Correlation scatter diagram of chronological age and $F_0$ in 20 children. $p > 0.05$. 
MEAN ESTIMATED AGE, YEARS

Figure 1: Scatter diagram of mean estimated age.
4C prenatal nanism with dysmorphic features (minor) Significance levels for correct and incorrect anomalies) is here called primordial diagnosis, sex, and for age deviation

<table>
<thead>
<tr>
<th>Voice no.</th>
<th>Type of nanism</th>
<th>Sex</th>
<th>Age years</th>
<th>Bone Age years</th>
<th>Height deviation S.D. units</th>
<th>Weight dev/height dev</th>
<th>F0, Hz P25 MD P75</th>
<th>Identification diagnosis</th>
<th>Frequency for sex</th>
<th>Age estimate deviation years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>mulibrey</td>
<td>boy</td>
<td>3.9</td>
<td>3.7</td>
<td>-3.6</td>
<td>0.97</td>
<td>277 317 361</td>
<td>.95 xx</td>
<td>.80 xx</td>
<td>+0.8 NS</td>
</tr>
<tr>
<td>2.</td>
<td>mulibrey</td>
<td>boy</td>
<td>4.9</td>
<td>5.0</td>
<td>-2.0</td>
<td>1.20</td>
<td>397 431 504</td>
<td>.78 xx</td>
<td>.75 xx</td>
<td>+1.3 NS</td>
</tr>
<tr>
<td>3.</td>
<td>mulibrey</td>
<td>boy</td>
<td>6.7</td>
<td>6.7</td>
<td>-4.5</td>
<td>0.90</td>
<td>359 418 442</td>
<td>.73 xx</td>
<td>.41 NS</td>
<td>-1.0 NS</td>
</tr>
<tr>
<td>4.</td>
<td>mulibrey</td>
<td>girl</td>
<td>6.9</td>
<td>4.8</td>
<td>-2.9</td>
<td>0.98</td>
<td>296 318 384</td>
<td>.37 xx</td>
<td>.68 x</td>
<td>-1.0 NS</td>
</tr>
<tr>
<td>5.</td>
<td>mulibrey</td>
<td>boy</td>
<td>8.4</td>
<td>8.5</td>
<td>-4.3</td>
<td>0.91</td>
<td>303 322 347</td>
<td>.75 xx</td>
<td>.82 xx</td>
<td>-1.1 NS</td>
</tr>
<tr>
<td>6.</td>
<td>mulibrey</td>
<td>girl</td>
<td>13.8</td>
<td>13.0</td>
<td>-5.6</td>
<td>1.06</td>
<td>322 387 423</td>
<td>.29 xx</td>
<td>.96 x</td>
<td>-8.0 xx</td>
</tr>
<tr>
<td>7.</td>
<td>primordial*</td>
<td>girl</td>
<td>6.5</td>
<td>4.0</td>
<td>0</td>
<td>1.05</td>
<td>296 389 444</td>
<td>.45 NS</td>
<td>.37 NS</td>
<td>-1.1 NS</td>
</tr>
<tr>
<td>8.</td>
<td>primordial</td>
<td>boy</td>
<td>8.8</td>
<td>7.5</td>
<td>-1.5</td>
<td>1.35</td>
<td>315 380 408</td>
<td>.60 NS</td>
<td>.16 x</td>
<td>-2.3 x</td>
</tr>
<tr>
<td>9.</td>
<td>primordial</td>
<td>boy</td>
<td>9.0</td>
<td>6.5</td>
<td>-2.7</td>
<td>0.94</td>
<td>291 358 396</td>
<td>.61 NS</td>
<td>.75 xx</td>
<td>-3.7 xx</td>
</tr>
<tr>
<td>10.</td>
<td>primordial</td>
<td>girl</td>
<td>12.3</td>
<td>15.5</td>
<td>-8.4</td>
<td>0.25</td>
<td>241 300 337</td>
<td>.36 x</td>
<td>.14 x</td>
<td>-3.5 x</td>
</tr>
<tr>
<td>11.</td>
<td>prenatal+familial</td>
<td>girl</td>
<td>5.0</td>
<td>4.0</td>
<td>-4.3</td>
<td>0.54</td>
<td>246 372 429</td>
<td>.36 x</td>
<td>.93 xx</td>
<td>-0.6 NS</td>
</tr>
<tr>
<td>12.</td>
<td>prenatal+familial</td>
<td>girl</td>
<td>5.1</td>
<td>2.5</td>
<td>-1.5</td>
<td>0.71</td>
<td>322 383 447</td>
<td>.29 xx</td>
<td>.77 xx</td>
<td>+0.3 NS</td>
</tr>
<tr>
<td>13.</td>
<td>prenatal+familial</td>
<td>girl</td>
<td>5.4</td>
<td>3.3</td>
<td>-0.5</td>
<td>0.68</td>
<td>216 314 352</td>
<td>.55 NS</td>
<td>.55 NS</td>
<td>-0.8 NS</td>
</tr>
<tr>
<td>14.</td>
<td>prenatal+familial</td>
<td>girl</td>
<td>9.4</td>
<td>7.5</td>
<td>-0.9</td>
<td>1.23</td>
<td>275 380 403</td>
<td>.26 xx</td>
<td>.20 xx</td>
<td>-2.7 x</td>
</tr>
<tr>
<td>15.</td>
<td>prenatal+familial</td>
<td>boy</td>
<td>10.0</td>
<td>8.4</td>
<td>-1.2</td>
<td>1.21</td>
<td>274 320 339</td>
<td>.20 xx</td>
<td>.93 xx</td>
<td>-2.2 x</td>
</tr>
<tr>
<td>16.</td>
<td>hyposomatotropic</td>
<td>girl</td>
<td>10.0</td>
<td>6.8</td>
<td>-1.6</td>
<td>0.78</td>
<td>340 418 444</td>
<td>.75 xx</td>
<td>.91 xx</td>
<td>-4.1 x</td>
</tr>
<tr>
<td>17.</td>
<td>hyposomatotropic***</td>
<td>boy</td>
<td>12.1</td>
<td>5.2</td>
<td>-0.7</td>
<td>0.56</td>
<td>275 340 389</td>
<td>.68 x</td>
<td>.75 xx</td>
<td>-4.4 x</td>
</tr>
<tr>
<td>18.</td>
<td>hyposomatotropic</td>
<td>boy</td>
<td>13.2</td>
<td>8.5</td>
<td>-0.5</td>
<td>0.70</td>
<td>282 342 374</td>
<td>.09 xx</td>
<td>1.00 xx</td>
<td>-3.9 x</td>
</tr>
<tr>
<td>19.</td>
<td>familial</td>
<td>boy</td>
<td>7.5</td>
<td>3.0</td>
<td>+3.5</td>
<td>0.56</td>
<td>264 301 420</td>
<td>1.00 xx</td>
<td>.79 xx</td>
<td>-0.4 NS</td>
</tr>
<tr>
<td>20.</td>
<td>familial**</td>
<td>boy</td>
<td>9.2</td>
<td>5.8</td>
<td>0</td>
<td>0.82</td>
<td>273 329 357</td>
<td>.32 x</td>
<td>1.00 xx</td>
<td>+0.6 NS</td>
</tr>
</tbody>
</table>

