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PPG PROFILE INVESTIGATIONS FOR DIFFERENT FINGERS IN A SUBJECT

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ABSTRACT

This paper explores using PhotoPlethysmoGraphy (PPG) finger profile data for identifying the three Ayurvedic doshas namely- vata, pitta and kapha. In this study the pulse profiles of all 10 fingers in 7 healthy subjects is acquired using Biopac MP150 data acquisition system. For a given subject the auto correlation (correlation of index finger with index finger) is found to be higher than correlation between different fingers (say between index finger and middle finger). Thus we may thus safely conclude that the profile of a given subject is unique for the specific finger.

Keywords: Doshas, PhotoPlethysmoGraphy (PPG), Finger Pulse Profile, Correlation.

1. INTRODUCTION

Medical science has the primary objective of providing healthcare to human beings. Various prevailing medical systems have modeled human body in different ways and thus have different approaches to cure the body suffering from any disease. Fortunately all the systems work. And that includes our Indian ancient system of Ayurveda as well. Amongst several endeavors made by the researchers worldwide, some point towards rejuvenating the art of diagnosing three basic Ayurvedic human constituents. These are known as doshas, namely vata, pitta and kapha [1]. Many Ayurvedic physicians used to diagnose these doshas by feeling the radial artery in the wrist region under the thumb [2]. It is important to document and quantize these Ayurvedic techniques using modern electronic equipment. This fusion of ancient Ayurvedic system with the modern technology would perhaps eternalize this dying art/science of Ayurveda. Using PhotoPlethysmoGraphy (PPG) it is quite possible that specific diagnosis may be reached by studying the finger pulse profiles.

PhotoPlethysmoGraphy (PPG) is an optical measurement technique used to detect blood volume changes in the micro vascular bed of tissues. Invisible infra-red light is sent in the tissue and the back-scattered light corresponds with the variation of the blood volume. PPG waveform comprises of a pulsatile ('AC') physiological waveform attributed to cardiac synchronous changes in the blood volume with each heart beat, and is superimposed on a slowly varying ('DC') baseline with various lower frequency components attributed to respiration, sympathetic nervous system activity and thermoregulation.

PPG wave complex can be used to study changes in the elastic properties of the vascular system with age and disease. Accurate detection of relevant features is necessary for clinical physiological monitoring such as Blood Oxygen Saturation SpO2, blood pressure, heart rate, cardiac output and breathing interval. The detection of PPG peaks helps in finding the beat-to-beat varying parameters. Dicrotic notch detection is very important in the assessment of hemodynamic parameters. Other applications include autonomic function assessment such as thermoregulation. Additionally, the shape of the PPG waveform differs from subject to subject, and varies with the location and manner in which the pulse oximeter is attached. Because the skin is so richly perfused, it is relatively easy to detect the pulsatile component of the

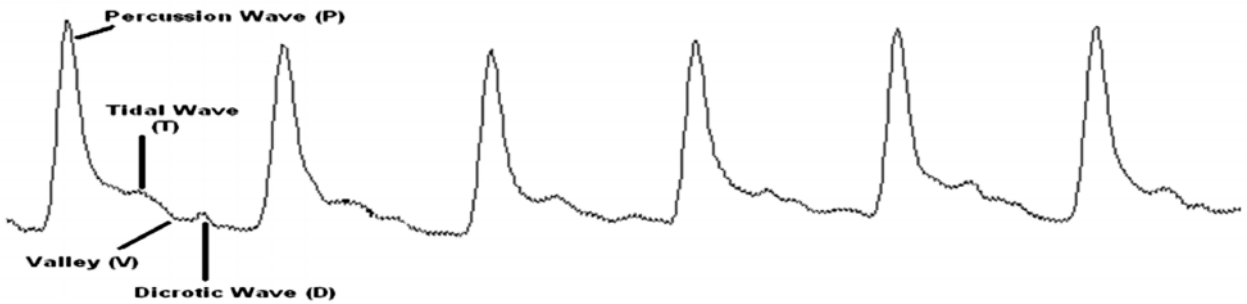

Figure 1: PPG Waveform

cardiac cycle. The DC component of the signal is attributable to the bulk absorption of the skin tissue, while the AC component is directly attributable to variation in blood volume in the skin caused by the pressure pulse of the cardiac cycle. The height of AC component of the PhotoPlethysmoGram is proportional to the pulse pressure, i.e. the difference between the systolic and diastolic pressure in the arteries [3].

