ECRONICON OPEN ACCESS

EC PULMONOLOGY AND RESPIRATORY MEDICINE

Research Article

Periodicity Detection of Menstrual Cycle through Body Motion Wave Reflecting Activities of Autonomic Nervous System

Jingbo He[1] and Hiroaki Okawai[2]*

[1]*Graduate School of Engineering, Iwate University, Japan*

[2]*School of Social Work, Seirei Christopher University, Japan*

***Corresponding Author:** Hiroaki Okawai, School of Social Work, Seirei Christopher University, Kita-Ku, Hamamatsu, Shizuoka, Japan.

Received: November 03, 2017; **Published:** November 27, 2017

Abstract

Autonomic nervous system (ANS) controls a lot of body functions such as pulse rate (PR), respiration rate (RR), digestion in unconscious processes and moreover menstrual cycle for young women. The purpose of the present study is to investigate the relationship between menstrual cycle and activities of ANS whereby females understand more of their physical condition. The PR and RR during sleep, for example, reflecting activities of ANS, have been known well to reveal body function accurately because they are one of the unconscious, i.e. honest, expression of state of health.

To obtain the data related to the above information during sleep, the body motion wave (BMW) method, carried out by using a dynamic air pressure sensor, was adopted to detect information of PR and RR during sleep over the course of night for five healthy female subjects (age 20 - 28 years). As a result, it was found that the transitions of PR during sleep were sensitive to show significant influence of the menstrual cycle reflecting the activation of estrogen and progesterone than basal body temperature (BBT) and, in addition, the magnitude of fluctuation of instantaneous PR reflected phase of menstrual cycle.

Thus, the transitions of PR during sleep obtained over the course of BMW had possibilities to check the menstrual cycle.

Keywords: *Sleep; Menstrual Cycle; Autonomic Nervous System; Pulse Rates; Body Motion Wave*

Abbreviations

ANS: Autonomic Nervous System; BMW: Body Motion Wave; BBT: Basal Body Temperature; PR: Pulse Rate; RR: Respiration Rate

Introduction

The menstrual cycle has been studied in many aspects both in the view of physiology and psychology. Basal body temperature (BBT) has been adopted among these studies to substitute for the health condition related to menstrual cycle. However, here arose a question of whether the BBT reveals the state of health well or not. Some studies, for example, showed the percentage of normal BBT in all normal subjects was even less than half [1,2]. In contrast, except for BBT, hormones concentration in plasma was also detected in some studies [3]. However, it is not easy to be applied in daily check.

To study a new method for detecting the menstrual cycle, we have paid attention to activities of the autonomic nervous system (ANS) that controls body condition through unconscious processes, e.g. pulse rate (PR), respiration rate (RR). As to ANS related to the menstrual cycle, Magdalena., *et al*. reported that the heart rate during the menstrual cycle showed a minimum in the early follicular phase and a maximum in the late luteal phase by analyzing heart rate variability (HRV) [4]. Massimiliano., *et al*. reported that the heart rate during sleep in the luteal phase was higher than that in mid-follicular phase [5]. Although these studies have proved that the ANS activities were related to the menstrual cycle, the specific transition is still not clear.

Therefore, the purpose of the current study was to investigate the transition of ANS activities throughout the menstrual cycle and to develop an accurate detection method for the cycle. Thus, the body motion wave (BMW)method carried out by using a pressure sensor named "dynamic air pressure sensor" was adopted to detect the PR, RR during sleep over the course of night, i.e., states of unconsciousness, since the detection method was available for a subject with non-restraint process in the daily life [6,7].

Methods

The measurement system for detecting activities of ANS was developed by Okawai., *et al* [6-11]. The measurement system was composed basically by a dynamic air pressure sensor (M.I.Lab), an A/D converter and a personal computer as shown in figure 1. The sensor was placed on a bed to detect dynamic air pressure arising between the sensor and a subject's body lying on a bed. The pressure signal detected by the sensor was converted to electric signal to be stored in a personal computer as a wave named "body motion wave (BMW)".