TOTAL 293 356 400 .52 NS .68 x -1.9 NS

* prenatal nanism with dysmorphic features (minor anomalies) is here called primordial
** familial short stature+delayed growth and maturation
*** brain anomaly

Significance levels for correct and incorrect diagnosis, sex, and for age deviation
NS p = > .05, x p = < .05, xx p = < .01

Table IV-A-I. Diagnosis, sex, age, bone age, deviation of height from the population mean for the bone age, relative weight, fundamental frequency (F0), analysis and voice identification of different voice items (the 56 judges condensed in one group).
show a correlation either. On the other hand, the correlation between the estimated age and $F_0$ approaches but does not reach a significant level, see Fig. IV-A-5. Examining the different cases, it is noticeable that the four most significant age deviations (cases 6, 9, 16, 17) correspond to very high $F_0$ values (387, 357, 418, 340 Hz), despite the ages of these children (13.8, 9.0, 10.0, 12.1 years).

Table IV-A-II shows the results from the voice identification test in the different sub-groups. Comparing the total means, group I (pediatricians and nurses experienced in the care of some of the patients studied) had better values in all the three estimations than group II (pediatricians and nurses not familiar with the patients, and group III (acousticians not familiar with the patients). Group I was significantly better than groups II and III in estimating the voices as growth retarded but the difference between groups II and III was not significant. As for the different voice items, both groups I and II estimated six voices as growth retarded but group I considered only two to be normal, while group II estimated seven voices as normal. Group III was cautious in this estimation: only two voices were regarded as growth retarded and six as normal.

In sex estimation all three groups were grosso modo equal. Group I: ten items right and two wrong at a significant level; group II: 12 items right and two wrong, and group III: nine items right and three wrong.

In age estimation group I was significantly better than groups II and III, which had an equal mean deviation from the calendar age, 2.4 years. If we look at the different items, group I estimated nine cases younger and four cases older than the chronological age; group II 16 cases younger and one case older, and group III 14 causes younger and one case older than the chronological age.

