Relation between frequency of opening and closing of vascular and area of skinby microvascular wave

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***Abstract*—This report will describe relation between frequency of opening and closing of vascular and area of skin by microvascular wave. We name it Microvascular wave (MVW) and it is automatic movement of blood vessel and considered to be driven by calcium wave of smooth muscle cells those consist blood vessel wall. The observation of such spatial and temporal waveform of the blood vessel through the skin by regular camera had not been evaluated since now. Our overall goal is to confirm the possibility of such measurement. In the experiment, we recorded red spots which is a snare of capillaries. Temporal change of those spots is flickering with period between several ten seconds and one minutes. We assume those flickering is caused by the opening and closing of blood vessels by MVW and measured temporal changes by recording visual image of skin. Relation between frequencies and size of area will be analyzed and reported.**

***Contribution*— This research investigated the relation between area size and frequency of microvascular wave using visual image of skin.**

Keywords— Microvascular wave; skin of hands

I. INTRODUCTION

Microvascular wave (MVW) is automatic movement of blood vessel and considered to be driven by calcium wave of smooth muscle cells those consist blood vessel wall [1-5]. When observing skin of hands visually, it is possible to confirm the structure consists of red spots which is a snare of capillaries. When we observe temporal change of those spots are flickering with period between several ten seconds and one minutes.The observation of such spatial and temporal waveform of the blood vessel through the skin by regular camera had not been evaluated since now. Our overall goal is to confirm the possibility of such measurement.

If we assume those flickering is caused by the opening and closing of blood vessels. We name it Microvascular wave (MVW) and it is automatic movement of blood vessel and considered to be driven by calcium wave of smooth muscle cells those consist blood vessel wall. It is considered that the frequency of automatic movement of blood vessels is lower in thick blood vessels on the central side and increases every time the blood vessels branch toward the peripheral side. With MVW, we can expect that anti proportional relation between the area of skin and frequency of flickering. This is because the perfused region of a relatively thick blood vessel should be wider than the perfused region of a thin blood vessel, so that it can be assumed that the width of the observed skin region and the frequency of flickering are inversely proportional. In this research, the anti-proportional relation between the area of skin and frequency of open and close flickering of skin blood vessel caused by MVW was examined.

II. EXPERIMENTAL METHOD

Subjects are three young (one female, age 32 ±7) and eight elderly (all male, age 75±7), agreed to be subject after be advised objective of the experiment. Video were recorded for the centers of the hands of subjects from the 20cm distance, using video camera (Everio R, JVCKENWOD co., Ltd.). Experiment was taking place in the quiet room with room temperature 24°C while hands are fixed on the table. Square area of 3cm and 5cm were captured in in 9 minutes each.

The number of subjects is still small because this is still trial phase. However, there are already valid result as shown below. And we are going to extend size of experiment in the next phase.

Figure 1 Photo of the hand used in the analysis.

III. Analysis

The videos were MPEG formatted since one of our intention is to use commercial camera device. MPEG formatted video were processed using free software, FFmpeg [6]. JPEG still images of 1080 pixel by 1920 pixel were derived from every single second throughout entire video. Then JPEG pictures were converted to RGB images using file conversion software.

Then average RGB values were calculated for the circular area with radius R at the center of hands for each second. The average value for each second is handled as time series and power spectrum of the temporal transition of value was calculated (Fig.2). To compare different size of area, we compared R 0,1,2,3,4,5,10,15 mm. R=0 is not actually R is zero but corresponds to observing the single pixel in the center of hands. Low frequency band powers (0-0.25Hz) and high frequency band powers (0.25-0.5Hz) were calculated for each different radius from power spectrum. And number of peak frequencies which exceeds average power were calculated for each radius. The analysis is compared for each color (R,G,B) because blood vessel visibility is different for each color.

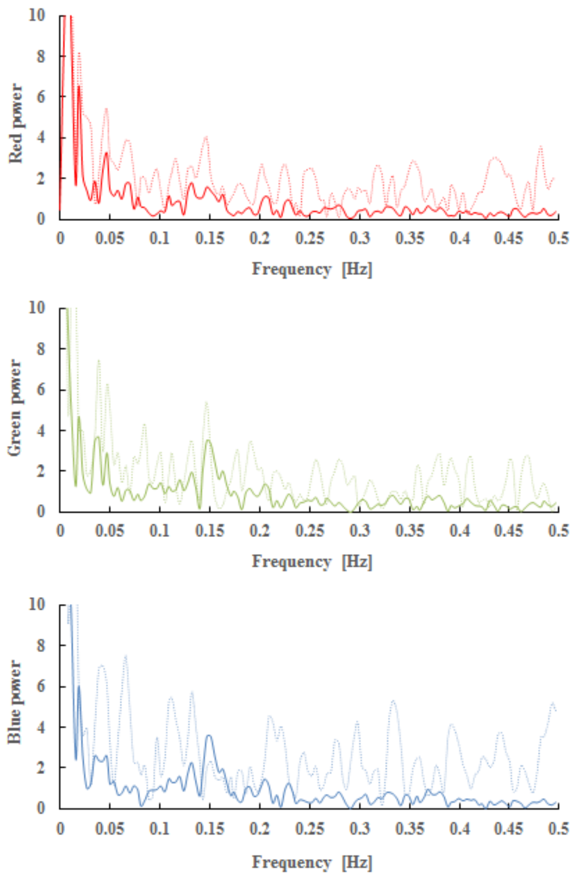

Figure 2 Power spectrum calculated from time series of RGB average values. (Solid line: R=0, dot line: R=15)