2. PROBLEM DEFINITION

One of the alternatives to quantize pressure pulses available at radial artery in the wrist region, traditionally used in Ayurvedic system, is to design a special hardware for its measurement. This has been done by some researchers and the technique has not been standardized so far [4, 5]. Moreover this equipment is not available commercially. Another alternative is to go in for commercially available standardized PhotoPlethysmoGraph (PPG). Using PhotoPlethysmo Graphy it is quite possible that specific diagnosis may be reached by studying these finger pulse profiles [6]. To establish this it is first required to study these finger pulse profiles and establish a correlation between various fingers of the same subject.

3. METHOD

The MP150 data acquisition system of Biopac is utilized to take the measurements. The PPG100C amplifier is coupled with the TSD200 photoplethysmogram transducer, which is placed on the tip of the finger. The data is acquired at 10,000 samples per second. Band-stop IIR filter at 50Hz frequency is used to remove noise. Profile of one finger is taken at a time and the data is acquired for at least 10 second. This exercise is repeated for the remaining nine fingers. As the pulse of each finger is taken at different time so it is first normalized on time-scale to eliminate any differences on account of the variation in beat to beat interval. This is done by taking 200 samples from peak to peak of two alternative pulses (say between peak 1 and peak 3), irrespective of the peak to peak duration. The correlation of each finger profile-data with respect to other fingers profile-data of the same person is calculated. The two profile-data are made to slide over each other by at least half the duration of pulse width with step size of 1 sample duration. The maximum of the correlations so obtained is retained. The formula to find correlation is given as:

$$r_{xy} = \frac{\sum x_i y_i - n\bar{x}\,\bar{y}}{(n-1)s_x s_y} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\sqrt{n\sum y_i^2 - (\sum y_i)^2}}$$

Where $\bar{x}$ and $\bar{y}$ are the sample means of X and Y, s_x and s_y are the sample standard deviations of X and Y, n is number of pairs of measurement, $\sum x_i y_i$ is the sum of product of paired variables, $\sum x_i$ sum of X variable, $\sum y_i$ sum of Y variable, $\sum x_i^2$ sum of squared X variable, $\sum y_i^2$ sum of squared Y variable.

4. RESULT AND DISCUSSION

The shape of pulse profile of each subject is different from the other. In some cases the difference is so prominent that can be observed simply by viewing the difference in the pulse shape of say right hand fingers of one subject as shown in Fig.2