As for the identification of Mulibrey, group I recognized cases 1, 2, and 3 as Mulibrey but not at a significant level due to a relatively large number of incorrect identifications.

Discussion

Auditory and instrumental analysis made from a short voice sample recorded from 20 children with different types of growth retardation revealed some significant deviations from normality.
### Table IV-A-11

<table>
<thead>
<tr>
<th>VOICE NO</th>
<th>DIAGNOSIS</th>
<th>SEX</th>
<th>AGE ESTIMATE DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>1</td>
<td>.75 NS</td>
<td>.40 NS</td>
<td>.20 x</td>
</tr>
<tr>
<td>2</td>
<td>.68 NS</td>
<td>.75 NS</td>
<td>.40 NS</td>
</tr>
<tr>
<td>3</td>
<td>.00 xx</td>
<td>.35 NS</td>
<td>.65 NS</td>
</tr>
<tr>
<td>4</td>
<td>.75 NS</td>
<td>.65 NS</td>
<td>.30 NS</td>
</tr>
<tr>
<td>5</td>
<td>.87 x</td>
<td>.95 xx</td>
<td>1.00 xx</td>
</tr>
<tr>
<td>6</td>
<td>.56 NS</td>
<td>.20 x</td>
<td>.15 x</td>
</tr>
<tr>
<td>7</td>
<td>.31 NS</td>
<td>.20 x</td>
<td>.55 NS</td>
</tr>
<tr>
<td>8</td>
<td>.43 NS</td>
<td>.35 NS</td>
<td>.20 x</td>
</tr>
<tr>
<td>9</td>
<td>.00 xx</td>
<td>.10 xx</td>
<td>.15 x</td>
</tr>
<tr>
<td>10</td>
<td>.43 NS</td>
<td>.10 xx</td>
<td>.10 xx</td>
</tr>
<tr>
<td>11</td>
<td>.87 x</td>
<td>.60 NS</td>
<td>.40 NS</td>
</tr>
<tr>
<td>12</td>
<td>1.00 xx</td>
<td>1.00 xx</td>
<td>.40 NS</td>
</tr>
<tr>
<td>13</td>
<td>.31 NS</td>
<td>.20 x</td>
<td>.30 NS</td>
</tr>
<tr>
<td>14</td>
<td>.68 NS</td>
<td>.80 x</td>
<td>.70 NS</td>
</tr>
<tr>
<td>15</td>
<td>1.00 xx</td>
<td>.65 NS</td>
<td>.60 NS</td>
</tr>
<tr>
<td>16</td>
<td>.81 NS</td>
<td>.85 x</td>
<td>.40 NS</td>
</tr>
<tr>
<td>17</td>
<td>1.00 xx</td>
<td>1.00 xx</td>
<td>1.00 xx</td>
</tr>
<tr>
<td>18</td>
<td>.56 NS</td>
<td>.20 x</td>
<td>.15 x</td>
</tr>
<tr>
<td>19</td>
<td>.93 xx</td>
<td>.90 xx</td>
<td>.45 NS</td>
</tr>
<tr>
<td>20</td>
<td>.43 NS</td>
<td>.20 x</td>
<td>.50 NS</td>
</tr>
</tbody>
</table>

**TOTAL**: .62 .52 .43 .72 .71 .64 -0.9 -2.4 -2.4

Significance levels for correct and incorrect diagnosis, sex, and for age deviation: NS $p > .05$, $x$ $p < .05$, $xx$ $p < .01$

Table IV-A-II. Voice identification: frequency of correct diagnosis and sex, and deviation of estimated age from chronological age in the different voice samples by the three groups of judges: I = pediatricians and nurses with some knowledge of these groups of patients, $N = 16$, II = pediatricians and nurses with no knowledge of these groups of patients, $N = 20$, III = acousticians with no knowledge of patients, $N = 20$. 
Eguchi and Hirsh\(^1\) have studied the F\(_0\) values from 84 normal children with a similar age range (3-13 years) and distribution to our present series. They found a continuous decrease in F\(_0\) with age, from the mean of 298 Hz at 3 years to the mean of 230 Hz at 13 years. In our series the F\(_0\) did not show any correlation with the chronological age nor with the developmental age, as estimated from bone maturation (bone age). This indicates that different types of growth retardation and different clinical pictures lead to a disproportionate development of F\(_0\).

