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A Study on Self Perceptual Method of Partial Auditory Disturbance in Extended High Frequency Band

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Abstract

Excessive use of earphones can overwhelm the auditory system and cause noise deafness in adolescents. Due to the structure and usage of the earphone, there is a high risk of partial auditory disturbance in the extended high frequency band. In adolescents with heavy earphone use, early detection of partial auditory disturbances in the extended high frequency band should be prevented from developing noise deafness. However, the pure tone hearing method below 8KHz, which is a conventional hearing test method, cannot judge partial auditory disturbance of extended high frequency band which may be caused by overuse of earphone. In this study, we propose a method for self perceptual partial auditory disturbance using extended high frequency hearing threshold. The proposed method listens to a sound source with 12 pure tone combinations of 9K ~ 20KHz and counts the number of sounds to be self perceptual partial auditory disturbance as shown in Chapter 3. In an experiment involving 18 males and females in their 10s and 20s, 13 were normal and 5 were suspected of partial auditory disturbance. Also, by explaining the proposed method to the experiment participant, all of the experiment participants were able to distinguish themselves from their partial auditory disturbance. These results confirm that the proposed method is suitable for self perceptual to partial auditory disturbance.

Keyword: Earphone, Noise deafness, Extended high frequency band, Partial auditory disturbance, Self perceptual.

1. INTRODUCTION

With the spread of smart phones, access to media contents has increased greatly, such as listening to music or watching TV anytime and anywhere. In order to enjoy media content anywhere and any time, earphones are needed. The earphone is an effective device that only you can hear the sound you want without harming the surroundings. However, excessive use of earphones can overwhelm the auditory system and cause noise deafness. Indeed, indiscriminate use of earphones among teenagers has been reported, as the hearing test of the 2010-2012 National Health and Nutrition Survey(Korea) indicates that 26% of teenagers aged 12-19 have a prevalence of noise deafness. In particular, since the earphone outputs sound by inserting a very small unit into a very small ear hole, the harmonics component of the extended high frequency band can be stronger, and there is a high risk of hearing loss in the extended high frequency band. In addition, due to individual differences and the mechanical characteristics of the earphone, resonance can occur at specific frequencies, which can cause continuous irritation to the auditory system. Therefore, there is a high risk of partial auditory disturbance in the extended high frequency band [1-6].

In order to protect the ear health of adolescents and earphone users, it is most important to check the condition of hearing loss, and it is very important to check the partial auditory disturbance due to the mechanical characteristics of the earphone. However, the existing hearing test method does not identify the hearing ability of the extended high frequency band that starts hearing loss, so there is a problem that can be discriminated by deafness only when the hearing loss is sufficiently made to interfere with the conversation. Therefore, in order to maintain a healthy hearing, there is a need for a method for checking whether the hearing loss in the extended high frequency band and partial auditory disturbance [7-9].

In this paper, we propose a method to self-perceptually evaluate partial auditory disturbance using extended high frequency hearing threshold. The partial auditory disturbance self perceptual for these extended high frequency bands is expected to be a great help in diagnosing the health of hearing and identifying the cause of hearing loss. Chapter 2 discusses sound organs and noise deafness analyzing sounds, and Chapter 3 describes how to self perceptually recognize partial auditory disturbance using extended high frequency hearing threshold characteristics. Chapter 4 explains experiments and results, and Chapter 5 concludes.

2. AUDITORY SYSTEM AND NOISE DEAFNESS

2.1 Auditory System

The human auditory system consists of an external ear, a middle ear, and an inner ear. The external ear collects sound

and echoes the tympanic membrane to the middle ear. The middle ear receives the vibration of the tympanic membrane and amplifies it using the auditory ossicle and delivers it to the inner ear. The inner ear analyzes the vibration transmitted from the middle ear and delivers it to the brain. It is cochlea to analyze the vibration in the inner ear. Cochlea is a column of liquid isolated from the basilar membrane in the center of the tube, and the location of the resonance varies depending on the nature of the vibration transmitted from the auditory ossicle. In the case of high frequency vibrations, the inlet of the basilar membrane causes resonance, and in case of low frequency vibrations, resonance occurs at the rear end of the basilar membrane. In this process, the stimulus of the sound is transformed into a biological electrical signal by the auditory hair cell in the cochlea and transmitted to the brain nerve to recognize the sound. Figure 1 shows the model when the cochlea is stretched horizontally [10-11].

