STUDIA PHONOLOGICA XXII (1988)

Voice Characteristics of Aged Persons

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Abstract

The voices of 20 males with a mean age of 78 years and 24 females with a mean age of 75 years were examined with a microcomputer and a phonation analyzer. In this study we examined the voice quality and phonatory function of aged persons.

The voice of aged male is characterized by a decrease of harmonics and that of aged female is characterized by a decrease of fundamental frequency. These changes may be caused by an atrophy of vocal fold in aged males and by an edematous change of vocal fold in aged females. In both aged males and females, amplitude perturbation becomes large and especially in aged males frequency perturbation also becomes large. These changes are thought to be caused by several factors related to aging, such as atrophy or edematous change of vocal fold mucosa, clumsiness of fine regulation of laryngeal muscles or a decrease of laryngeal muscles or a decrease of lubrication.

As a phonatory function test, both aged males and females showed a decrease of maximal phonation time. And aged males showed an increase of air flow rate. These changes may be caused by a decrease of lung function, and especially in aged males, these changes are thought to be related to the glottal gap.

Stimmecharakteristika Der Ältlicher Personen

Die Stimmen von 20 Männern im durchschnittlichen Alter von 78 Jahren und 24 Frauen im durchschnittlichen Alter von 75 Jahren wurden mit Hilfe eines Mikrocomputers und Phonation-Analysators geprüft. In der vorliegenden Studie haben die Autoren die Stimmqualität und die Stimmbildungsfunktion ältlicher Personen untersucht.

Die Stimme des ältlichen Mannes ist durch eine Verminderung der Harmonischen und die der ältlichen Frau druch eine Verminderung der Grundfrequenzen gekennzeichnet. Diese Veränderungen könnten wohl durch eine Atrophie des Stimmbandes in ältlichen Männern und durch ödematöse Veränderungen des

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Stimmbandes in ältlichen Frauen verursacht werden. Bei ältlichen Männern wie auch ältlichen Frauen entstehen große Amplitudenperturbationen und besonders bei ältlichen Männern treten große Frequenzperturbation auf. Diese Veränderung werden vermutlich durch verschiedene mit dem Altern verbundene Faktoren hervorgerufen, wie z. b. Atrophie oder ödematöse Veränderungen der Stimmbandschleimhaut, Schwerfälligkeit in der Feinregulation der Kehlkopfmuskeln, oder verminderte Lubrikation.

Bei der Stimmbildungsprüfung wiesten die ältlichen Männer sowohl als die ältlichen Frauen eine Verminderung der maximalen Stimmbildungszeit auf. Außerdem zeigten die ältichen Männer eine erhöhte Atemstromstärke. Diese, insbesonders in ältlichen Männern vermutlich mit der Stimmritze zusammenhängende veränderungen, könnten auf eine Herabsetzung der Lungenfunktion zurückgeführt werden.

1. Introduction

It is well known that the voice changes with aging and that this change is especially drastic during puberty. On the other hand, the voice of adults also changes as they advance in age, and the voice of aged persons is different from that of adolescents. Clinically, however, we often feel some difficulty in evaluating voice disorders in aged persons, whether they are normal or pathological, because we have a limited knowledge of the voice characteristics of aged persons. The purpose of this study is to determine the characteristics of voice in aged persons from the view points of their voice quality and phonatory function and to know the normal range of them in aged persons.

2. Methods And Subject

Voices of 20 males ranged in age from 70 to 91 with a mean of 78 years and 24 females ranged in age from 60 to 90 with a mean of 75 years were examined. None of them had a history of voice disorders or pulmonary disorders and they had no history of smoking habit.

As control groups, 10 healthy young males ranged in age from 25 to 35 with a mean of 30 years and 10 healthy young females ranged in age from 24 to 35 with a mean of 26 years were examined.

