AN ACOUSTIC STUDY OF VOWELS IN DOWN SYNDROME PATIENTS*

Masao Abe**

INTRODUCTION

Speech and language behavior during infancy is one of the important indicators for evaluating the general development of a child. There are many factors affecting speech and language development, such as intelligence, hearing, organic and functional conditions of the articulators, emotional status and language environment. Disturbances in one or more of these areas may result in speech and language disorders.[1),2),3)]

The Dwon syndrome is characterized by chromosomal abnormalities (the 21st trisomy), mental retardation, morphological abnormalities, etc. Among the various characteristics, mental retardation, organic and functional abnormalities of the articulators, and hypotonia of the related muscles are particularly relevant to speech and language disabilities in the Down syndrome.[4),5)] It has been reported by some authors that the pattern of language acquisition in early childhood of Down sundrome patients is essentially similar to that in normal children, although showing an appreciable delay. It is also reported, however, that their developed speech is more distorted than with simple mental retardation, particularly in the articulation skills.[6),7),8)]

In the present study, the development of vowel articulations in Japanese patients with the Down syndrome has been investigated by means of acoustic analysis.

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** Now at the Department of Otorhinolaryngology, Faculty of Medicine, University of Tokyo.

METHOD

The present study dealt with 103 Down syndrome patients with normal hearing, 57 male and 46 female, ranging in age from 4 to 21 years. As a control group, 88 normal children, 41 male and 47 female of 4 to 15 years old were examined. All the subjects lived in Tokyo or in adjacent areas.

The following test procedures were employed in the present study. The patients were asked to imitate five Japanese vowels pronounced in isolation by a speech therapist. For normal children from 4 to 5 years, the same procedure was employed. In the other age groups of normal children, the five vowels were pronounced slowly and clearly according to oral instructions. The vowels uttered by the subjects were tape-recorded in a relatively quiet room. The recorded samples were analyzed by a sound spectrograph and the lowest three formant frequencies(F_1 F_2 F_3) were estimated visually. In order to investigate the developmental process of vowels, the data were plotted on the Iri's vowel chart by using the following formulae.[9),10)]

$$x = 10 \log(F_2/\sqrt[3]{F_1F_2F_3})$$

$$y = 10 \log(F_3/\sqrt[3]{F_1F_2F_3})$$

Anatomical and physiological conditions of the articulators were evaluated by inspection of the tongue and the teeth and by examination of some simple non-articulatory movements of the lips and the tongue. The intelligence levels were assessed by using a test for mental retardation devised by Ohwaki.

RESULTS

1. Formant Frequencies

In order to compare the F_1 F_2 F_3 of the five vowels for each age and sex subgroup, the mean and standard deviation for each formant were calculated.

Under the age of 11 years, neither Down syndrome patients nor normal children showed differences in respect to sex. Therefore, data for both sexes will be compiled together in the following discussions for these age categories.