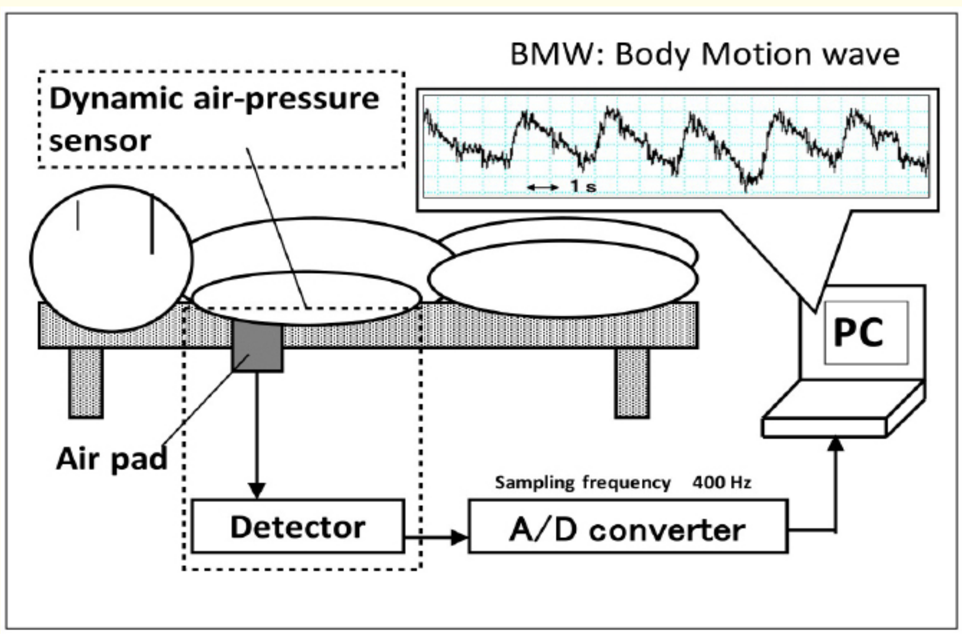


Figure 1: *Measurement system to detect body motion wave (BMW).*

The BMW data thus obtained was filtered into two waves: "respiration-origin BMW (R-BMW)" and "pulse-origin BMW (P-BMW)". Both waves were processed by programmable software VEE Pro 9.2 (Agilent Technologies) [6-11]. Basically, the peak-to-peak time, T (sec), of each R-BMW and P-BMW were converted by 60/T to reveal the number of times per minute, which were called instantaneous respiration rate and instantaneous pulse rate, and then the average number of times throughout one minute was calculated to get minute respiration rate (RR) and minute pulse rate (PR), respectively. Thus, the point is that no sensor was attached directly to a body, therefore, the measurement method can be employed at home and without the need for the involvement of medical professionals. The authors named such a method BMW method [6].

Experiment

Experiment by the BMW method was performed for 5 healthy women, A, B, C, D and E, of age 20 - 28 years old at their homes throughout more than 46 days. In addition, BBT was measured beneath the tongue with a sublingual thermometer available on the market. at waking before getting up every morning.

All of subjects received the examination for the research and confirmed as follows:

(i) The personal information was protected by dealing with a simple code or consecutive number and was deleted after checking data.

(ii) A subject spent her time as usual in the period for taking data, e.g. there was no restriction on food, drink, work, taking bath, exercise, interaction with friends, and not so frequent staying away from home.

(iii) A subject took data of BMW at her home every night and sent a USB memory stick to authorized author every two weeks.

(iv) A subject was able to know the processed data of her own, however, with confidentiality obligation because of research.

(v) A subject was able to decline being a subject at any time without saying the reason even though after getting started.

(vi) To compare the data thus obtained with information of behaviors of daily life, a subject was requested to write down the date of menstrual phase and her life activities, e.g. the bedtime, wake up time, extra daily event and taking liquor or medicine.