Each subject was asked to phonate the sustained vowel /a/ at a comfortable pitch and intensity. Examination of the sustained vowel were thought to be practical and representative. Then their voices were recorded by using a PCM recorder. Then a voice signal of 51.2 msec in duration for each subject was digitalized by an A/D converter at a sampling rate of 20KHz with 12-bits precision. These digitalized data were processed by a personal computer (NEC PC-

9801VM2, Japan). From these voice data of 1024 points (51.2 msec), the fundamental frequency, fundamental frequency perturbation, amplitude perturbation and energy ratio of harmonic components were calculated. This calculation was performed about 10 times for one subject, and the values (the fundamental frequency and so on) obtained were averaged, respectively.

As shown in Figure 1, pitch periods (Ti) of each wave, which are analogous and periodic, were transformed into frequency (Fi). The fundamental frequency was defined as the average of frequency of these periodic waves found within the data obtained at 51.2 msec.

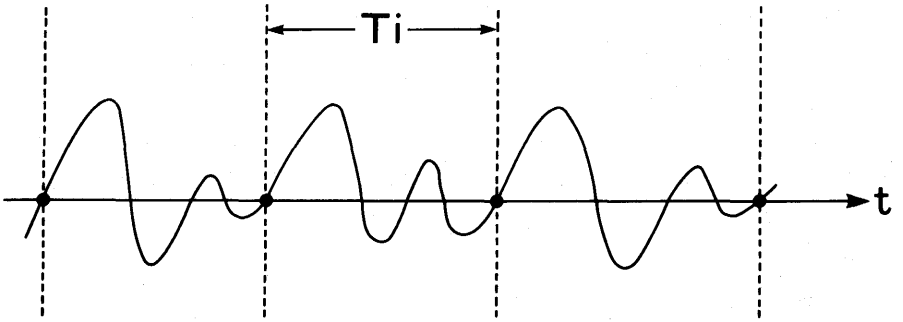

Fig. 1. Pitch period (Ti) of voice wave.

The fundamental frequency perturbation was defined as the sum of the semitone scales, which were logarithmic differences between two frequencies, divided by the number of periods measured.

Amplitude perturbation was difined as the standard deviation of maximum amplitude in each periodic wave divided by their means.

The energy ratio of the harmonic components was calculated as follows. From the voice data of 1024 points, the power spectrum was calculated by Fast Fourier Transformation (F. F. T.). Since the A/D conversion rate is 20KHz, it is possible to calculate the power spectrum until 10KHz, and 512 points correspond to 10KHz. As fundamental frequency has already been measured, a power of the harmonic component can be obtained with relative accuracy by approximating the curve of this power spectrum (Peak Picking Method). As described above, a power of the harmonic component corresponding to any times the fundamental frequency can be obtained. The energy ratio of harmonic components was defined as the sum of powers of the harmonic components divided by the total power in the linear scale. This summation was performed at up to 20 times the fundamental frequency, because especially in males, the second formant frequency becomes almost 20 times of the fundamental frequency. If the summation was performed at up to 10KHz, (effective maximal frequency by F. F. T.), there was little difference in following results.

The mean air flow rate during phonation was measured using a phonation

analyzer (Minato PA-500, Japan), and the maximal phonation time was also measured.

3. RESULTS

The relationship between the fundamental frequency and age is shown in Figure 2. The upper figure shows that of males and lower one that of females, and on the left side the range (mean ± standard deviation) of young controls is indicated. The subsequent figures are expressed in the same way. On the whole, no significant difference was seen between young and aged male, but a few cases with a high fundamental frequency were noted. On the other hand, in aged females, the fundamental frequency was found to be significantly lower than that in young females at the 0.1% level. In other words, a few males with high pitch voices were seen, but on the whole, there was no significant difference between the young and aged, while in females, the voice pitch appered to become lower with advancing age.