The formants of Down syndrome patients under 11 years of age were

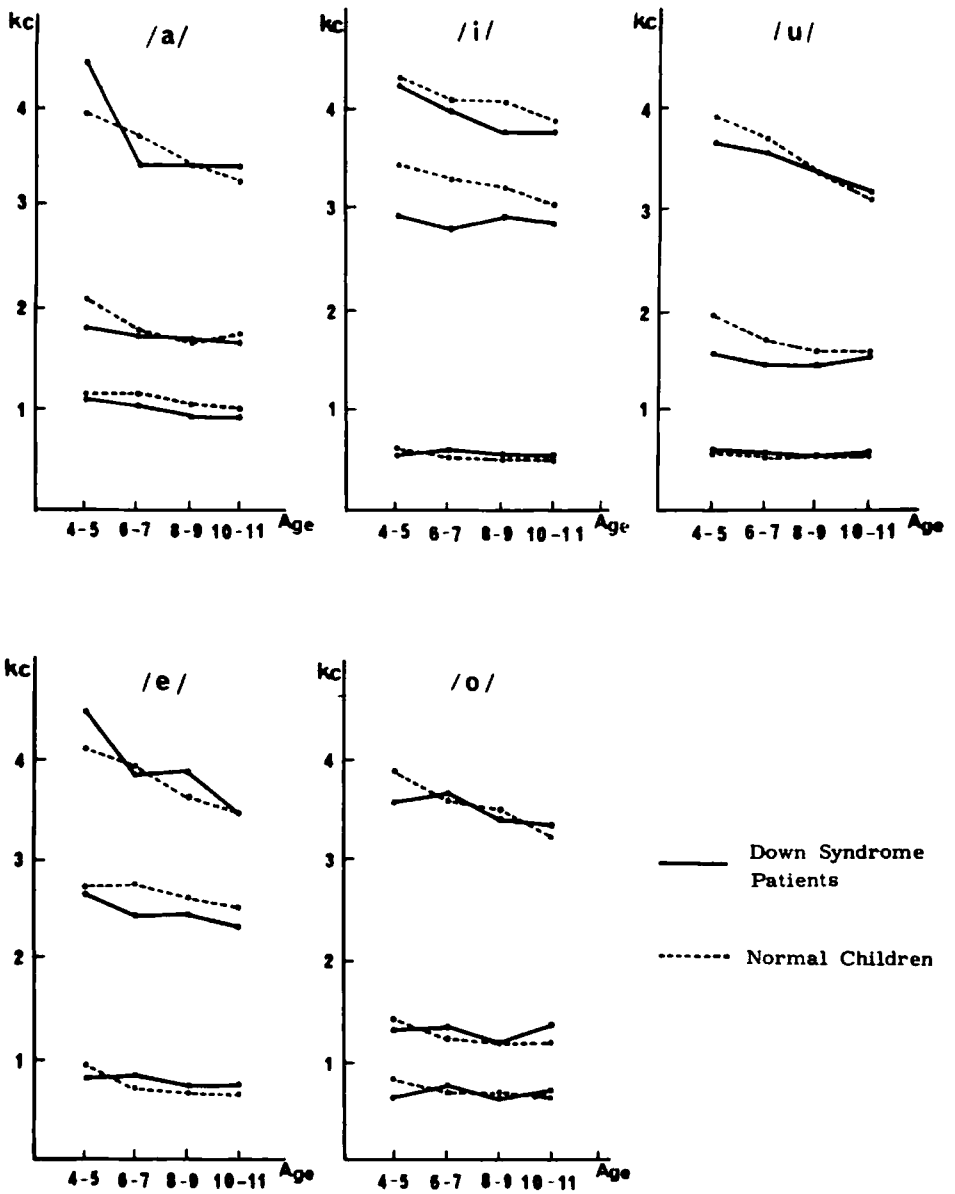

Figure 1. Formant frequencies

compared with those of normal children (see Figure 1). In Down syndrome patients from 4 to 5 years old, F_2 of /a/ was lower and F_3 of /a/ was higher (level of significance .05 T-test) than in normal children. In Down syndrome patients from 4 to 7 years old, F_2 of /i/ was lower than that of normal children (level of significance .05 T-test).

In the formants of females over 12 years, there were no significant differences between Down syndrome patients and normal children. The formants of the male cases over 12 years were examined in two age brackets, namely early adolescence (12 to 15 years) and later adolescence (over 16 years). In normal children, all formants of all vowels in early adolescence were markedly lower than those in the age range of 10 to 11. In Down syndrome patients, there was no such difference between the corresponding age groups.

2. Developmental Process of Vowel Articulation as Reflected in the Change in Vowel Charts

For each age group, the mean and standard deviation values were plotted on the Iri's vowel chart. In all age groups, the mean diagram showed that the five vowels of Down syndrome patients were close to each other when compared with a similar chart for the normal children. The standard deviation diagrams showed that the areas for five vowels in the chart were already clearly separated in normal children at the age of 4 to 5, while in Down syndrome patients the areas for different vowels considerably overlapped at these ages (see Figure 2). The vowel separation for Down syndrome patients started at the age of 10 to 11 for /i/ and in early adolescence for /a/. For /u/ /e/ and /o/ in Down syndrome patients, complete separation was not achieved during the age range covered in this study, but the tendency was noted that the older the age of the subject was, the lesser was the extent of overlapping.

