Study on the health index value using the waveform of the Korotkoff sounds

Tsuneyoshi Sugimoto (1) and Fumiyo Katayama (1)

(1) Toin University of Yokohama, Yokohama , Japan

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ABSTRACT

The Korotokoff sounds are used at only blood pressure measurement now. However, we think it seems that the information about the circulatory system of the human body is included in its waveform. Therefore we collected the waveform data of the Korotkoff sound and performed the data analysis. Several healthy 20's students in our laboratory and the over-sixties elderly people of the daycare center (more than 20 people) are cooperated with this data acquisition experiment. As a measurement system, a mercurial sphygmomanometer and a ceramic microphone for blood pressure measurements and a notebook computer are used. The second sounds of the Korotkoff sounds are used to acquire stable waveform. First, the waveform of speed of the youth are big and intense, but it looks there is few change in the case of the senior citizens. Next, from the frequency analysis, we can see the minus peak frequency in the case of the youth, but can not see clearly in the case of the elderly people. Finally, from the acceleration waveform which differentiated the waveform of speed, we can confirm more than five peaks in the case of the youth clearly, however, in the case of the senior citizens, we cannot confirm well after the fourth peak. From these results, we confirmed that the information about the health is included in the Korotkoff sounds in itself at the time of the blood pressure measurement. We will collect the waveform data of the Korotkoff sounds more and we will examine whether it can be established as a healthy index value with the meaning statistically or not.

INTRODUCTION

At the hospitals, the auscultation that used the Korotkoff sounds (K sounds) for a blood pressure measurement is used widely now. However, K sounds are utilized only for an index of the blood pressure value widely. It is thought that K sounds reflect the change of some kind of bodies to the degree of the difference arteriosclerosis of the viscosity of the blood as the collection of the cardiovascular system living body information. And it is the present conditions at the time of the blood pressure measurement not to use the waveform of the K sounds. Therefore, in this study, we pay attention to the waveform of the K sounds and examine whether there is a signature to show the change of the physical condition and the ill onset in the sound.

EXPERIMENTAL SETUP

Acquisition method of the Korotkoff sounds

Figure 1 shows the experimental setup for the Korotkoff sounds analysis [1][2][3]. A ceramic microphone is set in the inside of the cuff. The K sounds are taken in a notebook computer via a microphone terminal. With a manual operation type mercury sphygmomanometer, K sounds are confirmed with an earphone by auscultation. The second K sound is acquired among five points of the K sounds classification （Because the waveform is stable）. Decompression is stopped as of about 6 - 10mmHg from a K sounds start. Five K sounds are recorded by a sampling of 16bit, 11kHz in the same state. Figure 2 shows an example waveform of the second K sound.

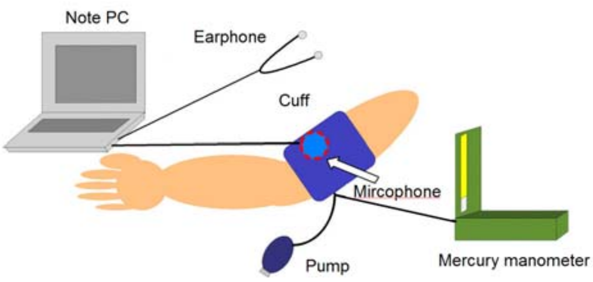

Figure 1. Fundamental concept of the Korotkoff sounds analysis. A microphone is set in the inside of the cuff. The waveform is recorded by using the microphone terminal of the notebook computer. The operator confirms the second Korotkoff sound while coordinating pressure with a pump.

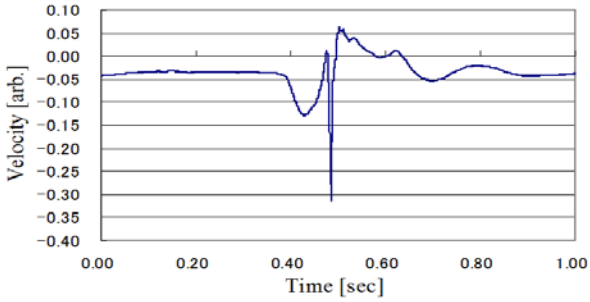

Figure 2. An example of the waveform of the second Korotkoff sound.

Experiment participants

Experiment participants are several healthy 20's student of our laboratory and over-sixties elderly people of the daycare center (more than 20 people).

INDEX VALUE FOR ANALYSIS

Minus peak frequency

The change of the K sound spectrum is compared with before and after exercise. An exercise bike is used for exercise and performed exercise of 100W for three minutes. Fiqure 3 shows an example of the K sound spectrum. From this figure, minus peak frequency is changed before and after exercise clearly. Figure 4 shows the average data for three days of the minus peak frequency change. From the frequency analysis result, we confirmed that the minus peak frequency in a low spectrum showed a clear change after the exercise [2].