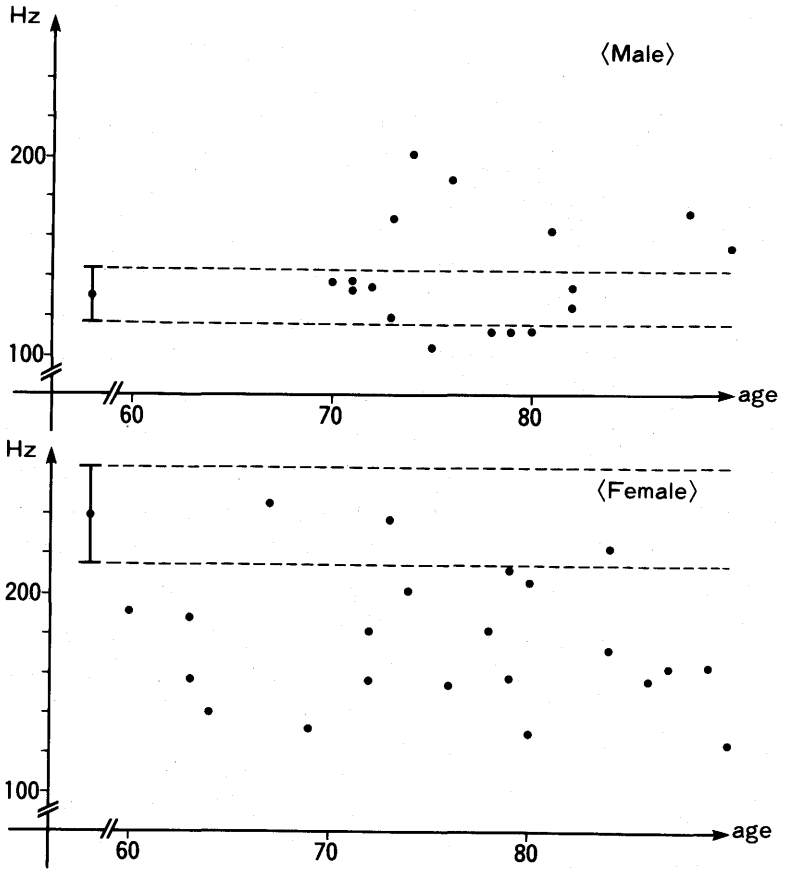

Fig. 2. Relationship between the fundamental frequency and age.

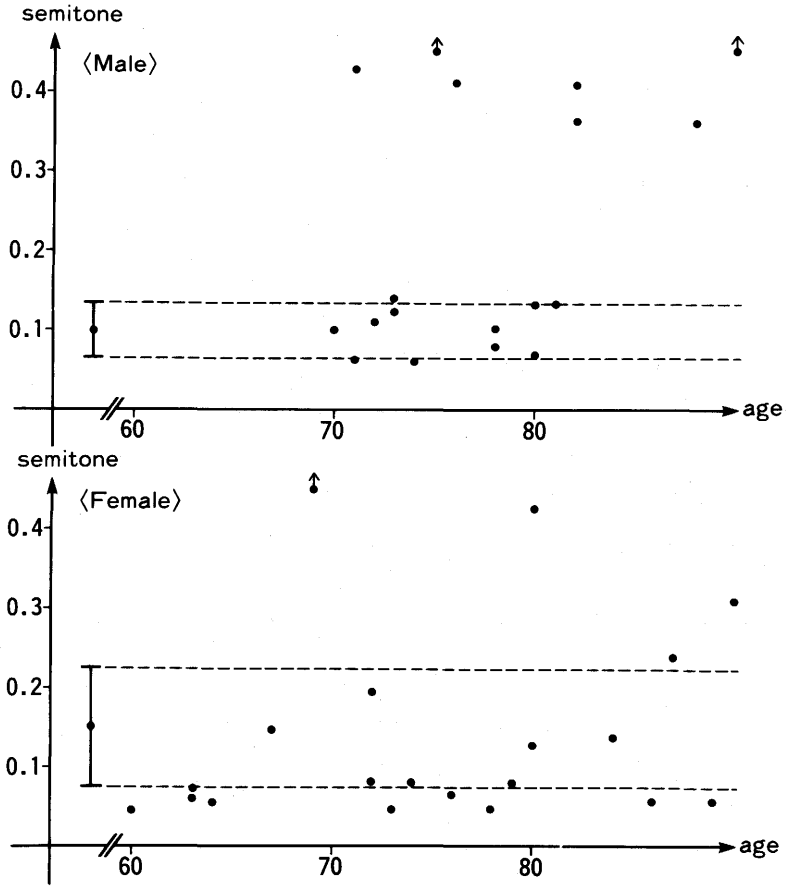

Fig. 3. Relationship between the fundamental frequency perturbation and age.