The conditions to select a subject were as follows:

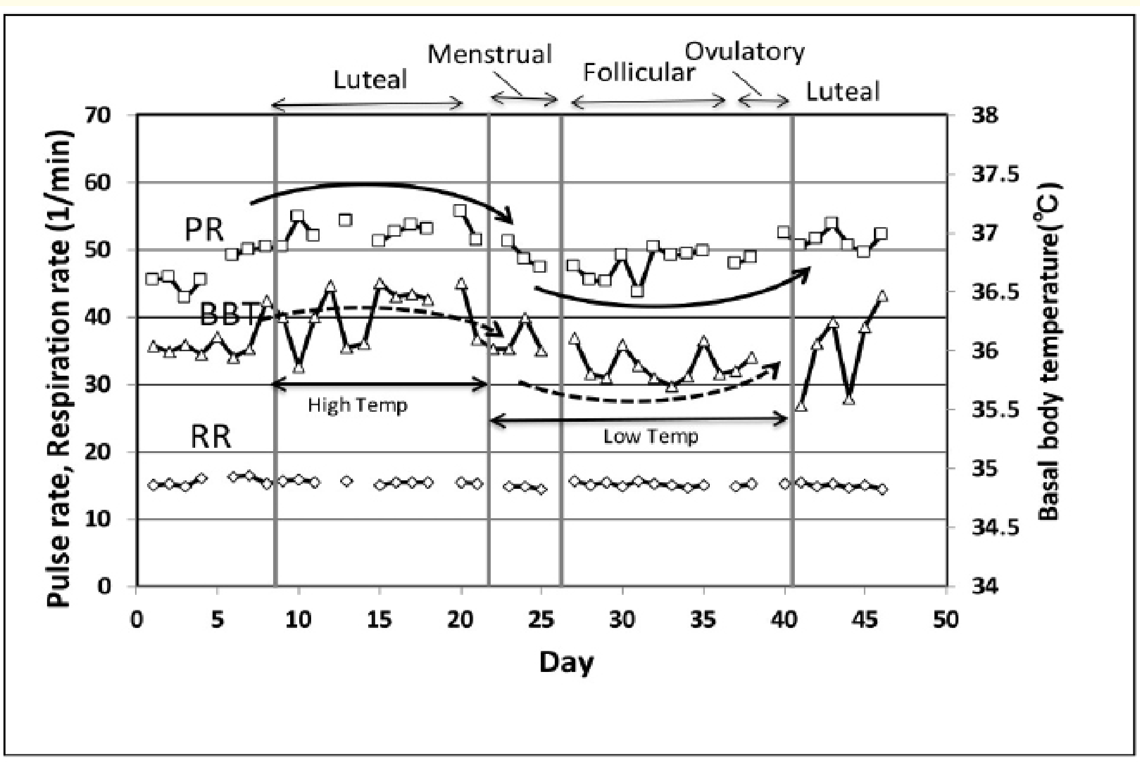
A subject (i) usually slept single in a room to avoid interference by dynamic signals occurred by others, (ii) usually kept time for bedding and getting up within two hours, (iii) did not usually take a nightcap and (iv) did not smoke absolutely.

