

Basic Characteristics of Microvibration on the Skin Surface

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SYNOPSIS

A small vibration on the body surface is expected to apply to a clinical examination of the autonomic nervous system. The vibration cannot be found by the naked eyes. It is called a microvibration (MV) or a minor tremor (MT). It is not cleared out why and how the MV occurs, but many papers about its occurrence and clinical application have been published. In this study, the typical spectrum of MV and the various causes of MV occurrence are studied. The relationships of MV with heart rate, muscle contraction and MV are discussed. The power spectrum of MV is obtained by using an autoregressive model.

1. INTRODUCTION

It is known that there is a small vibration on the body surface which cannot be observed with the naked eyes. It is called a microvibration (MV) or a minor tremor (MT). MV is distinguished from a physiological tremor (PT), which is observed when it is cold or when a person is seized with fear. The amplitude of PT (1G) ($G=9.8\text{m/s}^2$) is one thousand as large as that of MV (10^{-3}G) in acceleration. MV was reported firstly by Rohracher⁽¹⁾ in 1946, and its rhythm is closely

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similar to EEG (Electroencephalograph). Both of them are, however, unrelated. According to his report, MV occurs by skeletal muscular contractions. Homothermic animal have MV but poikilothermic animal do not. MV may be related to the activity of the autonomic nervous system which regulates the body temperature.

The mechanism of MV occurrence is theoretically studied and they are a reflection of the spinal nerves or the functions of heart activity. As temperature and autonomic drugs changes MV occurrence, MV is related to the spinal nervous system. From the above, MV is expected to apply to a clinical neuroscience. In this study, the power spectrum of MV is classified to 6 bands. So as to confirm the relation of MV with heart functions, muscle activity and autonomic nervous system, MV is measured in physical exercise, drinking, muscle exercise (hand-gripping), and mental and physical fatigue.

2. TYPICAL SPECTRUM OF MV

The power spectrum of MV is classified to θ -band (5.5-7.5 Hz), α_1 -band (7.5-8.5 Hz), α_2 -band (8.5-9.5 Hz), α_3 -band (9.5-10.5 Hz), α_4 -band (10.5-13 Hz) and β -band (13-20 Hz). According to Kuroki⁽²⁾, the further details are described in the typical spectrum of MV.

N group : There are most α -band (9.5-13 Hz) in this group. The appearance rate of θ -band is under 30%, α_1 -band is under 35% and β -band is under 33%.

S group (including a slow wave of MV) : A slow wave is superior. The appearance rate of θ -band is above 30% or α_1 -band is above 35%.

F group (including a fast wave of MV) : A fast wave is superior and the appearance of β -band is above 30%.

I group (including an irregular wave of MV) : This pattern is irregular. The both the appearance rate of θ -band (or α_1 -band) and β -band are above 20%.

34 healthy subjects are chosen, and they are men in age group 21 to 40 years. In head MV, all belongs to S group. In left thenar MV, 29 people belong to N group, 3 people S group and 2 people F group. This result conforms well to the above report⁽²⁾. Fig.1 illustrates typical spectra of N, S, F and I group.