Figure 3 shows the relationship between fundamental frequency perturbation and age. In males, there was an increase of frequency perturbation at a significance of 1%, but in females, there was no significant difference between the young and aged.

Figure 4 shows the change in amplitude perturbation. There was an increase in aged males and females at the 0.5% level. An increase in fundamental frequency perturbation (Liebermann [1], Hollien [2]), increase in amplitude perturbation (Kitajima [3]), increase in noise components (Kojima [4], Yumoto [5]) and so on have been pointed out as general acoustic characteristics of hoarse voice. From the above two results, especially voices of aged males seemed to become acoustically hoarse.

Figure 5 shows the relationship between the harmonic component ratio and age. In aged males, there was a decrease at the 1% level but in aged females, there was no significant difference between the young and aged. It is thought that a decrease of the harmonic component is equivalent to an increase of the noise component. Therefore, it can be said that the voice of aged males have more

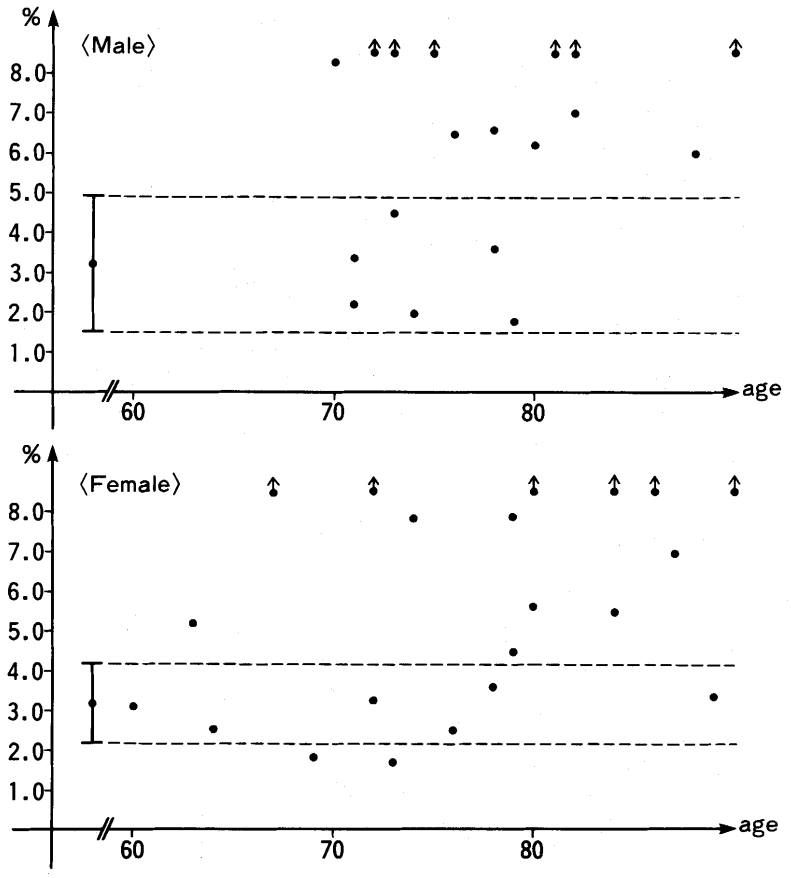

Fig. 4. Relationship between the amplitude perturbation and age.

noise component than that of young males.

The relationship between mean air flow rate and age is shown in Fiqure 6. In aged males, there was a slight increase in mean air flow rate, but in aged females, there was no significant difference between the young and aged.

Figure 7 shows the relationship between the maximal phonation time and age. In aged males and females, there were decrease in the maximal phonation time, but especially in aged males, a decrease in the maximal phonation time seemed to be more marked.

Table 1 shows a summary of the above results. The voice characteristics of aged males seem to be an increase in the fundamental frequency perturbation, an increase in the amplitude perturbation and a decrease in the harmonic component ratio. On the other hand, those of aged females are a decrease in the fundamental frequency and an increase in the amplitude perturbation. In the phonatory function test, an increase in the mean air flow rate was a characteristic of aged males.