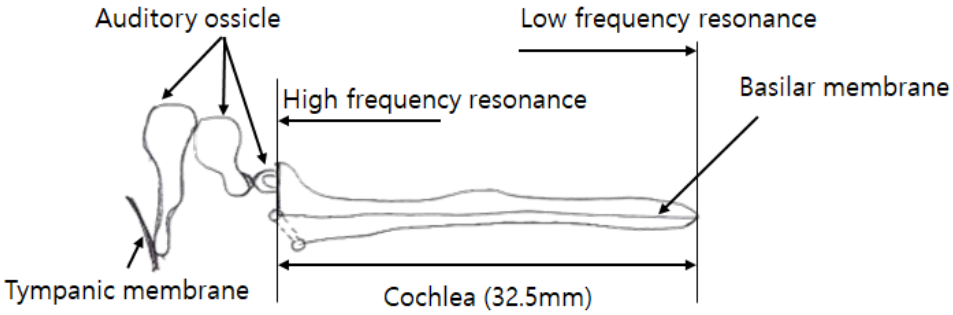

Fig 1. Model of Cochlea [11]

2.2 Noise Deafness

The human ear is very sensitive and can detect sound when the tympanic membrane moves only a few micrometers. The sensitivity of the ear is so high that it is easy to be damaged by loud sounds. Noise deafness is when hearing cells are damaged by loud sounds. Noise deafness is a disease that can occur in people exposed to the noise environment. Noise deafness may cause deafness in the entire frequency band, but it may be a partial auditory disturbance where sound is not heard in a specific frequency band if it is strongly and continuously stimulated in a specific frequency band. In addition to noise deafness, the aging of auditory cells with age is called presbycusis. In addition, various deafness may be caused by disease. Deafness can make communication difficult, leading to bad daily life and interpersonal relationships. When deafness interferes with social life, it can cause mental illnesses such as depression. Once damaged, hearing is virtually irreversible. Therefore, proper care should be taken to prevent hearing loss from being healthy [1-4].

Hearing damage caused by earphones is a typical noise deafness. Humans suffer hearing loss if they continue to hear the same sound for a long time. In the case of the earphone, the sound is very loud as it generates sound at the closest distance to the tympanic membrane, and most of the earphone users output the sound loudly in order to enjoy the rich sound. Also, looking at the type of earphones used by teenagers, most of them are listening to earphones for a very long time. Due to the use of earphones inserted into the ear canal and the structure of the earphones, the sound is likely to be loud in the high frequency band. Therefore, the structure of the earphone and the type of use of adolescents are very loud for a long time in the high frequency band, which causes a high risk of noise deafness due to auditory fatigue phenomenon [1-4].

In case of noise deafness caused by earphone, auditory cells are damaged first in high frequency band, so there may be no problem during actual conversation. In this case, it is very difficult to know the progress of the noise deafness because there is no inconvenience in spite of the progress of the noise deafness. Therefore, a hearing test method considering noise deafness characteristics by earphone is needed.

3. PROPOSED SELF PERCEPTUAL METHOD FOR PARTIAL AUDITORY DISTURBANCE

3.1 General Hearing Test

Common hearing tests include pure tone hearing test, immittance audiometry, speech audiometry, and infants audiometry. Among these, hospitals commonly use pure tone hearing test. The pure tone hearing test measures the hearing threshold for each frequency band while listening to the pure tone of 250 ~ 8KHz. The measured hearing threshold can be used to judge deafness, etc., compared to the expected average hearing threshold for each age group. Figure 3 shows the average hearing threshold by age group [12-14].

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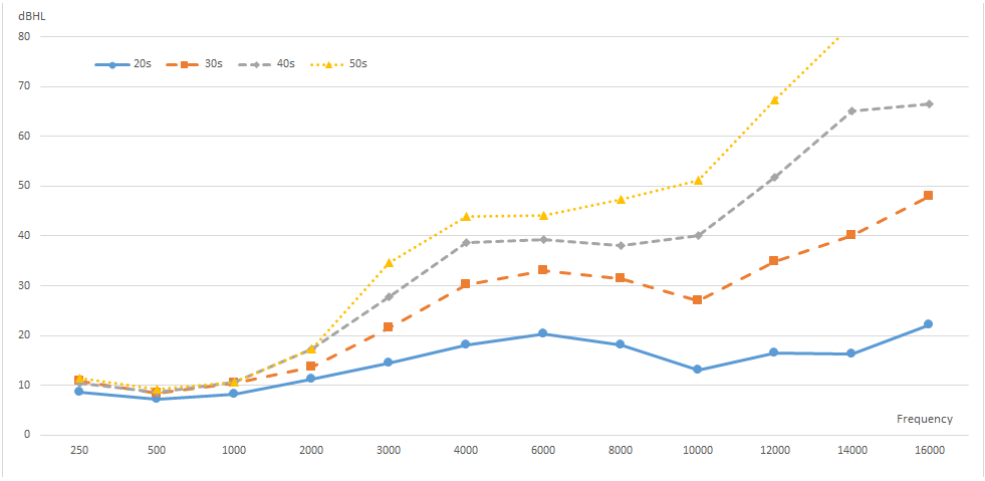