3. Factors Affecting the Articulation Skill

The mean IQ of all the patients examined was 31.6, ranging from 9.5

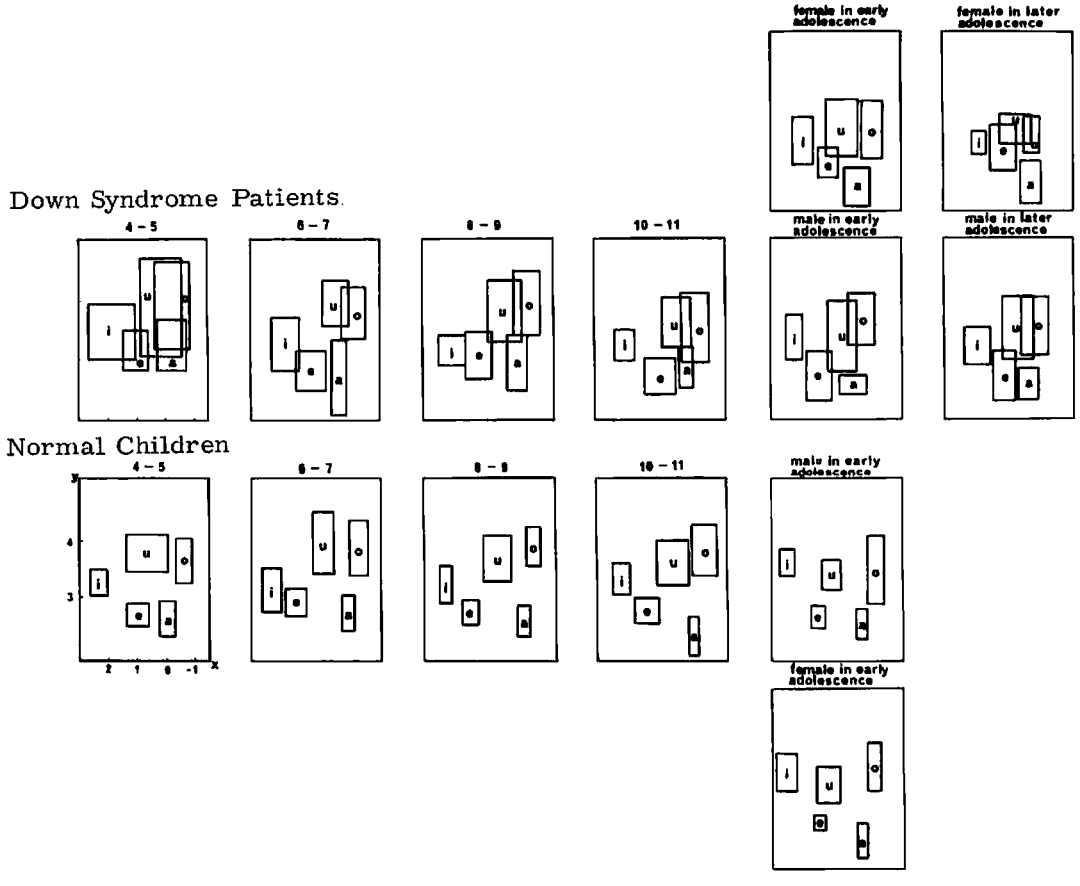

Figure 2. Iri's vowel chart (S. D. Diagram)

to 60.1 The number of patients with high IQ levels tended to be lower in the older age groups.

Insufficient lip movements were noted in approximately 20 to 30 % of all the patients, insufficient tongue movements in approximately 20 to 30 %, and macroglossia in 41.7 %.

COMMENTS

In the present study, one of the aspects of articulation disabilities in Down syndrome patients was observed by use of the vowel chart of Iri, and mental retardation and organic and functional abnormalities of articulators in Down syndrome patients were observed to affect these skills. In order to establish effective speech therapy for Down syndrome patients, the relations between those factors affecting articulation disabilities must be made clear. Comparisons between Down syndrome patients and cases of simple mental retardation, and a longitudinal follow-up study of each Down syndrome patient are considered to be necessary for the solution of this problem.

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