Results

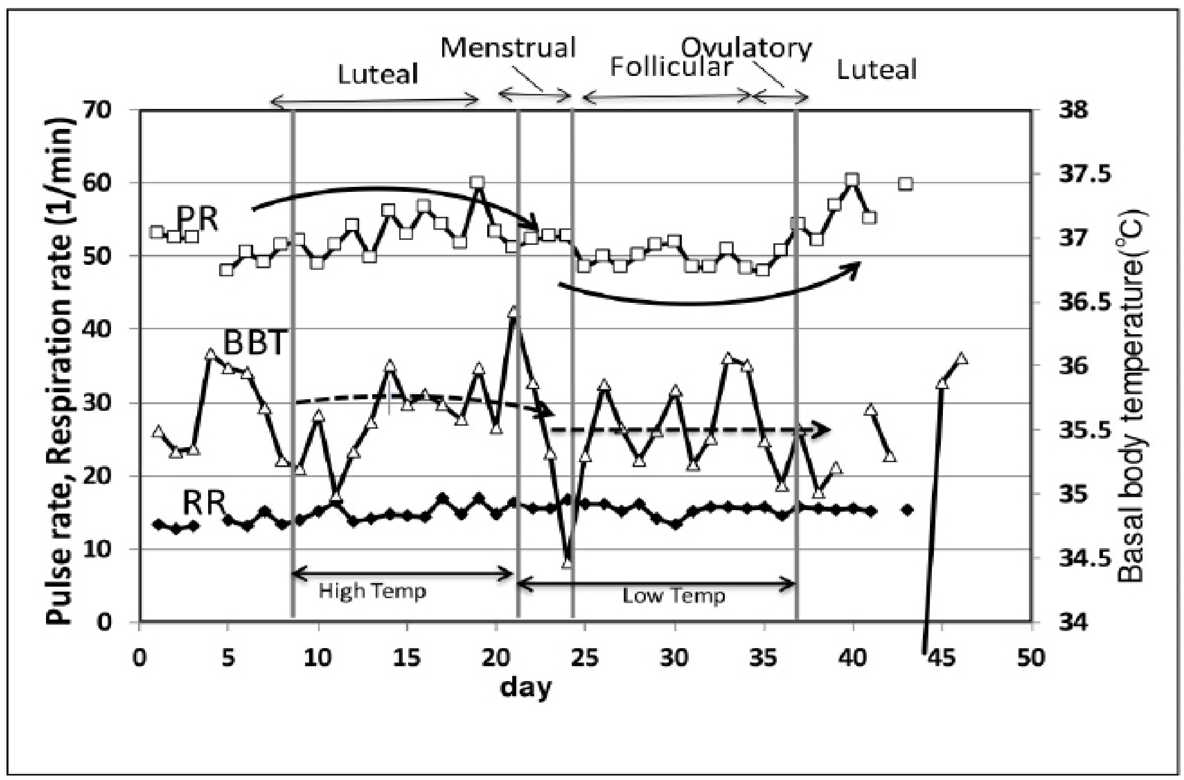
Transition of PR, RR, and BBT

Figure 2 shows the transitions of averages of minute PR and minute RR during each night, by left scale, and BBT for each morning, by right scale, throughout 46 days. Some lack points mean staying away home, making a mistake of booting a computer, attending extra party., *et al*.

As a result, it was found at first that the transition of BBT has a cycle having two phases, i.e., two periods of high and low level, as shown in figure 2 (a) in three of five subjects, however, such two phases did not occur clearly as shown in figure 2 (b), in two of five subjects.



(a) Example of which BBT showed two phases (Subject D).



(b) Example of which BBT did not show clear two phases (Subject C)

Figure 2: (a) and (b) Transitions of averages during each night of PR and RR, left scale, and of BBT, right scale, for two subjects throughout 46 days. PR: Pulse Rate; RR: Respiration Rate; BBT: Basal Body Temperature. The arrows express periods of the menstrual cycle though roughly.

In contrast, the transition throughout 46 days of simple average of PR of each night showed clear variation demonstrating two phases as shown in both figures (a) and (b), i.e. high PR during the high-temperature phase and low PR during the low-temperature phase. Such biphasic pattern of PR was recognized in all five subjects, whereas respiration rate decreased during menstrual phase in two subjects. Table 1 shows a summary of above findings.

Subject	A	B	C	D	E
Two phases in PR	Yes	Yes	Yes	Yes	Yes
Low RR during menstrual period	-	-	-	Yes	Yes
Two phase in BBT	Yes	-	-	Yes	Yes

Table 1: *Variation on PR, RR, and BBT throughout 46 days.*

As to PR behavior for a series of menstrual cycle, i.e., menstrual, follicular, ovulatory and luteal phases, PR average for each phase for five subjects were shown in figure 3.