Fig 2. Average hearing threshold by age group

The general pure tone hearing test focuses on the presence of discomfort in everyday life and only measures the sound below 8KHz. However, as shown in Fig. 2, most of the sounds can be heard well below 8KHz, and the variation of hearing threshold due to hearing loss is not large. Thus, when hearing is slightly reduced, discrimination against deafness may be reduced. In addition, since earphone users are expected to have partial hearing loss in the extended high frequency region of 8KHz or more, there is a limitation that earphone users cannot judge the progress of noise deafness.

3.2 Self Perceptual Method of Partial Auditory Disturbance Using Extended High Frequency Hearing Threshold

In this paper, we propose a self perceptual method for partial auditory disturbance using extended high frequency hearing threshold. The difference in average hearing thresholds in the 20s and 50s is shown in Figure 2, which is about 30dB at 8KHz, about 25dB at 4KHz, and only 2.4dB at 1KHz. On the other hand, it is about 51dB at 12KHz and about 70dB at 16KHz. That is, in the conventional pure tone hearing test that measures hearing below 8KHz, discrimination of hearing loss judgment is reduced, and when hearing problems occur in a band above 8KHz, judgment is not possible. Even in the 1KHz band, the hearing threshold difference between the 20s and 50s is only 2.4dB, so if the hearing loss is judged in the 1KHz band, the hearing is already severely damaged [7-11].

However, in the band exceeding 8KHz, the discrimination of hearing loss can be increased because the difference in hearing threshold against the hearing is very large. Therefore, in the band exceeding 8KHz, discrimination is very high even for small hearing loss, so that the general public can easily measure hearing. Also, the recognition result is clear for each band of extended high frequency. By listening to the pure tones of each band by using the auditory characteristics of the extended high frequency band, it is self perceptual to determine whether the partial auditory disturbance of the high tone sound. Figure 3 shows age-recognized sounds with 75dB of extended high frequency pure tones.

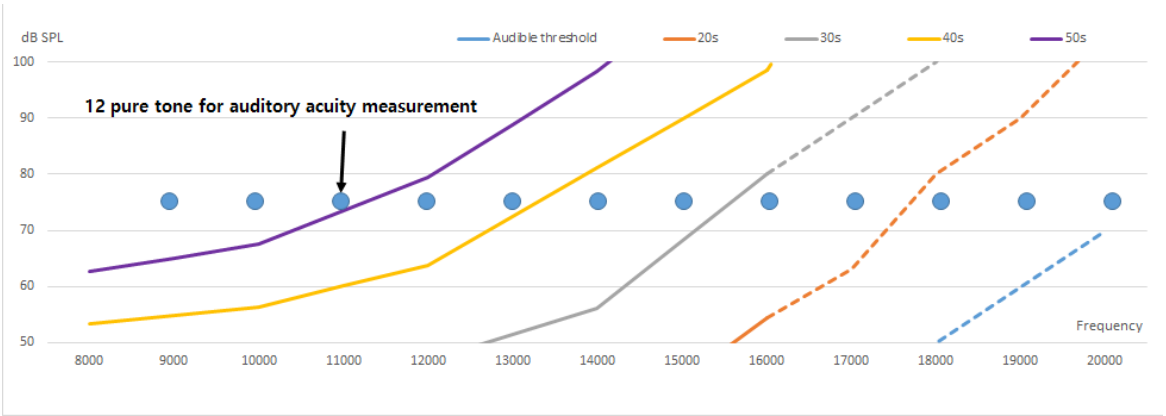

Fig 3. Estimation of pure tone recognition by age group at extended high frequency

Looking at Figure 3, we can predict the number of hearing by age when 12 pure tones ranging from 9K to 20KHz are heard. According to Figure 3, the number that can be heard by age group is expected as teenager can hear all 12 sounds, 20s can hear 9 sounds, 30s can hear 7 sounds, 40s can hear 5 sounds, and 50s can hear 3 sounds. However, if the hearing of the specific band is deteriorated due to noise deafness, the sound cannot be heard in the middle. In order to check for this partial auditory disturbance, a method of separating sound as shown in Table 1 is applied.