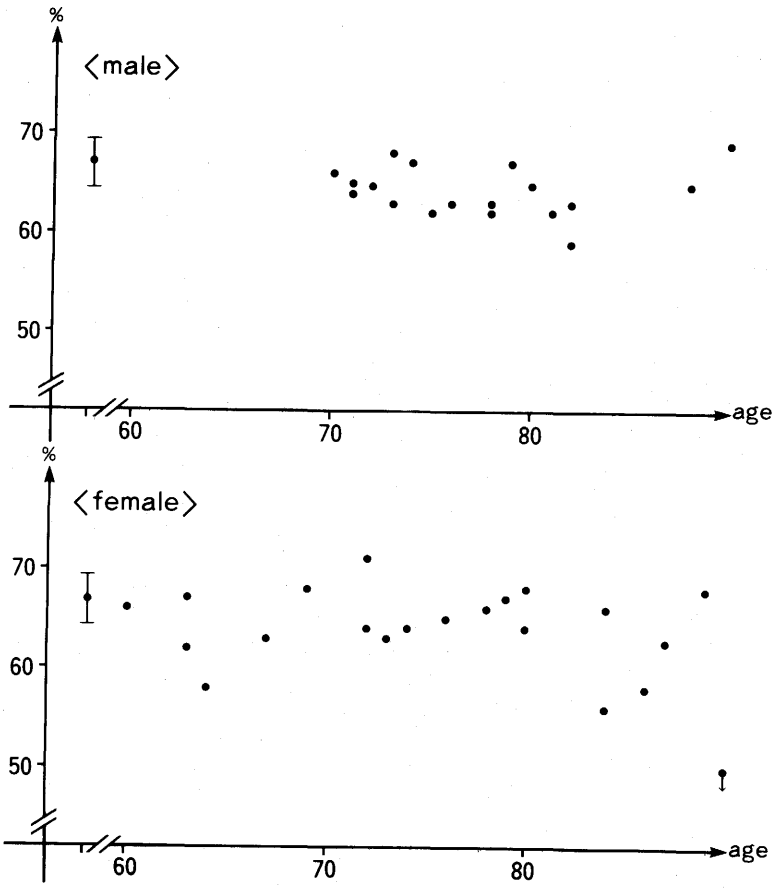

Fig. 5. Relationship between the harmonic component ratio and age.

4. Discussion

Previous reports have stated that the fundamental frequencies of aged males increase with aging in males (Mysak [6], Hollien & Ship [7], Honjo & Isshiki [8], and Böhme & Hecker [9]). In this study, there were no significant differences between the fundamental frequencies of aged males and young males.

However, as shown in Figure 2, there were some aged males with a high fundamental frequency. Honjo & Isshiki [8] and Böhme & Hecker [9] have shown that the fundamental frequency in females decreases with aging, and their report was consistent with our results. Considering the report of Honjo & Isshiki [8] and our results, it appears that there is a tendency for the fundamental frequency to increase in males and to decrease in females. These changes seemed to be influenced largely by morphological changes in the larynx due to endocrinological changes, such as a change in the estrogen system after memopause in females, and a change in the androgen system in males.

