

## *Measurement of Microvibration on the Skin Surface*

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### SYNOPSIS

There is a small vibration which goes undetected by the naked eyes. It is called a microvibration (MV) or a minor tremor (MT). The MV on the body surface is expected to apply to a clinical examination of the autonomic nervous system. It is not cleared why and how the MV occurs, but there are many papers about its occurrence and clinical application. In this study, MV measuring system, its estimation and basic characteristics are examined. The difference between head MV and thenar MV, individual MV and diurnal and seasonal change are discussed. The power spectrum of MV is obtained using an autoregressive model.

### 1. INTRODUCTION

A physical movement is observed on the body surface when it is cold or when a man is seized with fear. As regard to observable vibration in time of sickness, it is marked one of the pathological process from clinical medicine. It is called a physiological tremor (PT) which is observed in voluntary movement. But it is known that there is a small vibration on the body surface which cannot be observed by the naked eyes even if the surface is fixed. It is called a microvibration (MV)

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or a minor tremor (MT). The first report on MV was published in 1946 by Rohrer<sup>(1)</sup> and since then a number of related reports have been increasing. MV and EEG (Electroencephalograph) resemble each other closely in wave but are unrelated. Homothermic animals have MV but poikilothermic animals do not. So it seems that MV is related to the activity of the autonomic nervous system which regulates the body temperature.

The mechanism of MV has been discussed many times before : 1)the spinal nerves and muscle nerve activity in relation to MV; 2)the function of heart activity on MV; 3)the activity of both of them on MV. MV is of use for the examination of autonomic nervous system. It is known that the temperature and autonomic drugs change MV. So MV is related to the spinal nerves. In this study, the basic characteristics of MV at rest are examined.

## 2. MEASUREMENT AND ANALYSIS OF MV

### 2.1 Microvibration

Fig.1 shows the time-courses of MV on the body surfaces (head and left thenar). The function of heart has direct effects upon MV because a superior wave of MV appear simultaneously with the heart beat. The amplitude of MV differs with each other in body. In general, the thicker is the subcutaneous muscle, the smaller is the amplitude of MV. The amplitude of MV on left thenar is 2 or 3 times as large as that on head. The measurement of MV should be performed without involuntary movements, because MV is influenced by small physical actions. There are many papers on MV. Sugano<sup>(2)</sup> says that the amplitude and frequency of MV increase or decrease when central nerves stimulants or depressants are injected into cats. According to Inanaga<sup>(3)</sup>, the frequency components of MV change with mental states: mental arith-

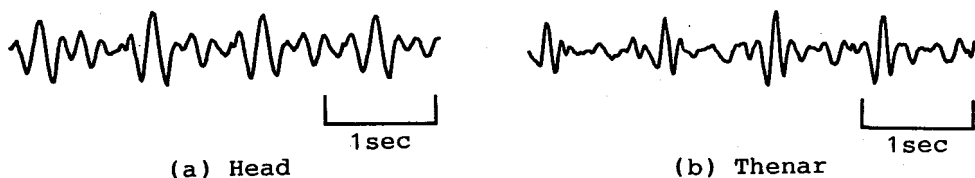


Fig.1 Microvibration on the body surfaces.

treatment of psychogenic or nervous disorders. Sato<sup>(5)</sup> thought that MV is an indication of unrest in dentistry. Harada<sup>(6)</sup> reported the relationship between vibration disorders and MV. The relationship between MV and fatigue are investigated. Therefore it is hoped that MV is applied to the examination of autonomic nervous system.

## 2.2 MV Measuring System

Fig.2 illustrates a measuring system of MV. The pick-ups (NIHON-KODEN , MT-3T) were attached to the head and the left thenar with adhesive tape. The polygraph (NIHON-KODEN, 360 system) has a low pass filter with 0.3 time constant and its high-pass filter is used to eliminate noise above 30Hz. Analog data is converted to digital and stored in a digital recorder (TEAC, DR-F1). The obtained data is analyzed by a personal computer (EPSON, PC-286V).

The subject was laid in a dark room, relaxed in supine position. Both arms were extended loosely parallel to the body axis with palms somewhat abducted.