Table **1**. Proposed pure tone array for extended high frequency band

Sound source		9 K	10 K	11 K	12 K	13 K	14 K	15 K	16 K	17 K	18 K	19 K	20 K
Total		O	O	O	O	O	O	O	O	O	O	O	O
Play by 1/2	A		O		O		O		O		O		O
	B	O		O		O		O		O		O	
Play by 1/3	C			O			O			O			O
	D		O			O			O			O	
	E	O			O			O			O		
Hearing threshold at 75dB		50s				40s			30s			20s	

When the sound is heard in the arrangement shown in Table 1, people with normal hearing in their 20s and partial auditory disturbance at 15 kHz are expected to recognize the same number of sounds as in Table 2.

Table 2. Estimated number of times to hear 20s

Sound source		20s with normal hearing	20s with partial auditory disturbance at 15KHz
Total		9	8
Play by 1/2	A	4	4
	B	5	4
Play by 1/3	C	3	3
	D	3	3
	E	3	2

As shown in Table 2, people with normal hearing and those with partial auditory disturbance can be distinguished according to the number of sounds perceived for each sound source. When A≤B and C≤D≤E, it may be determined that the normal hearing person. However, a partial auditory disturbance may be suspected if the number of sounds perceived by the source that was heard earlier, such as A> B or C <D> E, is greater than the number of sounds that were heard later.

4. EXPERIMENT AND RESULT

The self perceptual method for partial auditory disturbance of the extended high frequency band proposed in Chapter 3 was conducted in 18 males and females in their teens to 10s ~ 20s. Experimental participants are people who think that hearing is normal because they do not have any communication problems. The experiment participant was given 12 pure tones ranging from 9K to 20KHz with 75dB as shown in Table 1. The experiment was conducted in a daily environment where self perceptual work was possible, such as general offices and university classrooms. The equipment used in the experiment was LG Notebook 15U480, and the sound source was generated and played using Audition CC. The age, sex, and measurement results for each experiment participant are shown in Table 3.

Table 3. Measurement result

Index	**Age**	**Sex**	**The number of hearing times for each sound source**					**Judgment result of partial auditory disturbance**
			A	**B**	**C**	**D**	**E**	
1	12	Woman	5	6	3	4	4	
2	15	Woman	5	6	3	4	4	
3	12	Woman	5	5	3	3	4	
4	15	Woman	5	6	3	4	4	
5	24	Man	4	4	3	3	3	
6	23	Man	5	5	2	3	4	
7	24	Man	4	4	3	3	3	

Index	Age	Sex	The number of hearing times for each sound source					Judgment result of partial auditory disturbance
			A	B	C	D	E	
8	23	Man	5	5	2	3	4	
9	24	Man	5	5	4	3	3	Suspected partial auditory disturbance
10	24	Man	4	6	3	3	4	
11	23	Man	4	5	3	3	3	
12	23	Man	4	5	3	3	3	
13	23	Man	4	4	2	4	3	Suspected partial auditory disturbance
14	23	Man	3	4	2	2	3	
15	24	Man	5	4	2	4	3	Suspected partial auditory disturbance
16	24	Man	4	4	2	3	4	
17	24	Man	5	4	2	4	3	Suspected partial auditory disturbance
18	24	Man	5	4	3	3	4	Suspected partial auditory disturbance

In the table, 13 participants were judged to be normal hearing and 5 participants were suspected to be partial auditory disturbance. The lower the frequency, the better the hearing threshold in the extended high frequency band, but the 5 participants suspected of partial auditory disturbance had fewer pure tones perceived at lower frequencies. After explaining the purpose and method of the experiment to the experiment participants, we asked them to judge the partial auditory disturbance. As a result, all experiment participants could judge the same as judgment result of partial auditory disturbance in Table 3.