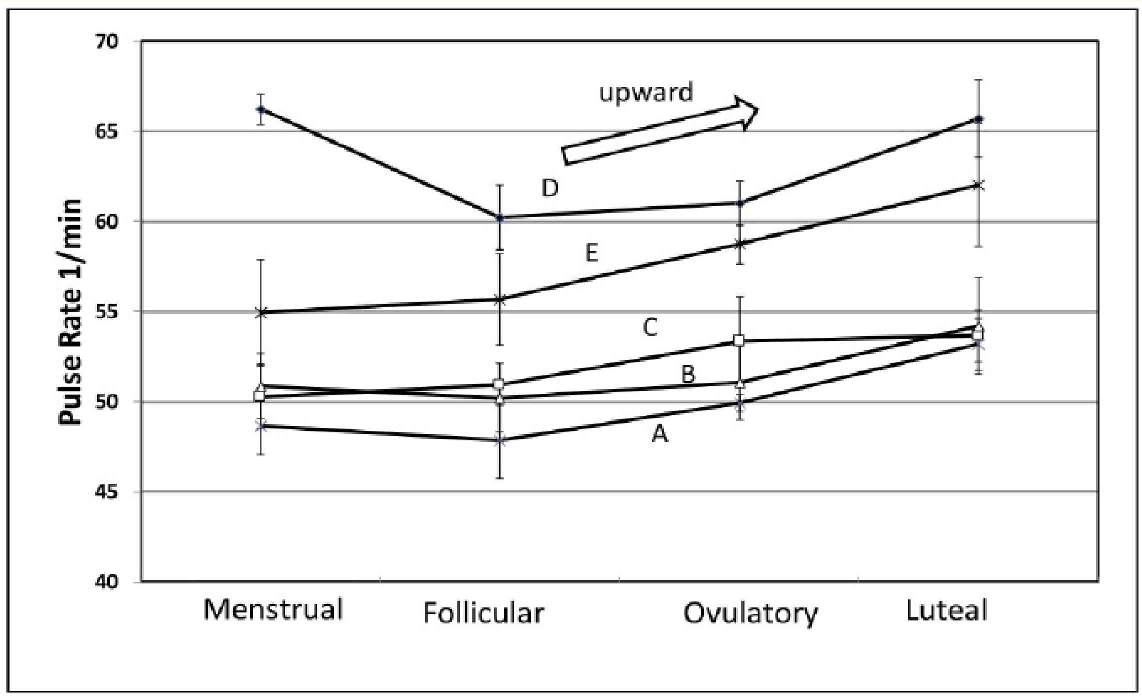


Figure 3: *Average of PR of 5 subjects in each phase of menstrual cycle (Mean ± SD).*

As a result, PR shifted upward from follicular phase to luteal phase for all of five subjects. In contrast, for the menstrual phase, PR showed different tendency among five subjects. PR for the subjects A, B and D showed larger values than those at follicular phase, whereas PR for the subjects C and E did less values.

Detailed transition of PR over the course of a typical one night

In the next, authors paid attention to the viewpoint of transitions of PR and RR over the course of a night depending on the menstrual cycle as well as the average of PR or RR during a night mentioned above. Figure 4 shows transitions of PR, i.e. minute PR, for each night of the follicular and luteal phases, respectively, for subject D. As a result, it was found that PR for follicular phase, the upper, had the range 48 - 60 and varied upward, whereas that for luteal phase had the range 48-70 and varied rather downward along a wave of increase and decrease.