## 2.3 Estimation of MV

In this study, the power spectrum of MV was calculated using an autoregressive (AR) model. Data points for sampling is 512 every 10s, sampling frequency is 100 Hz and frequency resolution is 0.1 Hz. The spectrum is classified to  $\theta$  band (4-8 Hz),  $\alpha$  band (8-13 Hz) and  $\beta$  band (13-20 Hz) similar to electroencephalogram analysis. The changes of MV

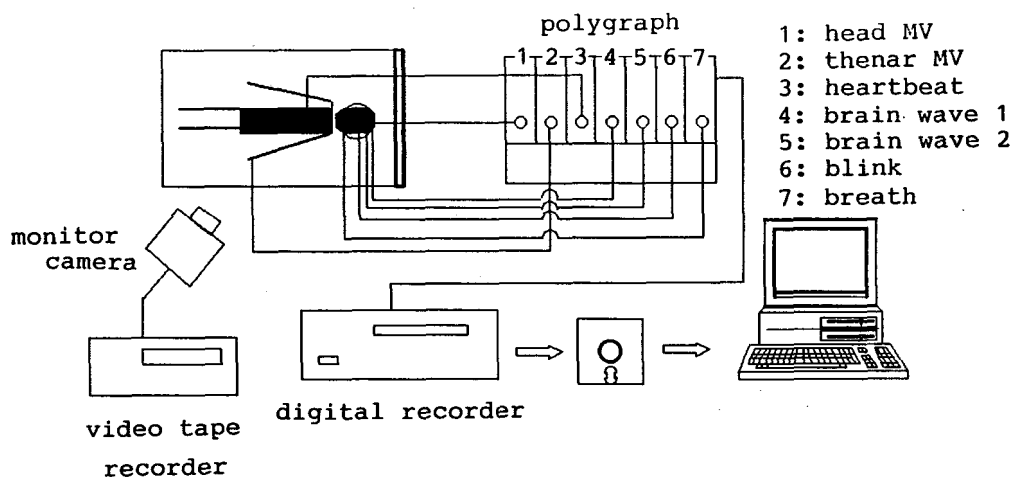


Fig.2 MV measuring system.

spectrum in time are displayed on a monitor. The sum (S) and appearance rate (E) of MV spectrum are calculated. MV spectrum of each band ( $\theta, \alpha, \beta$ ) for 512 points is expressed  $A_\theta, A_\alpha, A_\beta$  respectively. For example  $E_\theta, S_\theta$  in  $\theta$  band are given as following:

$$E_\theta(t) = \frac{\sum_{\theta} A_\theta(t)}{\sum_{\theta} A_\theta(t) + \sum_{\alpha} A_\alpha(t) + \sum_{\beta} A_\beta(t)}$$

$$S_\theta(t) = \sum_{\theta} A_\theta(t)$$

The spectrum of MV is obtained using an AR model. FFT (Fast Fourier Transform analysis method of MV have been published (7)). Calculating time using AR model is much later than that using FFT. Resolution of power spectrum in AR model, however, is superior to that in FFT. Then AR model analysis is available for short data.

### 3. BASIC CHARACTERISTICS OF MV

#### 3.1 MV from Head or Left Thenar

Fig.3 illustrates MV waves obtained from head and left thenar.  $\theta$  band is superior in the head MV, and  $\theta$  band and  $\alpha$  band in the left thenar. Therefore the left thenar MV is more useful than the head MV, because the spectrum of the left thenar MV is bigger than that of head MV. The left thenar, however, is inclined to be disturbed by body movement and it is difficult to use it during sleeping.

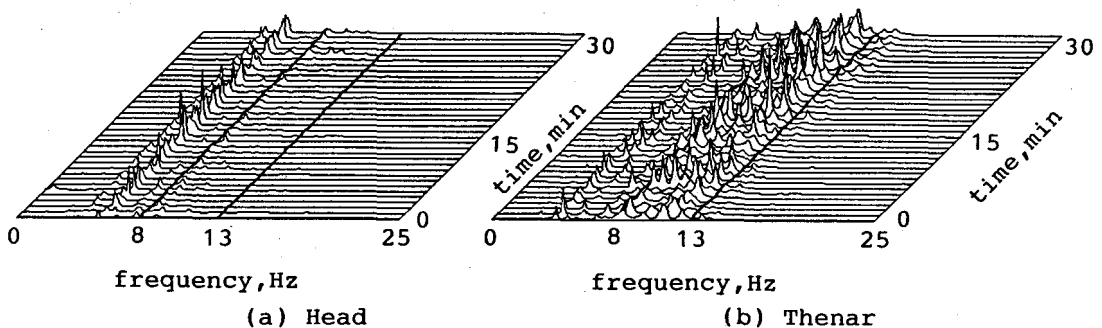


Fig.3 The head MV and the thenar MV.