IV. Discussion

Figure 3 shows the difference in power at each R value for R = 0 (corresponding to 1 pixel). Solid is low frequency band and fine dotted is high frequency band. In younger subjects, decrease of power by increase of radius was larger. Especially decrease was larger in the high frequency band. Also, with younger subjects, power of low frequency power was gently getting smaller and power of high frequency band was larger for larger area size of skin. In contrast, power was not clearly changed for larger area size in case of elder subjects.

Figure 4 shows the number of peak frequencies in the low and high frequency band exceeds average power calculated for each measured radius. In younger subjects, number of peaks were increased as size of area increased for red color. In case of green color, it decreased up to R=3 and then increased again from R=4. The number of peak frequencies in the high frequency range of blue was smaller than that of red and green. On the other hand, the number of peak frequencies in the elderly increased compared with that in the young.

From those results, it is considered as with younger subjects, each pixel's opening and closing of skin blood vessel were not synchronizing and had different frequencies. That is possible reason of decrease of power for wider size of area. Especially, for the low frequency band, more frequency line will be expected to be observed when size of areas is widened. In contrast, it is mentioned that opening and closing phase are synchronized in elderly even when observing wider size of area.

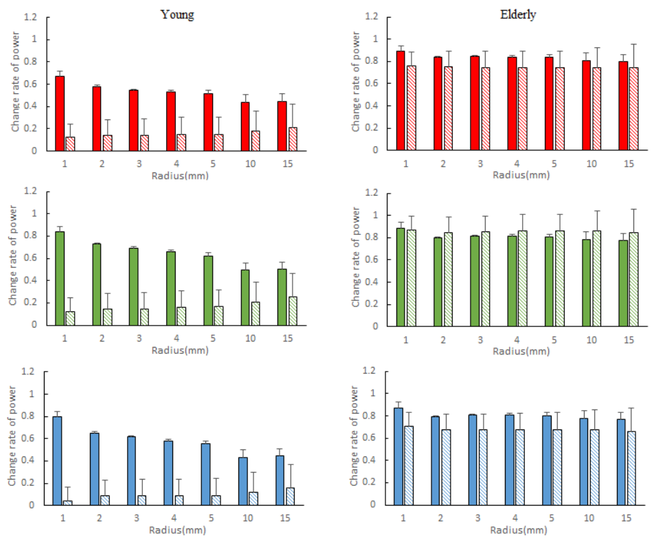

Figure3 Difference in power at each R value for R = 0.
Left:young(n=3), Right:eldery(n=8)
Solid: low frequency band, fine dotted: high frequency band
Upper red power, Middle green power, Lower blue power, mean ±S.E.

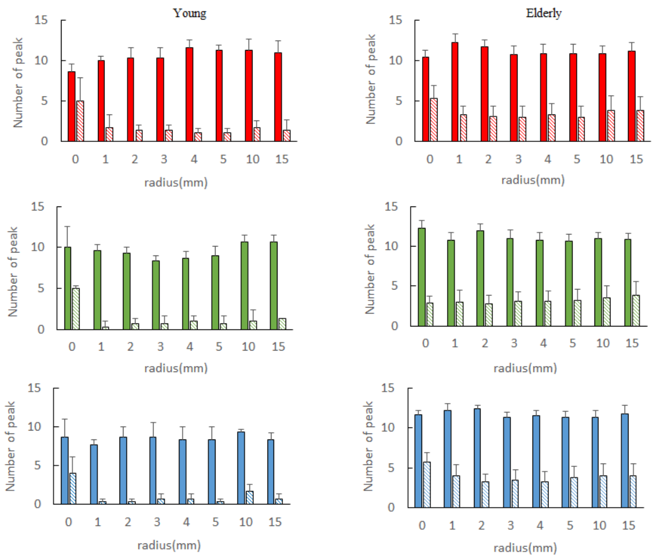

Figure 4 Number of different peak freuqnecy for each radius.
Left:young(n=3), Right:eldery(n=8)
Solid: low frequency band, fine dotted: high frequency band
Upper red power, Middle green power, Lower blue power, mean ±S.E.

V. Conclusion

The amount of data is still insufficient to support those hypotheses, so we need to confirm phenomenon with increased number of data. We think that nature of MVW is to avoid necrosis of portion caused by loss of blood flow by lower resistance of circulation or lower blood pressure. We also would like to prepare about an experiment for elderly subjects considering sickness.

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