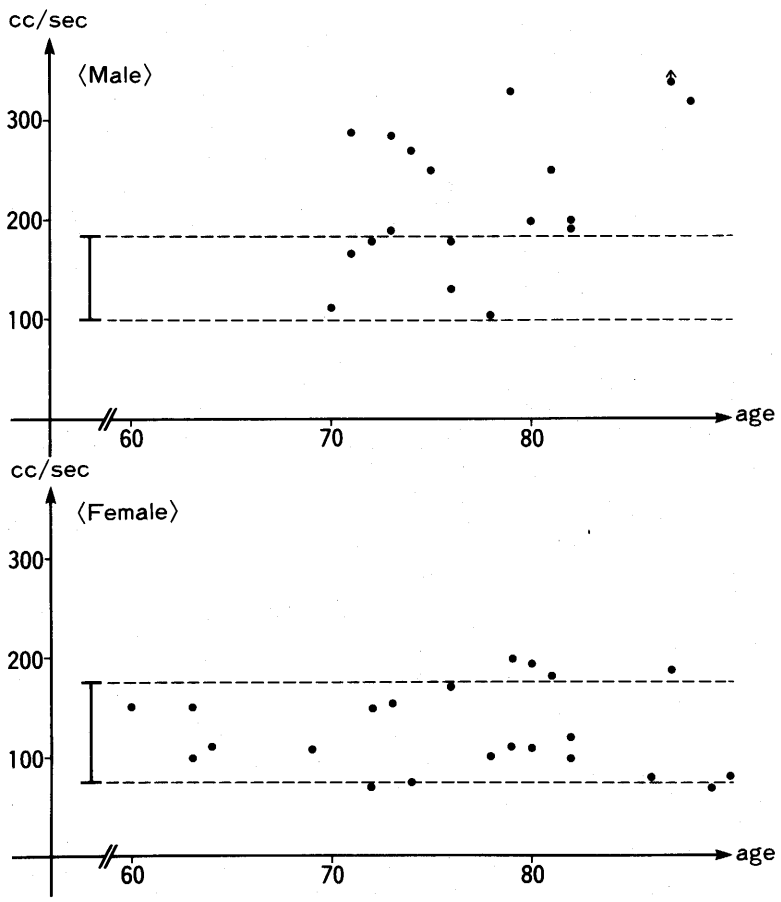

Fig. 6. Relationship between mean air flow rate and age.

In aged males, the fundamental frequency perturbation increased, while in females there was no significant difference between the young and aged. Wilcox & Horii [10] reported an increase in the fundamental frequency perturbation in males. But Honjo & Isshiki [8] noted that in males there was no difference between the young and aged and it increased in females, so their results completely contradicted our results. This difference may be attributable to different sampling rates or sampling durations of voice data, or different methods of patients selection.

An increase in the amplitude perturbation was observed in both males and females. There have been very few studies concerning the relationship between age and amplitude perturbation. Ramig & Ringel [11] reported an increase in the amplitude perturbation in males. So far, increases in both the fundamental frequency perturbation (Liebermann [1], Hollien [2]) and amplitude perturbation (Kitajima [3]) have been assumed to be one of the characteristics of a hoarse voice. From our results it appeard that acoustic hoarseness occurs especially in males.

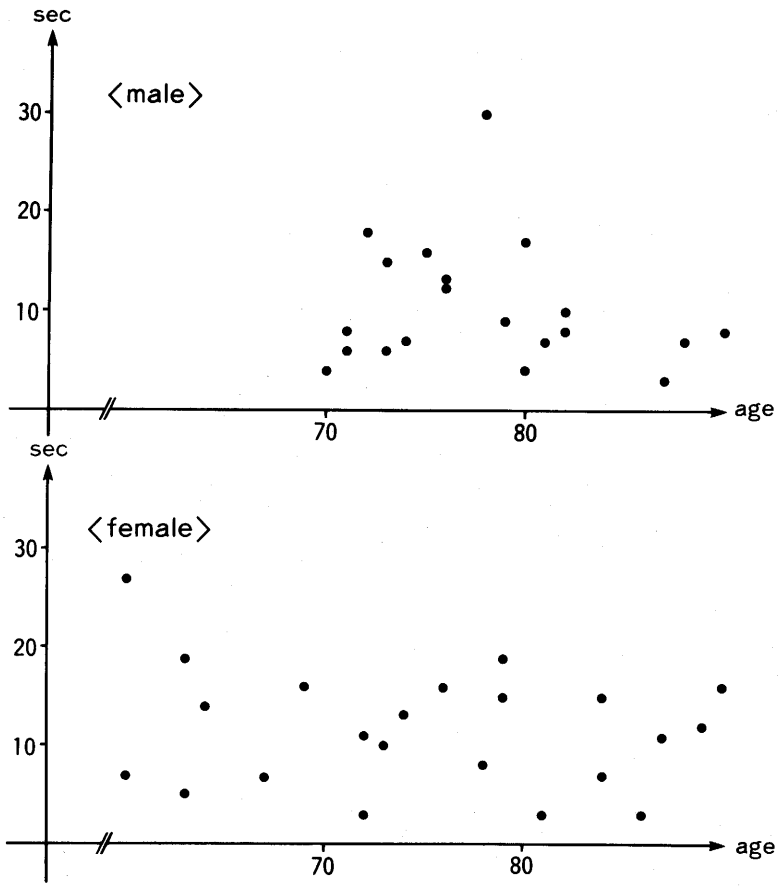

Fig. 7. Relationship between the maximal phonation time and age.