3. BASIC CHARACTERISTICS OF MV

3.1 Heart beat and MV

3.1.1 MV before/after physical exercise

A heart beat influences on MV. Fig.2 illustrates a left thenar MV

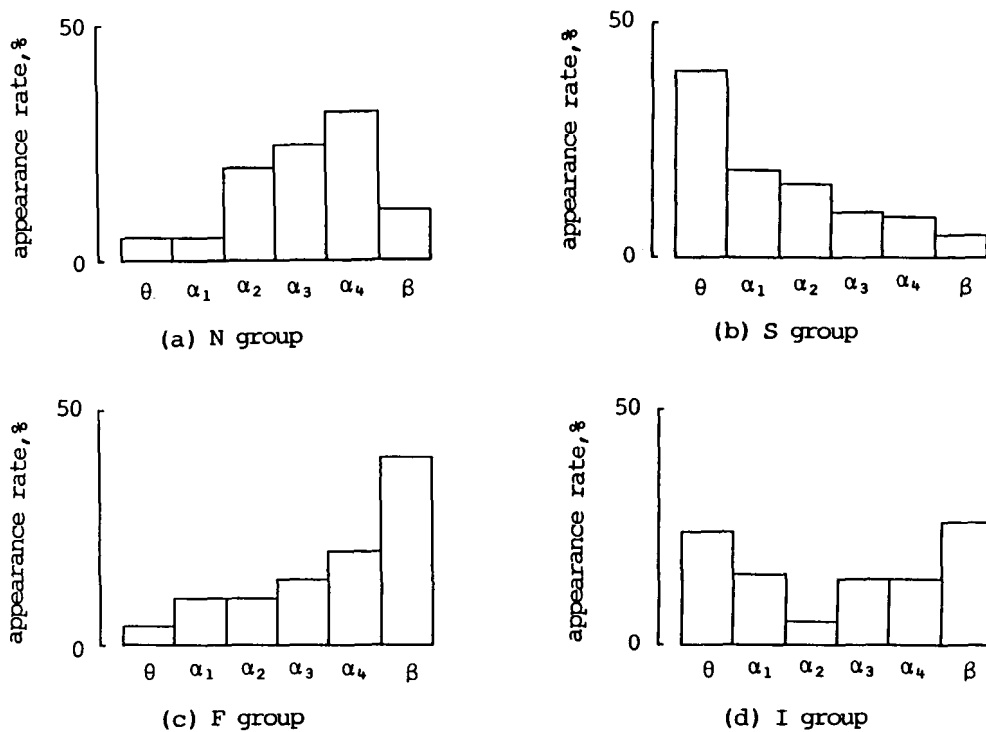


Fig.1 MV pattern.

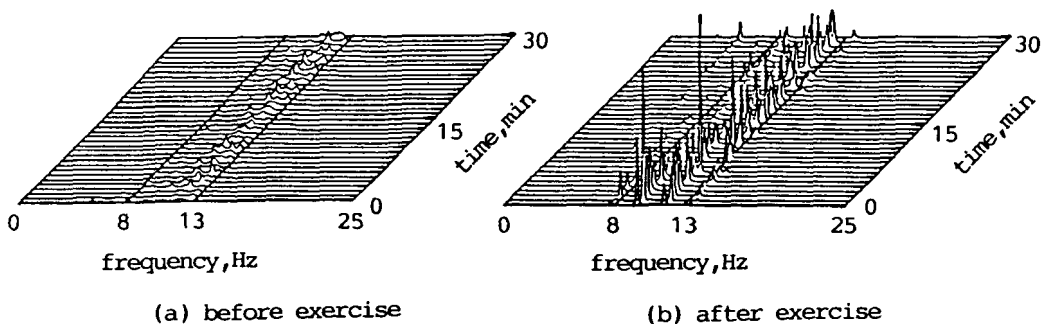


Fig.2 MV before/after physical exercise.

before/after physical exercise (running 5 kilometer on a treadmill inclined by 5 degree). Frequency band of MV does not change but the spectrum becomes bigger after physical exercise. In head MV, a similar result was obtained as for the left thenar MV.