### 3.2 MV from Left and Right Thenar

It is better to measure the thenar MV on the palm which is not used in daily life. The thenar MV on both palms was measured for confirmation. Fig. 4 illustrates  $E_{\alpha}$  of the both thenars. Fig. 4(a) shows that  $E_{\alpha}$  of the left thenar is larger than that of the right in right-handed people. Fig. 4(b) shows  $E_{\alpha}$  that the left thenar is as large as the right in the left-handed men. Then the left thenar MV may be measured

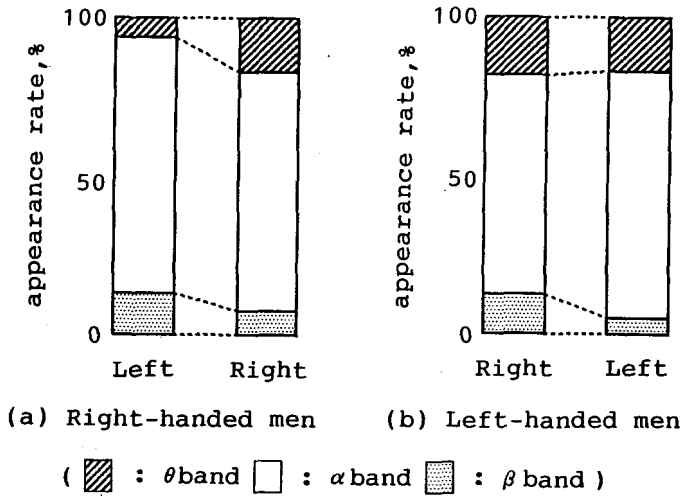


Fig.4 Thenar MV on both palms.

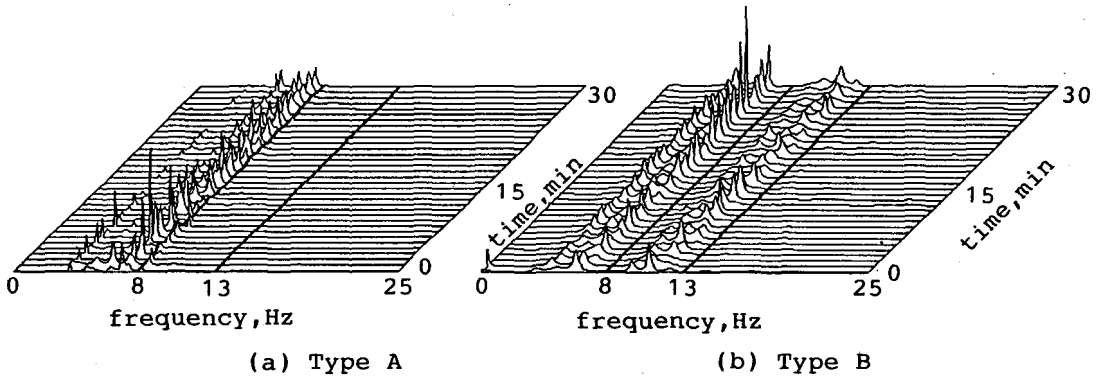


Fig.5 Individual difference of the head MV.

in both thenar. It was confirmed that the thenar MV was measured on the left thenar.

### 3.3 Variation of Individual MV

In measuring a variation of individual MV, the measuring conditions (room temperature, bodily temperature, posture, fatigue *etc.*) should be kept constant in order to avoid other factors than individual differences. Fig. 6 shows one example of a time-course of the head MV spectrum of two men. The individual difference is realized from Fig. 5. There is a type A who has  $\theta$  band spectrum and a type B who has  $\theta$ ,  $\alpha$  band spectrum. In these experiments, there are eight same in type A, three in type B and one is the mixture with type A and B.

In the left thenar MV,  $S_{\alpha}$  is bigger than the other band but someone has  $S_{\theta}$  and  $S_{\alpha}$  equal to  $S_{\beta}$ . Then the left thenar MV doesn't have a remarkable individual difference as same as the head MV.

### 3.4 Diurnal Change of MV

Diurnal changes of the head MV and the thenar MV are measured. The subject was working on the desk the whole day. Nine subjects were measured before and after a meal, morning, afternoon and evening. Fig.