5. CONCLUSION

The earphone is a convenient device that only you can hear the sound you want. However, excessive use of earphones has caused noise deafness among teenagers. Such earphones can have a high sound level at very high frequency bands due to their structure and usage. In this case, there is a high risk of partial auditory disturbance that damages the auditory system to the sound of some of the extended high frequency bands. However, the pure tone measurement method of 8KHz or less, which is the hearing test method in the hospital, does not know whether the hearing damage in the extended high frequency band. Therefore, adolescents who frequently use earphones should find early detection of partial auditory disturbances in the extended high frequency band that are most likely to be damaged and prevent the progress of noise deafness.

In this study, we proposed a self perceptual method for partial auditory disturbance of extended high frequency band using hearing threshold characteristics of extended high frequency band. The proposed self perceptual method counts the number of sounds heard by playing 12 pure tones of extended high frequency band in various arrangements (A, B, C, D, E in Table 1). If you hear less B than A, less D than C, or less E than D, you are discriminating by partial auditory disturbance. In the experiment involving 18 participants, 13 participants were normal and 5 participants were judged to be partial auditory disturbance. In addition, explaining the self-perceptual method, all experiment participants succeeded in self-perceptual. These results confirm that the proposed method is indeed a suitable method for self perceptual partial auditory disturbance.

It is hoped that the propagation of the proposed self perceptual method for partial auditory disturbance will improve the noise deafness of adolescents.

REFERENCE

[1] Will there be deafness if plug in earphone and fall asleep? (MBC NEWS 2019.08.17.)

[2] Increasing noise deafness in the younger class. How is it prevented? (Healthy Living Encyclopedia, Samsung Medical Center, 2019)

[3] H. J. Sim, "Noise-Induced Hearing Loss", Hanyang Med Rev, Vol.35, 2015, pp.84-91.

[4] J. W. Kim and M. J. Bae, "Study on Hearing Loss According to Sound Pressure Level of The Earphones", Proceedings of The Institute of Electronics and Information Engineers of Korea, 2009, pp.1086-1087.

[5] Bong-Young Kim, Eun-Young Yi and Myung-Jin Bae, "A Study on the Distinguish of the Defective Product of Ceramic Toilet by Sound Characteristics",

Journal of Engineering and Applied Sciences(JEAS), Vol.14, No.4, 2019, pp.1247-1252.

[6] Hyung-Woo Park, Sang-Bum Park, Myung-Jin Bae, "A Study on the Characteristics of Electroencephalography (EEG) by Listening Location of OLED Flat TV Speaker", Springer, Computational Science/Intelligence & Applied Informatics, Studies in Computational Intelligence, Vol.787, 2018, pp.83-92.

[7] Kim, B.-Y., Ahn, I.-S. and Bae, M.-J. "Study on Measurement Method of Auditory Acuity Using Hearing Threshold of Extended High Frequency", Journal of Engineering and Applied Sciences, Vol.14, No.12, 2019, pp. 4153-4157.

[8] N. J. Kim, J. H. Lee and J. K. Kwon, "The Impact of Noise Expose on the Hearing Threshold Extended High Frequency", Journal of Annals of Occupational and Environmental Medicine, Vol.20, No.2, 2008, pp.81-92.

[9] H. J. Kwon and M. J. Bae, "A Study on a method of measurement of Noise induced Hearing Loss", Proceedings of The Institute of Electronics and Information Engineers of Korea, July 2009, pp.1084-1085.

[10] T. J. Lee, J. H. Yu, G. U. Choi, Y. J. Lee, J. I. Soo and K. Y. Kang, How Audio Technology Changes Future, The Electronics Times Co., LTD., Korea (2011).

[11] S. T. Lee, Principles and Application of Sound, Cheong Mon Gak, Korea (2004).

[12] [http://terms.naver.com] Audiometry (Seoul National University Hospital)

[13] Bong-Young Kim, Myung-Sook Kim and Myung-Jin Bae, "Study on the Sound Transmission Characteristics of Rescue Signal 'Ya-Ho'", International Journal of Engineering Research and Technology, Vol.12, No.2, February 2019, pp.222-226.

[14] Ik-Soo Ahn and Myung-Jin Bae, "A Study on a Automatic Audiometry Aid by PSM", International Journal of Engineering Research and Technology, Vol.11, No.8, August 2018, pp.1263-1272.

[15] Bong-Young Kim and Myung-Jin Bae, "A Study on Identification Rate Difference of Sound Color Marker According to Bandwidth-limited of Voice Signal", International Journal of Engineering Research and Technology, Vol.11, No.9, September 2018, pp.1463-1470.