3.1.2 MV before/after drinking

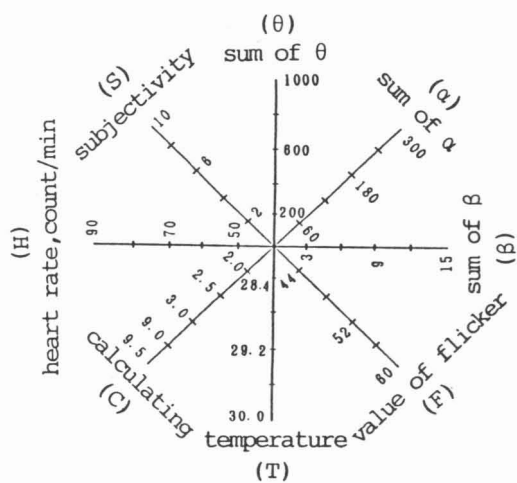
MV before/after drinking is measured in order to confirm a relation between heart beat and MV. A value of flicker, a skin temperature, a heart rate and a correct solution rate in mental arithmetic are examined at the same time. Fig.3 (a) illustrates axis and scale of polygonal graph. Fig.3 (b) and (c) show each value before drinking, in drinking a little and drunken. The subject evaluates subjectively a degree of drunken by a numerical value (0-10). The correct solution rate in the mental arithmetic is a ratio of a calculating time to a correct answer of judgment. As a degree of drunken goes on, a value of flicker, a skin temperature and a heart beat increase, and a correct solution rate decreases. This results as follows : Judgment decreases by alcohol, and the body becomes warm. Fig.4 illustrates three-dimensionally a head MV before/after drinking. The power spectrum of MV after drinking is larger than that before drinking. Drinking accelerates a heart rate. Then the activity of the heart functions is closely related to the mechanism of MV occurrence.

3.1.3 Discussions

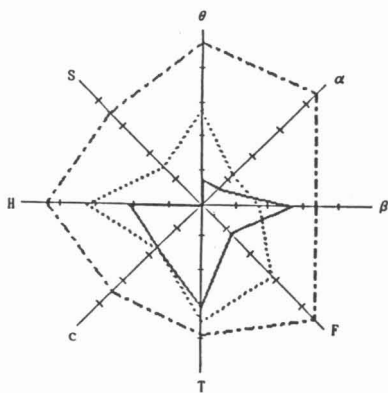
After physical exercise, a heart rate and a blood circulation rise very much. A heart rate rises after drinking, too. Thus, the heart beat and the blood circulations influence on the mechanism of MV occurrence. It is supposed that a superior wave of MV appears simultaneously with the heart beat⁽³⁾.

3.2 Muscle activity and MV

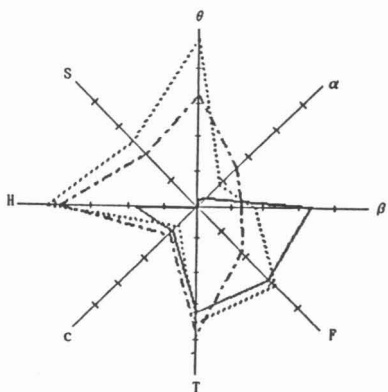
So as to examine the influence of muscle on MV, MV is measured before/after hand-gripping. Fig.5 illustrates averaged power spectra for ten minutes. Fig.5 (a) illustrates a MV spectrum before gripping and (b) after gripping. The sum of MV decreases after hand-gripping. The appearance rate of β -band is 25.5%, but after hand-gripping it is 37.8%. Increasing of the appearance rate of β -band, is supposed to be based on muscle excitement⁽⁴⁾. In running (physical exercise), however, such an observation has not been made. When the muscle stimulates itself by hand-gripping, the appearance rate of β -band increases. The



