Shimmer Change According to Fundamental Frequency Variation of Korean Normal Adults

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ABSTRACT

The present study was performed to investigate change in shimmer according to F_0 variation precisely, and to offer suggestions for a clinical application.

The analysis for the present study was done by the fundamental frequency (F_0) and shimmer measurement results of the previous 120 Korean normal adults' voice study of Pyo et al. (2002), used three vowels, /i/, /a/, and /u/.

Through the analysis of 60 female samples from the previous study, we found that F_0 of the vowels was the highest in /u/, and the lowest in /a/, but, on the contrary, shimmer was highest in /a/ and lowest in /u/. Thirty of 60 subjects showed such an inverse relationship between F_0 and shimmer, as a whole. In the vowel /a/, 47 of 60 subjects showed the increased F_0 and decreased shimmer, in /i/, 32 subjects, and in /u/, 33 subjects showed the same results.

The decrease in shimmer means the improvement of voice quality, so by these results, we expect to answer the question why the patients with spasmodic dysphonia can improve their voice quality with increased pitched voice production.

Keywords: Normal Voice, Female, Shimmer, Fundamental Frequency

1. Introduction

For the treatment of voice disorder patients, we need to know the characteristics of a disordered voice, which means that we should know how they are different from normal voices. Then, it is useless to say that we should know what the normal voices are, and for that purpose, hundreds of thousands of speech scientists and speech pathologists tried to find the definition and characteristics of normal voices.

Pyo et al. (2002) reported the results of acoustic studies on the voices of 120 Korean normal adults (60 males and 60 females, each); when they compared the mean of F_0 and

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shimmer of the three Korean vowels, /i/, /a/, and /u/ in females' data, the F_0 were 211.6 Hz, 216.9 Hz, and 220.4 Hz, and the shimmer was 2.582%, 1.573%, and 1.478%, respectively. It shows that shimmer appeared to be decreased as the fundamental frequency (F_0) was increased.

With these results, we hypothesized that the increase of F_0 can result in decrease in shimmer, which means that the increase F_0 can influence of the improvement of voice quality. If this hypothesis proves to be true, we can explain why the patients of spasmodic dysphonia can improve their voices when they speak with a high-pitched voice.

Therefore, the present study was performed to investigate the change in shimmer according to F_0 variation precisely, and to find the suggestions of the results for the clinical application.

2. Method

2.1 Subjects

The subjects were Korean normal females between the age of 20 and 39 years (mean age: 26.97 (SD: 4.56) years) old who were participants of the previous Pyo et al. (2002)'s study. They showed significantly different fundamental frequency among the three vowels, /i/, /a/, and /u/, but male subjects did not, therefore only female subjects could participate in the present study. As ascertained in the interview, they showed no history of voice disorders or hearing impairments, and had no disordered voice. This was confirmed by the experienced voice therapists.

Our reason for confining the range of age as 20 to 39 years was to exclude the possibility of the influence of postclimacteric hormonal change.

2.2 Instruments

For the acoustic analysis, MDVP (Multidimensional Voice Program) of CSL (Computerized Speech Lab., Kay Elemetrics Co. (1994), U. S. A.) was used, and, for capturing the samples, head microphone (C410, AKG Acoustics), the cardioid condenser microphone, recommended by Titze & Winholtz (1993), was used.

2.3 Experimental procedures

2.3.1 Capturing

All of the subjects visited our laboratories to record their voice samples, and the samples were obtained under the direction of experienced voice therapists.

To capture the voice samples, a microphone was worn on subjects', ears, and the distance between their lips and microphone was maintained at approximately 6 cm, following Titze and Winholtz's (1993) recommendation.

For the analysis, we selected /a/, /i/, and /u/, because these three vowels, so-called 'corner vowels' are the articulatory-based (i.e., physiologically-based) primary cardinal vowels, which are the basic elements of vowel quarilateral (Denes & Pinson, 1993).

All of the subjects produced the three vowels with comfortable pitch and loudness. Experimenters did not limit the repetitions, but reminded the subjects that too many repetitions can influence the results.

2.3.2 Analysis

Following Pyo et al. (2000), we edited 1.5 second-sustained portions from the whole sample which can be regarded as the most typical portion of the voice, and the edited portion was analyzed by the MDVP analysis system. Of 33 parameters of MDVP results, we used F_0 and shimmer for further analysis.