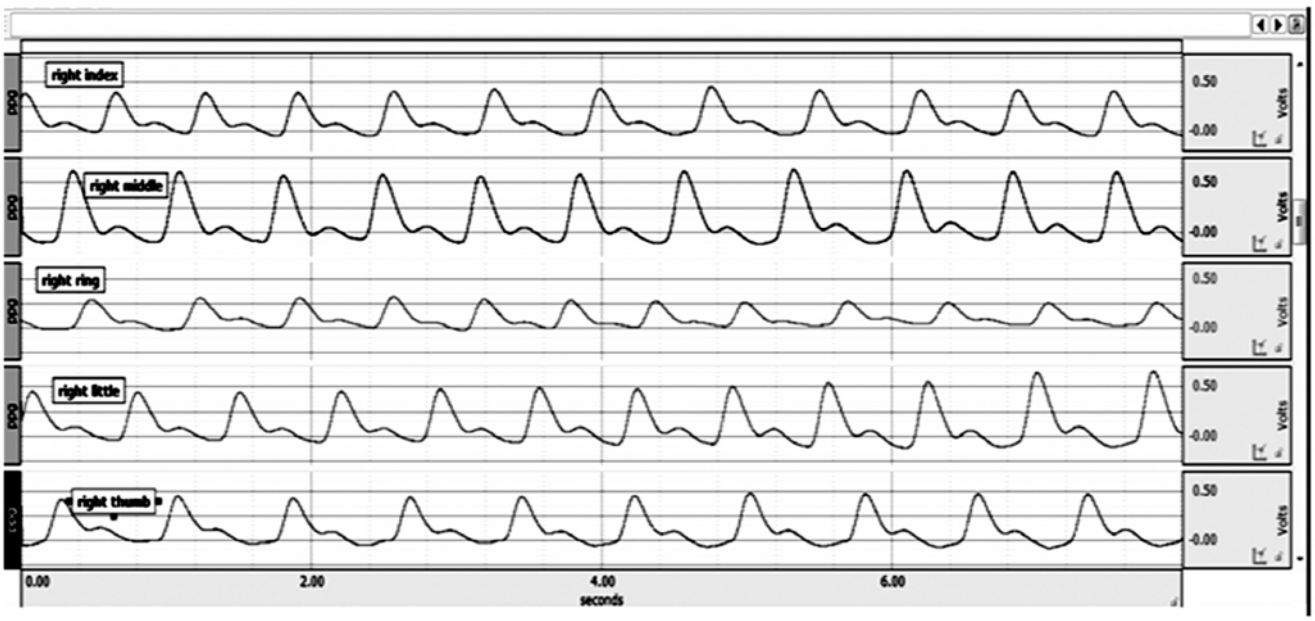

Figure 2: Right Hand Fingers Pulse Profiles of One Subject

Table 1
Correlations of Subject 1

subject 1	*rightindex*	*rightmiddle*	*rightring*	*rightlittle*	*leftindex*	*leftmiddle*	*leftring*	*leftlittle*
rightindex	**0.9976**	0.993	0.982	0.9957	0.9919	0.986	0.9824	0.9653
rightmiddle	0.993	**0.9938**	0.9577	0.9843	0.9862	0.9784	0.9732	0.9565
rightring	0.982	0.9577	**0.9951**	0.991	0.9786	0.9757	0.977	0.9581
rightlittle	0.9957	0.9843	0.991	**0.9962**	0.9926	0.9915	0.9913	0.9724
leftindex	0.9918	0.9862	0.9785	0.9926	**0.9983**	0.9869	0.9856	0.9669
leftmiddle	0.986	0.9784	0.9757	0.9915	0.9868	**0.9943**	0.9922	0.992
leftring	0.9823	0.9732	0.977	0.9913	0.9856	0.9922	**0.9932**	0.9807
leftlittle	0.9653	0.9565	0.9581	0.9724	0.9669	0.992	0.9809	**0.9925**

The result of correlation of the pulses with respect to the same finger of the same subject as well as the other fingers of the same subject is given in table 1. It is seen that correlation of any finger with any other finger is different for each combination. Further it is observed that the autocorrelation is higher than correlation between two different fingers of the same subject in 67 out of 70 cases.

5. CONCLUSION

For a given subject the autocorrelation (say correlation of right index finger pulse with another right index finger pulse taken subsequently) is found to be higher than correlation between different fingers (say between right index finger and right middle finger) in most of the cases. Total 7 subjects are observed for all 10 fingers each and it is found that autocorrelation is highest in each finger in 67 out of 70 cases. We may thus safely conclude that the profile of a given subject is unique for the specific finger. This preliminary study opens up a possibility of studying the pulse profile of different fingers in the same person to find the relative features leading to detection of different Ayurvedic doshas in a given person. The study may be extended for the larger number of subjects and the data acquisition for all the ten fingers of a subject may be done simultaneously using ten transducers and ten amplifiers.

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