The general level of the F\(_0\) in this series was relatively high; the mean F\(_0\) obtained from all the 20 median values of the individual voices was 356 Hz with a range of 300-431 Hz. In the material of Eguchi and Hirsh the mean F\(_0\) calculated from all the age groups was 260 Hz. Significance test performed for the difference between the F\(_0\) values of Eguchi's and Hirsh's series and the present material gives p \(<\) 0.001. The F\(_0\) values in their material were estimated from the narrow band spectrograms at the vowel formant sectioning points while in this study, the F\(_0\) was analyzed from each sample by using an automatic, computer-based method. The voice material used by Eguchi and Hirsh consisted of two short sentences in English: "he has a blue pen" and "I am tall", repeated 5 times by each subject. The voice sample recorded from each subject in the present study was a sentence of command in Finnish, "tulkaa hiihtämään!" (in English = come to ski!). This sentence was selected because it was equally familiar to all the children and it will be even easy to make mentally subnormal patients to say it in a natural, loud voice. Despite the methodological differences between our study and that of Eguchi and Hirsh, we feel justified considering the difference in F\(_0\) to be significant. Also several other studies on the F\(_0\) of normal children\(^2,7\) support the significance of this difference.

In the auditory analysis the 56 judges with pediatric or acoustical training estimated eight of the 20 voices as growth retarded and eight voices as normal; the judging was contradictory in four cases. This estimation did not correlate with the chronological age of the children. However, more male than female voices were regarded as abnormal. A preliminary spectrographic inspection of the voice material indicates a lack of coordination between articulation and phonation in most of the
cases regarded as abnormal. As to the subjective observation of the phonatory qualities, about half of the children in this series seems to have some kind of general phonatory subnormality, mainly variable degrees of hoarseness or nasality. The nature and significance of these subnormalities will be discussed in a later paper.

The sex of the 20 cases was relatively well identified; in only three cases, one boy and two girls, the identification was significantly wrong. On the average, boys were incorrectly estimated as girls more often than girls as boys. One of the girls identified as a boy had the lowest $F_0$ value in the whole material (300 Hz). She was the only patient in our series who had been treated with anabolic steroids for her growth retardation. It is most probable that the androgenic effect of that medication was responsible for the lowering of her voice, as well as for the undue advancement of her bone age (Table IV-A-I).

As to the auditory judging of age, there was a general tendency to estimate the subjects to be younger than their chronological age. In spite of an obvious trend, the correlation between the $F_0$ and the estimated age was not significant. This is certainly explained in part by the masking effects of phonatory dysfunctions.

The present series of patients with growth failure was clinically heterogenous. The largest single subgroup consisted of six children with Mulibrey-nanism. The four children with what we have called primordial nanism (prenatal growth failure with dysmorphic features), and the five other children with a prenatal growth failure do not represent homogeneous groups comparable to the Mulibrey series. Three children with hyposomatotropic nanism and two children diagnosed as representing the normal variant of delayed growth and maturation were also included. They may not be fully representative of these etiological groups. Our series, as a whole, is large enough to provide a general view on the voice abnormalities associated with growth failure, though defining the possible specific voice characteristics of the different subgroups awaits further work.

The one feature common to the whole series irrespective of etiological and clinical differences was an abnormally high fundamental frequency. Whether this is a distinctive feature of an abnormally slow
growth in contrast to the normal slow variant, remains unclear. Presumably, the rate of maturation of voice conforms to the general rate of maturation. The normal slow growers are expected to end with a normal adult voice, whereas the pathological cases may remain different.

Effective treatment is available to relatively few children with growth failure. The hyposomatotrophic patients will grow at a higher than normal rate and catch up their agemates when substitution therapy with human growth hormone is instituted. Anabolic steroids have been used in many different types of growth failure. They do accelerate the growth but may advance the bone maturation even more and may thus even decrease the final height. It will be interesting to follow the effect of these treatments on the voice qualities. Especially, the anabolic steroids, being in fact derivatives of male hormone, may lower the fundamental frequency as a specific "side-effect", as had presumably happened in one of our patients. Following of \( F_0 \) may provide a sensitive mean for detecting an undesirably strong androgenic effect before this is evident by other means of observation. This may help to adjust the dose of the drug to the level appropriate to the individual patient. On the basis of these observations we have added the use of a simple \( F_0 \) indicator (3)* in the follow-up routine of our patients receiving medication for the advancement of growth.

Acknowledgment

The authors express their gratitude to Mrs. Pirjo Fahlström, Institute of Occupational Health, Helsinki, for the statistical work in this study.

References:


* made by AB Specialinstrument, Stockholm, Sweden.
(5) Sundberg, J. and Tjernlund, P.: "Real time notation of performed melodies by means of a computer", paper 21 S 6 in the Congress Volume of the 7th ICA, Budapest, 1971.
