

# A New Definition of BMI Scale by Relationship between Respiration and Unconscious Behavior during Sleep with Body Motion Wave

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## ABSTRACT

*Recently, health problems due to overwork, apparent suicide produced by the progress of the social stress and lifestyle diseases and lifestyle diseases like hyperpiesia or obesity have been reported. From this, it has become of interest to avoid these problems and to keep the health. However, the indicators for health control and physical condition haven't been defined. Body Mass Index (BMI) has traditionally been used as an indicator of health. But, there are many unclear points left in the criteria of BMI to utilize. Sleep would be an important theme to know and to keep health. During sleep, the biological information related to health state would be appeared because of predominant activity of autonomic nervous system under the state of unconsciousness. From these, the authors investigated the relationship between BMI and autonomic nervous activity. Nineteen healthy young adults participated in this study and performed sleep experiment by adopting a pressure sensor named "dynamic air-pressure sensor" and a pressure sensor array. As a result, the authors found some relationships among respiration state, motions of muscles and unconscious behavior depending on BMI. This result about sleep behavior would suggest a new definition for BMI. For example, large value of BMI brings influences, maybe bad, to respiratory behavior during sleep.*

*Keywords: Autonomic Nervous Activity, Body Mass Index (BMI), Body Motion Wave (BMW), Breathing Pattern, Sleep, Sleeping Posture*

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## 1. INTRODUCTION

Recently, health problems due to overwork, apparent suicide or lifestyle diseases produced by the progress of the social stress have frequently been reported (Fiocco et al., 2013; Grimm et al., 2012). Then, keeping health is one of the significant themes. However, the control of the health and physical condition in the daily life is left to the individuals, and the standard of physical

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condition depends on the person to person or day to day. So, there are many unclear points in the quality of health control or physical condition. From this, a standard for health should be needed concretely.

Sleep would be one of the significant themes to study how to check health precisely to promote. Also it is one of the essential activities for life sustaining which accounts for about 1/4 to 1/3 in a day. Because of predominant activity of autonomic nervous system under unconscious state during sleep, it would be possible to precisely detect biological information related to health state (Akerstedt et al., 1997; Wagner et al., 2012). The activity of autonomic nervous system is necessary for sustaining life (Farmer et al., 2013; Hossam et al., 2013). Therefore, measurement of sleep state would produce a sign or index of health state. In this point of view, the polysomnogram has been traditionally adopted in order to detect biological information and promote the study for sleep. This method can obtain biological information in a comprehensive manner by using electroencephalograph (EEG), electrocardiograph (ECG), electromyography (EMG), and so on. However, it is not easy to use or measure health state in daily life continuously in long-term because only qualified staff in medical or research facilities can take such data (Sforza et al., 2004; Carneiro et al., 2012).

In these years, we have studied sleep in daily life by adopting a pressure sensor named “dynamic air-pressure sensor” and a pressure sensor array (Okawai et al., 2011). These sensors fabricate a non-restrained measurement system as described later, so that a subject can take natural sleep. Thus, the biological information such as rates of pulse and respiration were calculated from the pressure wave named “Body Motion Wave (BMW)” detected by using the above dynamic air-pressure sensor, and sleeping posture and body pressure distribution detected by the above pressure sensor array. In our previous study, we have found (i) periodicity of rates of pulse and respiration, (ii) some characteristics in the wave pattern of respiration and (iii) the effects of changing of sleeping posture on the rates of pulse and respiration (Okawai et al., 2010).

From these, we aimed to show the relevance of biological information and health indicator. In this study, we focused on Body Mass Index (BMI) as health indicator. BMI is defined by the relationship between height and weight only and easy to use, so has been used as one of the indexes for health state (Mohanty et al., 2011; Forshee et al., 2008) and suggested by World Health Organization (WHO). However, there are many unclear points left in the criteria of BMI to utilize. In addition, as biological information during sleep, we adopted respiration state and unconscious behavior. While pulse information have been discussed the association with activity of autonomic nervous system by the spectral analysis of the ECG (Myllymaki et al., 2011; Södervall et al., 2013; Hayano et al., 1991), respiratory information has not been studied in detail. And also, while it have been said that it have relationship with sleep problems like Sleep Apnea Syndrome (SAS) or Sudden Infant Death Syndrome (SIDS) (Dwyer et al., 2009; Joosten et al., 2014; Werner et al., 2010), unconscious behavior like sleeping posture have not been investigated in detail.

For this reason, at the present study, we investigated the relationship between BMI and sleep state, by adopting respiratory information or unconscious behavior detected by the above measurement system through the night as described in detail next.

## 2. METHOD

### 2.1. Measurement System

Two types of pressure sensor will be described here. At first, the dynamic air-pressure sensor (M.I.Labs) was adopted in order to detect information of physical motions during sleep. This

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