(a) axis and scale polygonal graph

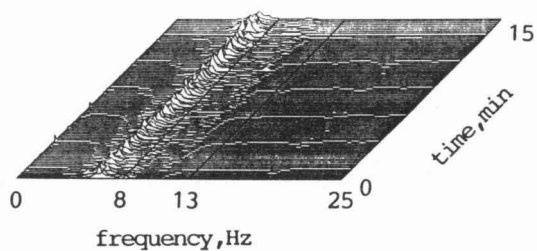


(b) subject A

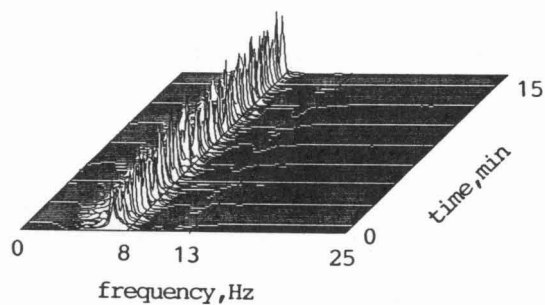


(c) subject B

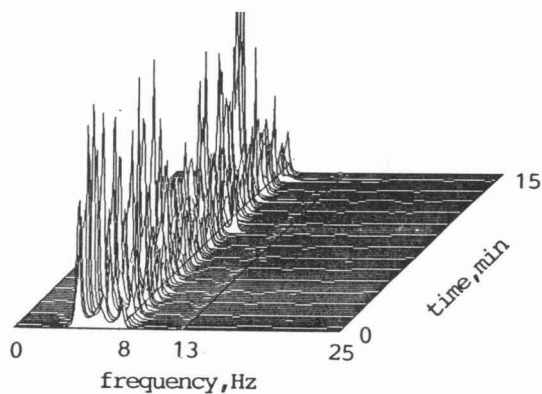
Fig.3 MV before/after drinking.



(a) before drinking



(b) drinking a little



(c) drunk

Fig.4 3D, MV before/after drinking.

muscle activity as well as the activity of the heart functions, is related to the mechanism of MV occurrence.

3.3 Autonomic nervous system and MV

In order to examine the relation between MV and an autonomic nervous system, MV is measured in case of lack of sleep, and stop smoking. The solid curve in Fig.6 shows the head MV of subject without physical and mental fatigue. The peak of the spectrum of θ -band is recognized. The dotted curve in Fig.6 is the spectrum in case of the lack of sleep, and the broken curve is that in a morning after sleep-

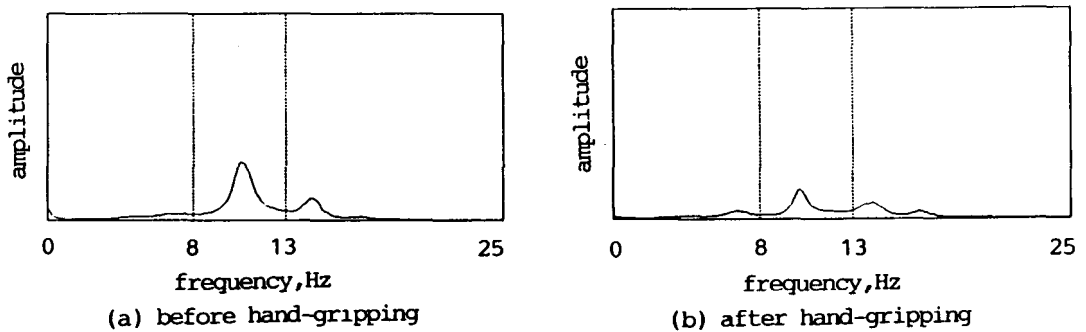
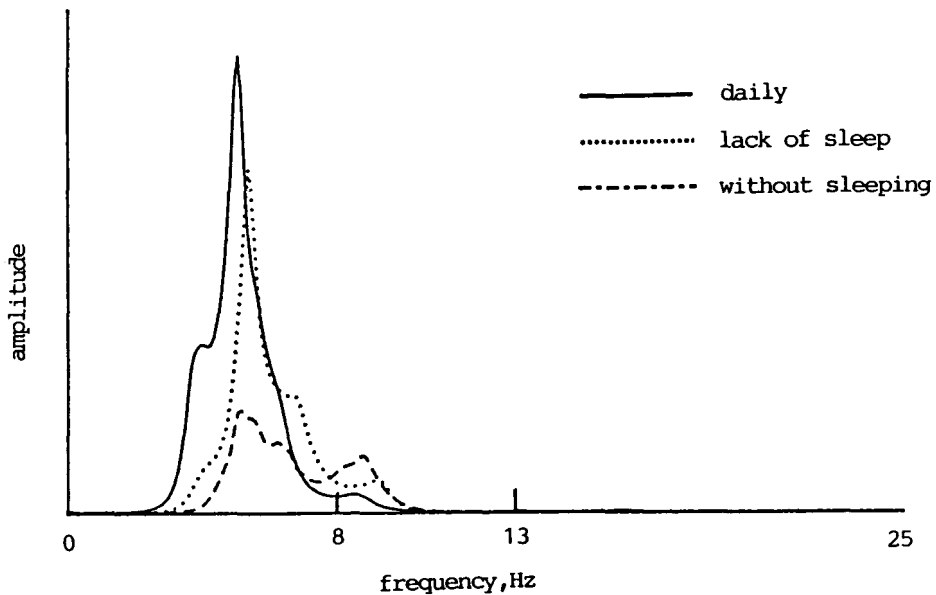