Table 1. Summary of the results.

	aged males	aged females
fundamental frequency	↗ →	↓
frequency perturbation	↑	→
amplitude perturbation	↑	↑
harmonic components	↓	→
mean air flow rate	↑	→
maximal phonation time	↓↓	↓

An increase in the noise component may also be one of the characteristics of hoarse voise. Kojima & Gould [4] and Yumoto & Gould [5] have reported methods for measuring the level of the noise component, but for this study we used a different method. Energy of the harmonic component was measured by approximation from the power spectrum using Fast Fourier Transformation, and

the ratio with the total power was calculated. Using a peak picking method, the power of the harmonic components can be measured with considerable accuracy. A decrease in the harmonic components in aged males was seen when compared with young adults, and no change was observed in aged females. Since a decrease in the harmonic components is thought to be equivalent to an increase in the noise component, it was suggested that the noise component of voice increases in aged males.

An increase in the mean air flow rate during easy phonation was observed in aged males, but in aged females, the mean air flow rate was within the nomal range. Our result is thought to be confirmed by the report of Honjo & Isshiki [8], who found that a glottal gap was seen frequently in aged males but in aged females edematous changes were frequently observed. A decrease in lubrication, which is often observed in the larynx of aged person, may be one of the factors which influences the mean air flow rate.

The maximal phonation time decreased in aged males and females, and this result was consistant with the report of Ptacek & Sander [12]. As the explanation for this result, Segre & Aires [13] pointed out a decrease in pulmonary function, especially a decrease in the vital capacity. Also we observed that in aged males the maximal phonation time decreased more markedly than in aged females. This results may be caused by an increase in the mean air flow rate due to an increase in the glottal gap during phonation.

REFERENCES

1. Liebermann, P.: Perturbation in vocal pitch. J. Acoust Soc Am33: 597-603 (1961).
2. Hollien, H.; Michel, J.; Doherty, E. T.: A method for analyzing vocal jitter in sustained phonation. J. Phonetics 1: 85-91 (1973).
3. Kitajima, K.; Gould, W. J.: Vocal shimmer in sustained phonation of normal and pathologic voice. Ann Otol 85: 377-381 (1976).
4. Kojima, K.; Gould, W. J.: Computer analysis of hoarseness. Acta Otolaryngol 89: 547-554 (1980).
5. Yumoto, E.; Gould, W. J.: Harmonics-to-noise ratio as an index of the degree of hoarseness. J. Acoust Soc Am 71: 1544-1550 (1982).
6. Mysak, E. D.: Pitch and duraction characteristics of older males. J. Speech Hear. Res. 2: 46-54 (1959).
7. Hollien, H.; Shipp, T.: Speaking fundamental frequency and chronologic age in males. J. Speech Hear Res 15: 155-159 (1972).
8. Honjo, I.; Isshiki, N.: Laryngoscopic and voice characteristics of aged persons. Arch Otolaryngol 106: 149-150 (1980).
9. Böhme, G.; Hecker, G.: Gerontologische Untersuchungen über Stimmufang und Sprechstimmlage. Folia phoniat. 22: 176-184 (1970).
10. Wilcox, K. A.; Horii, Y.: Age and changes in vocal jitter. J. Gerontology 35: 194-198 (1980).
11. Ramig, L. A.; Ringel, R. L.: Effect of physiological aging on selected acoustic characteristics of voice. J. Speech Hear Res 26: 22-30 (1983).
12. Ptacek, P.H.; Sander, E.K.: Phonatory and related changes with advanced age. J. Speech Hear Res 9: 353-360 (1966).

13. Segre, R.; Aires, B.: Senescence of the voice EENT Monthly 50: 223-227 (1971).

(Received Oct. 31, 1988)