The pattern of shimmer change according to F_0 variation among the three vowels was observed, and we counted the number of subjects which showed that a vowel of the highest F_0 has the lowest shimmer among three vowels, or vice versa.

3. Results

Before we investigated the change in shimmer according to F_0 variation among the three vowels, we also compared NHR and jitter, as well as shimmer with F_0 variation, for we found that NHR and jitter also decreased as F_0 increased.

When we counted the number of subjects which showed that a vowel of the highest F_0 has the lowest shimmer among three vowels, or vice versa, that of NHR was 17, and that of jitter was 2. As we saw, even though the mean of jitter also decreased as F_0 increased like that of shimmer, most of subjects with the exception of 2 persons did not follow the pattern. So, we did, and will, focus on shimmer.

When we considered the relationship between F_0 and shimmer change, on the whole, the results can be seen in Table 1.

As we see, 30 of 60 subjects showed the inverse relationship (i.e., 'F_0 increase, shimmer decrease' in Table 1) between F_0 and shimmer change, which indicates that the order of F_0 increase is the same with that of shimmer decrease. On the contrary, a direct relationship (i.e., 'F_0 increase, shimmer increase' in Table 1) could be found in 3 subjects, one-tenth of inverse relationship. We regarded 'others' to be the cases in which there were no regular relationships between F_0 and shimmer change. Twenty-seven subjects' results were categorized as 'others', though the number is close to half of all subjects, it was smaller than the number of inverse relationship.

We investigated the relationship between each vowel, starting with /a/, the results can be seen in Table 2.

Table 1. The relationship between F_0 and shimmer change (Whole)

	Fundamental Frequency	Shimmer	Number
F_0 increase, shimmer decrease	/a/ < /i/ < /u/	/a/ > /i/ > /u/	28
	/a/ < /u/ < /i/	/a/ > /u/ > /i/	2
	Sum		30
F_0 increase, shimmer increase	/u/ < /i/ < /a/	/u/ < /i/ < /a/	1
	/u/ < /a/ < /i/	/u/ < /a/ < /i/	1
	/i/ < /a/ < /u/	/i/ < /a/ < /u/	1
	Sum		3
Others			27
Total Sum			60

Table 2. The relationship between F_0 and shimmer change in /a/

	Fundamental Frequency	Shimmer	Number
F_0 increase shimmer decrease	Lowest	Highest	47
	Highest	Lowest	0
F_0 increase shimmer increase	Lowest	Lowest	0
	Highest	Highest	2
Others			11
Total Sum			60

The examples of the most representative inverse relations of F_0 and shimmer change are seen in /a/, where almost 5/6 subjects showed a relation, and when we recall that the mean of F_0 of /a/ was the lowest of the three vowels, we considered, in turn, that the inverse relation of F_0 and shimmer change can be seen more precisely in lower F_0 than in higher ones.

The inverse or direct relationship between F_0 and shimmer change in /u/ is as follows:

Table 3. The relationship between F_0 and shimmer change in /u/

	Fundamental Frequency	Shimmer	Number
F_0 increase shimmer decrease	Lowest	Highest	33
	Highest	Lowest	0
F_0 increase shimmer increase	Lowest	Lowest	4
	Highest	Highest	4
Others			19
Total Sum			60

The superiority of inverse relation can be also seen in the case of vowel, /u/, even though the numbers of subjects are much smaller than /a/.

In the case of vowel /i/, most samples of F_0 were second order, usually higher than /a/ and lower than /u/, and the same pattern was found in most samples of shimmer. When the F_0 of /i/ showed second in the order, if shimmer of /i/ also showed second among three vowels, the relationship between F_0 and shimmer could not be clearly classified into inverse or direct relation, because, strictly speaking, it means no change has occurred in the order. Such cases could be seen in 32 subjects, so in the case of /i/, we could not confirm the abovementioned inverse relationship between F_0 and shimmer change.

4. Discussion & Conclusion

It is known that the cricothyroid muscle (henceforth, CT m.), the sternohyoid muscle (henceforth, SH m.), and the lateral cricoarytenoid muscle (henceforth, LCA m.) play predominant roles in elevating pitch, especially CT m. (Atkinson, 1978).

It can be confirmed by Titze's (1994) explanation on the interaction of CT m. and the thyroarytenoid muscle (henceforth, TA m.) in the change of F_0. Titze stated that, if lung pressure increases, then the subglottal pressure also increases, and will thus increase the tension of TA m., which causes the increase of F_0. The increase of F_0 can be done by TA m., and when it reaches high pitch, the activity of TA m. will decrease, so, CT m. can play a primary role in the control of F_0.