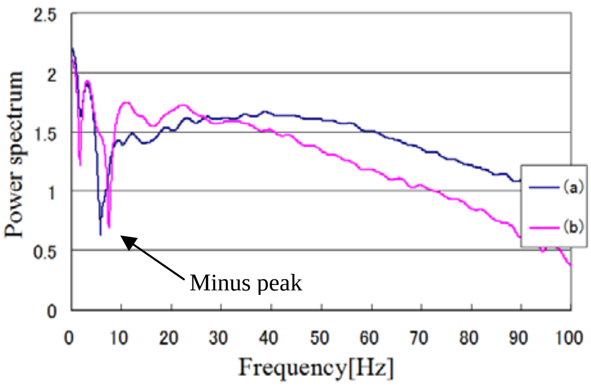

Figure 3. An example of the minus peak frequency. The frequency of the minus peak changes before and after exercise. (a) black line : before exercise , (b) red line : after exercise.

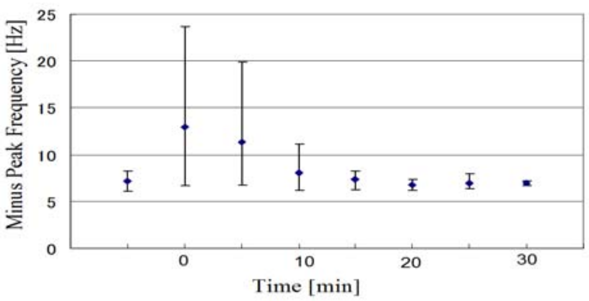

Figure 4. The average data for three days of the minus peak frequency change, before and after exercise.

Acceleration plethysmogram

The acceleration pulse wave (acceleration plethysmogram: APG) is provided by the second floor differentiation of the finger-tip's blood pulse. It is used for an aging index of the blood vessel. Five characteristic peaks are appeared in this waveform. These peaks can observe even the acceleration waveform which is provided by differentiating K sound of the upper arm part (Because the ceramic microphone is a velocity sensor). Figure 5 shows the acceleration waveform at the upper arm. As the aging of the blood vessel proceeds, b rises and c-e drops. Therefore, APG aging index (APGAI) is considered by the wave height ratio with a, as shown in the following equation (1) [4][5].

APGAI=(b-c-d-e)/a・・・(1)

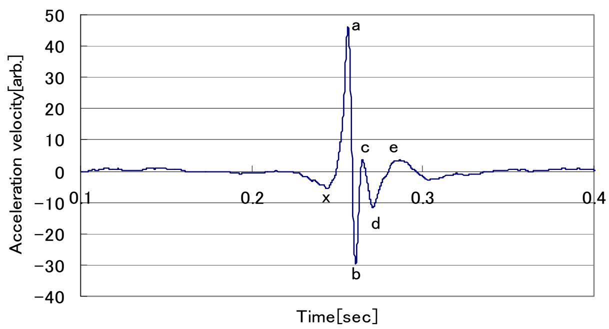

Figure 5. An example of the acceleration waveform at the upper arm. a-e show the five characteristic peaks. x is appeared only in the upper arm data.

EXPERIMENTAL RESULTS

Velocity waveform

Figure 6 shows the waveform examples of 20's male (Fig.6(a)) and 80's male (Fig.6(b)). From this figure, we can see the clear difference between both waveforms. We think this is because the difference of the blood vessel's hardness. Therefore, 20's blood vessel is easy to vibrate because it is soft. And it looks the waveform of 80' has a small amplitude in itself.

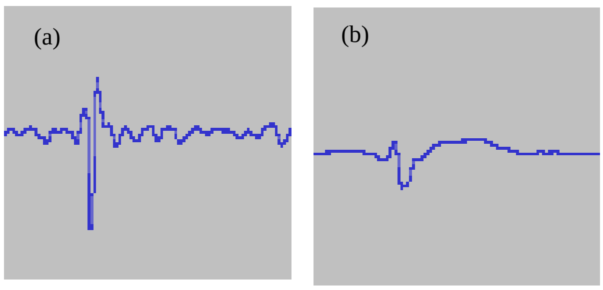

Figure 6. Examples of the velocity waveform of the second Korotkoff sound. (a) 20's male, (b) 80's male.

Minus peak frequency

Figure 7 shows a spectrum example of 20's male. From this figure, we can find two shape minus peaks clearly. However, in the case of the senior citizen, such a characteristic disappears. Figure 8 and Figure 9 show spectrum examples of the senior citizens. From these figures, we can not find the minus peaks clearly. Therefore, it seems that the minus peak value is not so effective for a healthy index value for the senior citizen.

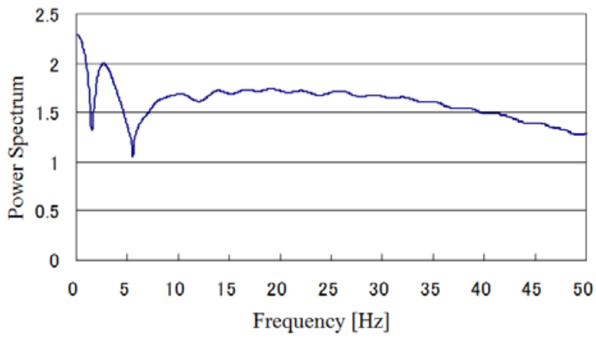

Figure 7. A spectrum example of 20's male.