Fig.5 The muscle activity and MV.



MV Fig.6 MV through lack of sleep-

less night. The subject is in physical and mental fatigue. The more the subject lacks sleeping, the lower the spectrum of MV becomes. 2 frequency peaks are recognized in the broken curve. Though the appearance rate of θ -band is superior when he is at rest, α -band increases when he is in fatigue. The left thenar MV shows a similar tendency. From the description above, it is cleared out that one peak of spectrum is recognized when he is at rest, but some peaks of spectrum, which are lower than that, are recognized when he is in fatigue. This is similar to the characteristics of some peaks of spectrum which are recognized when people gets diabetes mellitus.

Next is the head MV of the subject, who smokes daily, is measured while he stops smoking. The subject becomes fatigue while he stops smoking. Fig.7 (a) shows the head MV when he smokes daily. The period when he stops smoking, takes place in the order, Fig.7 (b)(c)(d). Two peaks of spectrum, which becomes lower, are recognized when he becomes fatigue in the order, Fig.7 (b)(c)(d). The results in fatigue are in approximate agreement with those when the subject lacks sleep. Fig.7 (e) shows the power spectrum when he smokes again, which is similar to (a).

From these experiments, it is cleared out that MV occurrence is closely related to the autonomic nervous system. Some peaks of power spectrum are appeared in fatigue and lower than at rest. The autonomic nervous system promotes or inhibits MV occurrence.

4. DISCUSSIONS

Many factors, which have influence on MV, have been investigated so far. Superior are a temperature, a mental condition(tension *etc.*), a fatigue, a season and a menstrual cycle. Medical drugs and a body circulation dominate, too. There are many discussions about the mechanism of MV occurrence based on the autonomic nervous system, the spinal nerves, the functions of heart and the muscle activity. The approved mechanism of its occurrence is, however, not obtained.

A superior wave of MV appear simultaneously with the heart beat. From the experiments of exercise and drinking, it is cleared out that the blood circulation changes MV occurrence. Some factors, except for heart functions, have an effect on MV occurrence : When a heart of a cat was excised by a surgical operation, the amplitude of MV decreased but did not disappear⁽⁵⁾. It is confirmed that muscle activity is