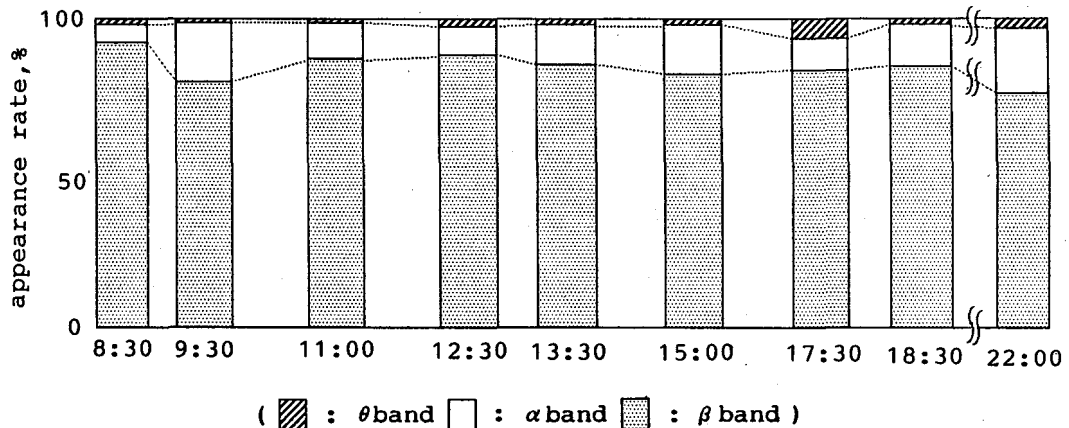


Fig.6 Diurnal change of appearance rate of the head MV.

6 illustrates a bar graph of the appearance rate of the head MV spectrum. The appearance rate is averaged in 60 times, from 5 to 10 minutes after being at rest. A horizontal axis is time. Fig. 6 shows that the head MV becomes less in the order,  $S_\theta$ ,  $S_\alpha$ ,  $S_\beta$ . The thenar MV becomes less in the order,  $S_\alpha$ ,  $S_\theta$ ,  $S_\beta$ . Sugano<sup>(2)</sup> says that  $S_\theta$  increases by fatigue. In this study  $S_\theta$  increases and  $S_\alpha$  decreases, too.

The sum of MV spectrum changes during a day. The head and the thenar MV, however, have a tendency to increase and decrease. It is said that the sum of MV spectrum changes with a cardiac minute volume or heart beat change caused by breathing. In this study, it is considered that these factors caused the change in sum of MV spectrum. This result shows that the appearance rate of MV is constant if the measuring conditions (room temperature, bodily temperature, posture, fatigue *etc.*) don't change.

### 3.5 Seasonal Change of MV

Fig.7 illustrates seasonal changes of the thenar MV. The appearance rate and sum of MV spectrum are averaged during 20 minutes. The sum of MV spectrum doesn't change so much except in December and the appearance rate MV doesn't change. In factors of seasonal change the biggest one is a room temperature. Inanaga<sup>(3)</sup> says that  $E_\theta$  increases when it is cold  $E_\beta$  increases when it is hot. In this study, the seasonal change of MV can't be recognized. In seasonal experiment, it is necessary to keep measuring conditions (fatigue *etc.*).

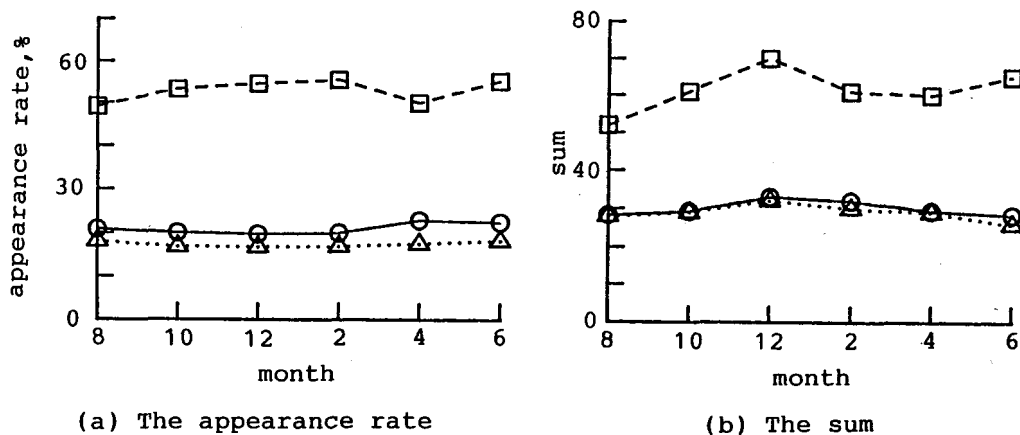


Fig.7 Seasonal change of the thenar MV.

#### 4. CONCLUSIONS

In this study, the measuring system of MV and analysis and estimation of MV are described. In addition basic characteristics of MV becomes clear.

(1)The head MV is different from the thenar MV.

(2)There is variations of individual MV but there aren't daily change and seasonal change of MV so much.

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