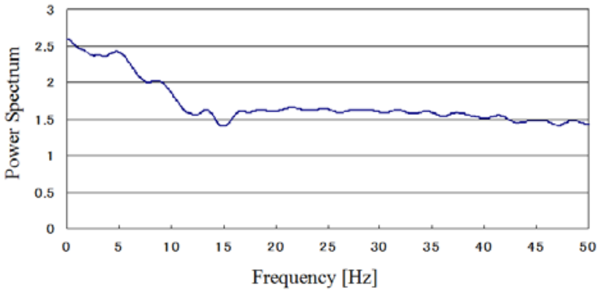

Figure 8. A spectrum example of 80's male. The minus peak can not find clearly.

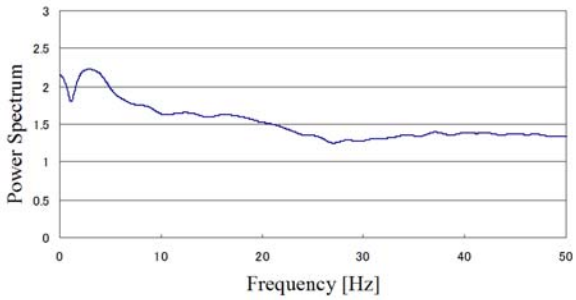

Figure 9. A spectrum example of 80's female. Only one minus peak can find clearly.

However, sometimes it is an effective index value for the healthy youth. As an example, a spectrum shows a changing example in the presence of the dislocation career. Figure 10 shows an example of the influence by the presence of the dislocation careers. Participant is a 20's healthy student, but his left shoulder has dislocation experience and performs the operation to cure a dislocation habit. The gray line shows the data of right arm without dislocation career and the blue line shows the data of the left arm with dislocation career. As shown in Fig.10, the gray line has two shape minus peaks clearly, but the blue line has only one minus peak and in addition, except low frequency, it is a characteristic that spectrum in itself is small. From this figure, it is possible to know the difference between both arms. Even in the case of a senior citizen, the spectrum data can use for examining the difference of the right arm and the left arm.

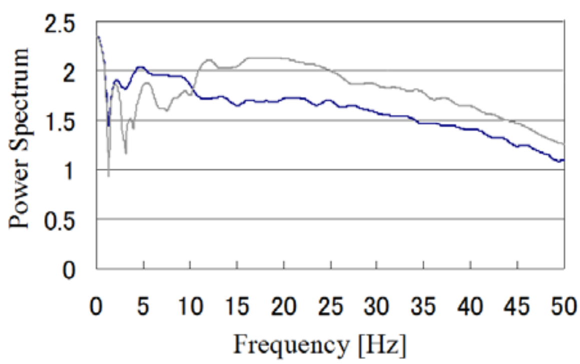

Figure 10. The influence by the presence of the dislocation careers. Gray line : without dislocation career (right arm), Blue line : with dislocation career (left arm).

Acceleration plethysmogram

Figure 11 shows an example of the acceleration waveform. Gray line shows the data of 20's male and blue line shows the data of 80's male. From this figure, the waveform of youth has more than five peaks clearly and the amplitude shrinking with time. However, in the case of the waveform of senior citizen, after the fourth peak position is uncertain and after that there is a part where the amplitude grows big. Therefore the APGAI is effective for youth, but it seems that it is difficult to just apply as the healthy index value for the senior citizen, and some kind of improvement is necessary.

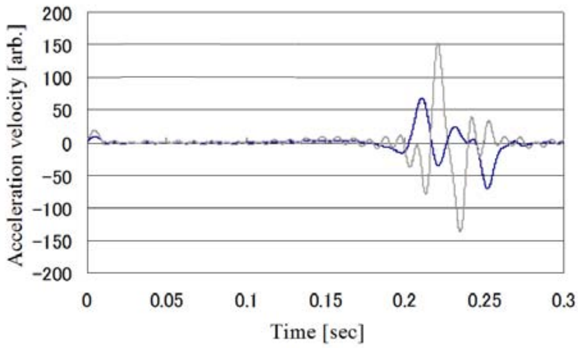

Figure 11. An example of the acceleration waveform. Gray line : 20's male, Blue line: 80's male.

CONCLUSION

We performed examination about the healthy index value with waveform information to be included in the second Korotkoff sound. Using the waveform of a youth and the senior citizen, we performed the evaluation of the frequency analysis and acceleration waveform. As a result, a difference of the waveform of the youth and the senior citizen is too big to apply the common index. However, we confirmed that these indexes are effective for youth at the same time. Therefore, we are going to study about the new healty index value or improve these indexes that can apply to a senior citizen in the future.

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