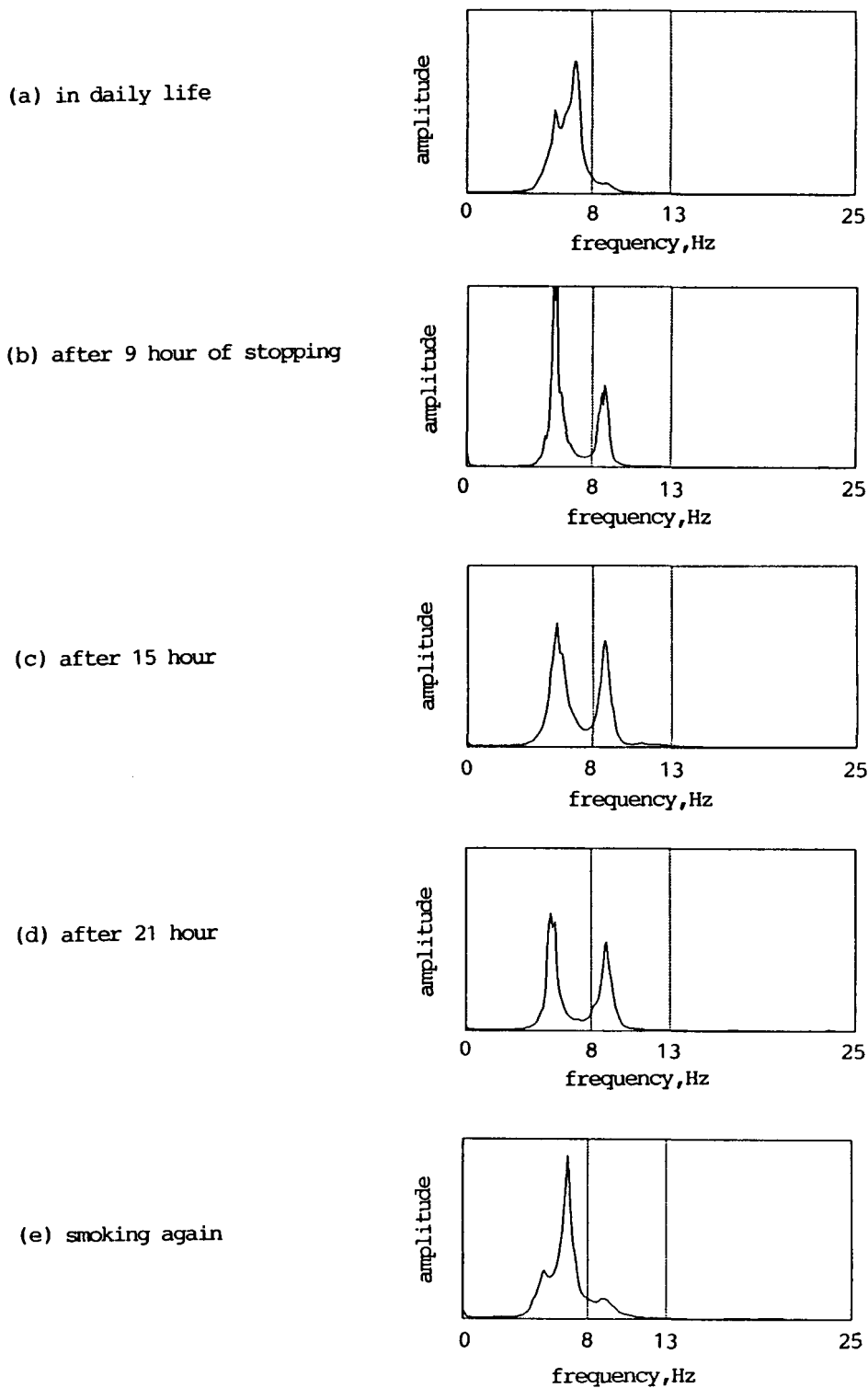


Fig.7 MV in giving up smoking.

related to MV occurrence. The thicker is the subcutaneous tissues, the smaller is the amplitude of MV⁽⁵⁾.

To study a MV occurrence, MV is measured in smoking. The subject who does not smoke daily, was "forced" to smoke. After smoking 3 cigarettes including a nicotine, the subject got tired and turned out to be a facial phenomenon. The value of flicker rose from 42.7 to 46.2, and the judgment of the subject dropped. The solid curve, the dotted curve, the broken curve in Fig.8 illustrate the left thenar MV before smoking, while smoking and after 40 minutes of smoking, respectively. The power spectrum of the left thenar MV became large while smoking and after smoking. It showed the same tendency in the head MV. A heart rate before smoking was 64(beat/minute), but while smoking it went on to 81(beat/minute). As same as in drinking, it is cleared out that the functions of the heart is related to MV occurrence. Though a heart rate went down after 40 minutes, the spectrum did not decrease. This result is as follows : Cigarette increases a muscle activity in relation to MV occurrence. Both the functions of heart and muscle activity are influencing on MV occurrence. It is pointed out that the sympathetic promotes MV and the parasympathetic nerves inhibits MV⁽²⁾.