He also stated that increase in lung pressure increases the vibrating depth of TA m., which increases the amplitude of vocal fold vibration. Increase in the amplitude means that the activity of TA m. also increases, which will increase the pitch. From these, we can observe that the change of amplitude can also change F_0, which means that amplitude perturbation, i.e., shimmer can influence F_0. Increase of the tension of TA m. cause make vocal folds to become tightly closed, for TA m. is one of the adductor muscles. It will, then, increase the subglottal pressure, and it will influence on the amplitude. So, as reverse, F_0 can influence on shimmer.

Many previous studies showed shimmer to be a good predictor of voice quality. Deal & Emanuel (1978) reported that shimmer is a more accurate index of perceived vocal noise than jitter, and Horiguchi et al. (1987) suggested that shimmer is better discriminator of pathology than jitter. Hall (1995) measured jitter, shimmer and SNR in the morning, afternoon, and evening, and found that jitter displayed significantly different results during those three times. However shimmer did not show the different results which reflects the consistency of shimmer.

Wolf, Fitch & Cornell (1995) reported that in deciding severity of voice quality, considering the several parameters together and considering only shimmer did not show different results; Wolf, Fitch & Martin (1997) showed shimmer has significant correlation with all the levels of severity. Orlikoff & Baken (1989b) reported the reliability of jitter measurement seemed to be influenced by heartbeat-related phenomena, but shimmer did not.

When we compared the change of mean of jitter, shimmer and NHR which are known to be the representative parameters determining voice quality, with F_0 change, as F_0 increases, all of the three parameters showed decreasing pattern. This means that increasing F_0 can improve the voice quality.

When we investigated the pattern precisely, subject by subject, the abovementioned whole patterns could be barely detected in jitter and NHR, because only a small portion of subjects showed such a pattern. Only shimmer showed that half of the subjects followed the pattern. We can conclude then, that of the three important parameters for voice quality decision, jitter, shimmer and NHR, only the shimmer showed consistency with the whole and the individual patterns, the mean of jitter or NHR may, therefore, not reflect the individual constituents. The previous studies advocating the efficiency of shimmer can be regarded as other evidence of the consistency of shimmer.

The fact that increase of F_0 will decrease shimmer and, consequently, cause the improvement of voice quality will give voice therapists some kind of cues for improving their patients' voice quality. For example, we can find a comfortable pitch range which can incite improved voice quality by gliding up and down scales. After finding comfortable pitch levels, we can help the patient's gradual pitch lowering to his/her optimal pitch level with breath support.

Using high-pitched voice production is a strategy which can be used easily in the spasmodic dysphonia patients. Izdebski (1992) stated that in spasmodic dysphonia, high-pitched or falsetto speech are much less affected, or may be normal, regardless of loudness. Even though we cannot know whether the patients are aware of the fact or not, it is true that many with spasmodic dysphonia reported that they usually felt more comfortable when they spoke in higher pitch than ordinary level. We consider that decrease in shimmer by increased F_0 will help their voice production, and it can be supported by Koike, Takahashi & Calcaterra's (1977) description that shimmer is closely related with the regularity of glottal dynamics. That is, decrease of shimmer by increased F_0 means improvement of the regularity of glottal dynamics, meaning the improvement of involuntary spasm of the vocal folds.

These explanations can be applied to the fact that those who stuttered were able to be helped by FAF (Frequency Altered Feedback) which gives auditory feedback to the users with a raised pitch level rather than that of original voice. When we consider that spasmodic dysphonia is also called 'laryngeal stuttering', the effect of FAF can be easily explained by the abovementioned theoretical basis of the spasmodic dysphonia patients' strategy using pitch raising.

The present study analyzed the sustained three vowels, /i/, /a/, and /u/; the results may not be expanded to clinical setting unless modified, because of the unnaturalness in which they were produced. Intrinsic fundamental frequency refers to the fact that there are characteristic fundamental frequency patterns within a given talkers' vowel set (Katz & Assmann, 2001). The intrinsic fundamental frequency of sustained /i/, for example, and that of /i/ in conversation speech can be different to each other, which means that the relationship between F_0 and shimmer in conversational speech may not be the same as that of the present study. It is our suggestion, therefore, that, for the clinical application, we should also investigate naturally produced vowels in conversational speech.

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