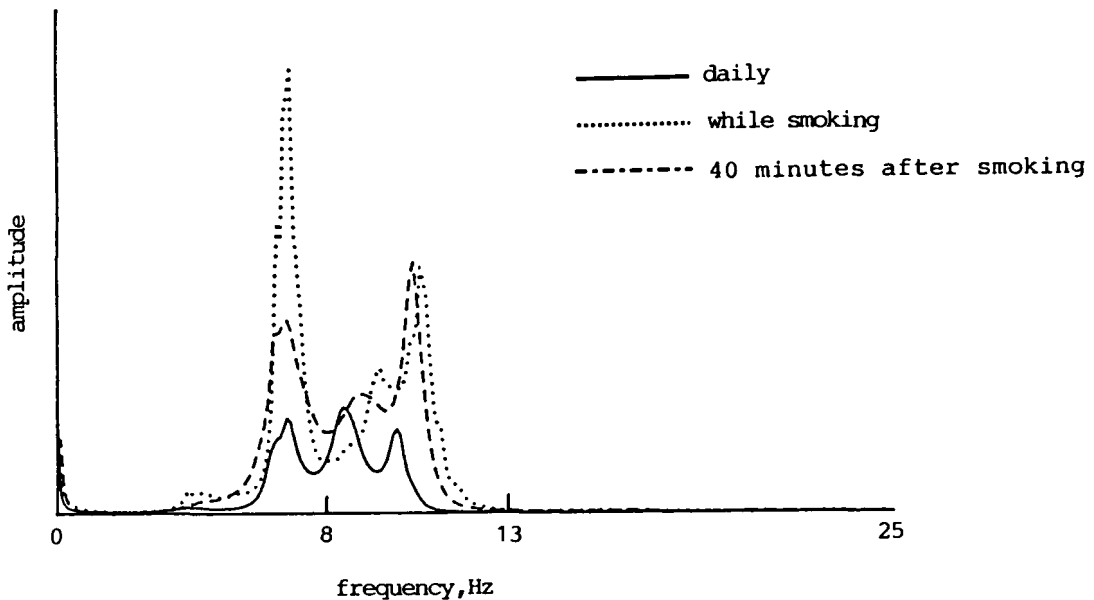


Fig.8 Smoking and MV.

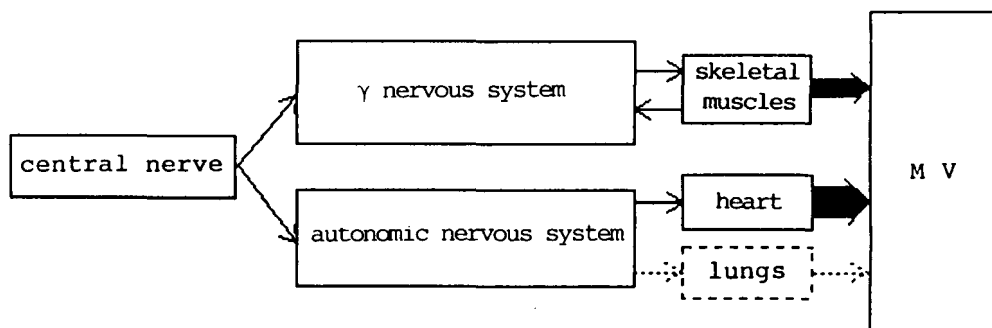


Fig.9 An occurrence model of MV.

Fig.9 illustrates the MV occurrence based on the hypothesis. The thicker is an arrow, the closer relates MV.

5. CONCLUSIONS

The summary of this study is as follows :

- (1) MV was measured before/after physical exercise and drinking. It was confirmed that MV was closely related to the functions of heart.
- (2) MV was measured before/after hand-gripping of muscle. It was confirmed that muscle activity was related to MV.
- (3) It became clear that MV was related to autonomic nervous system.

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