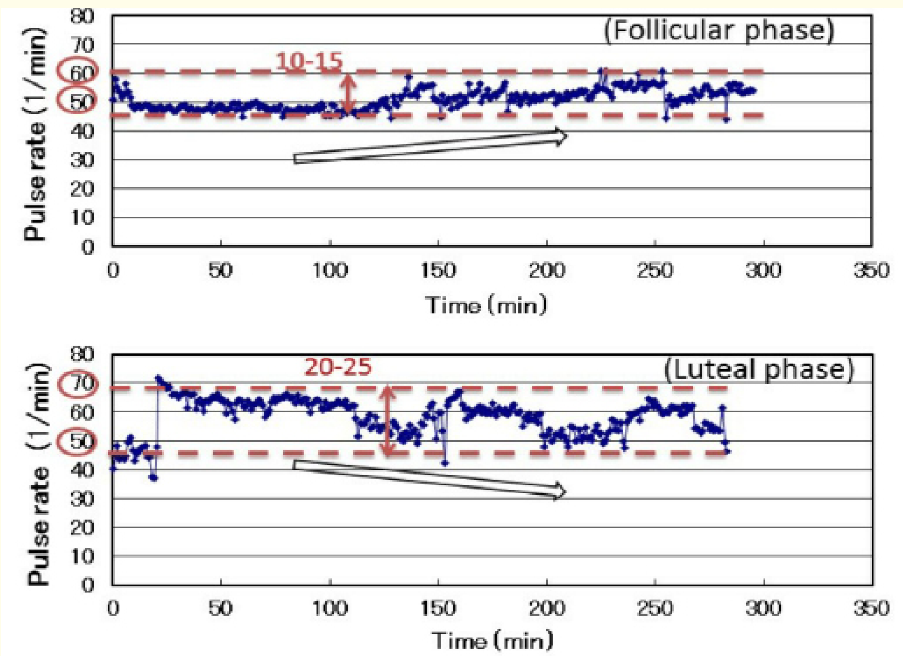


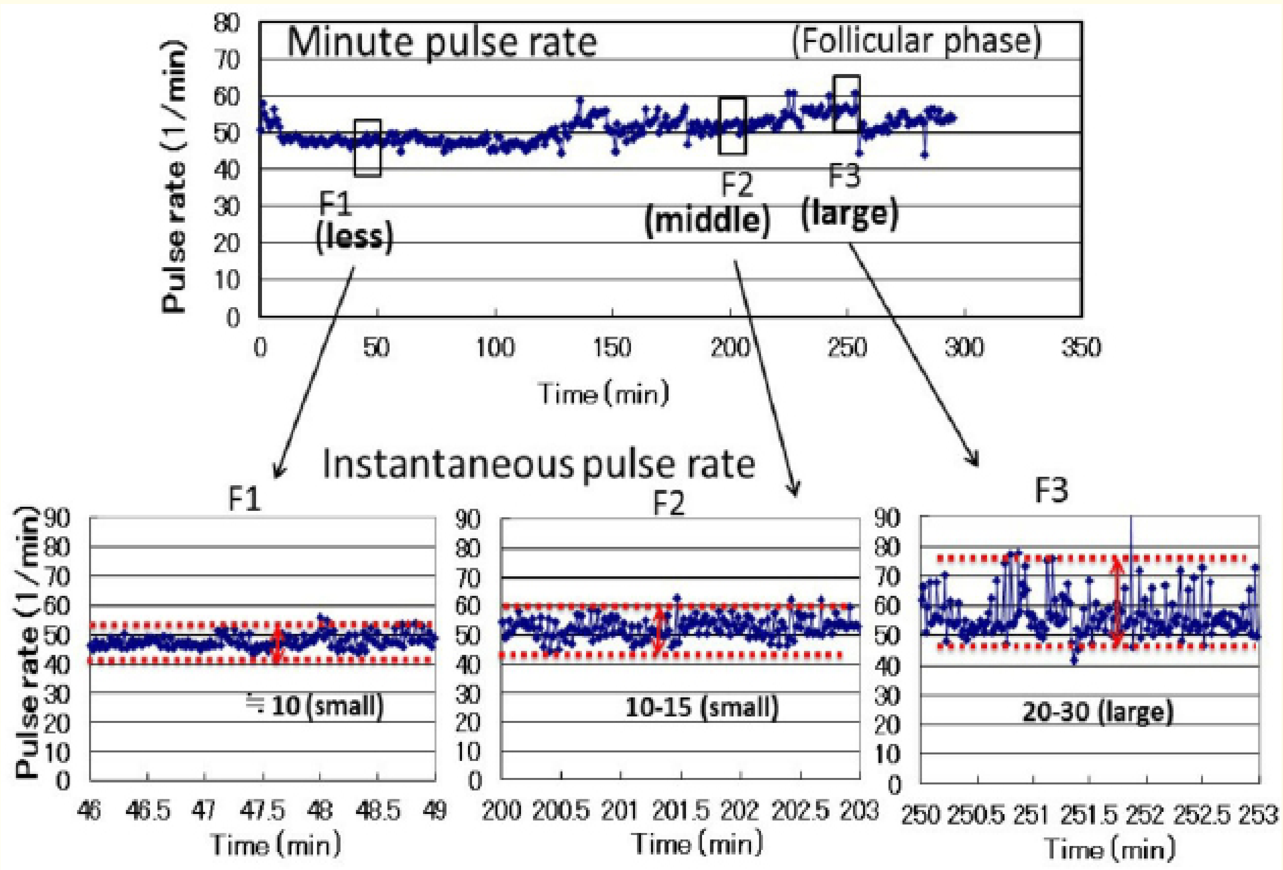
Figure 4: *Transition of minute PR for a subject in follicular phase, upper, and luteal phase, lower.*

Instantaneous PR in follicular phase and luteal phase

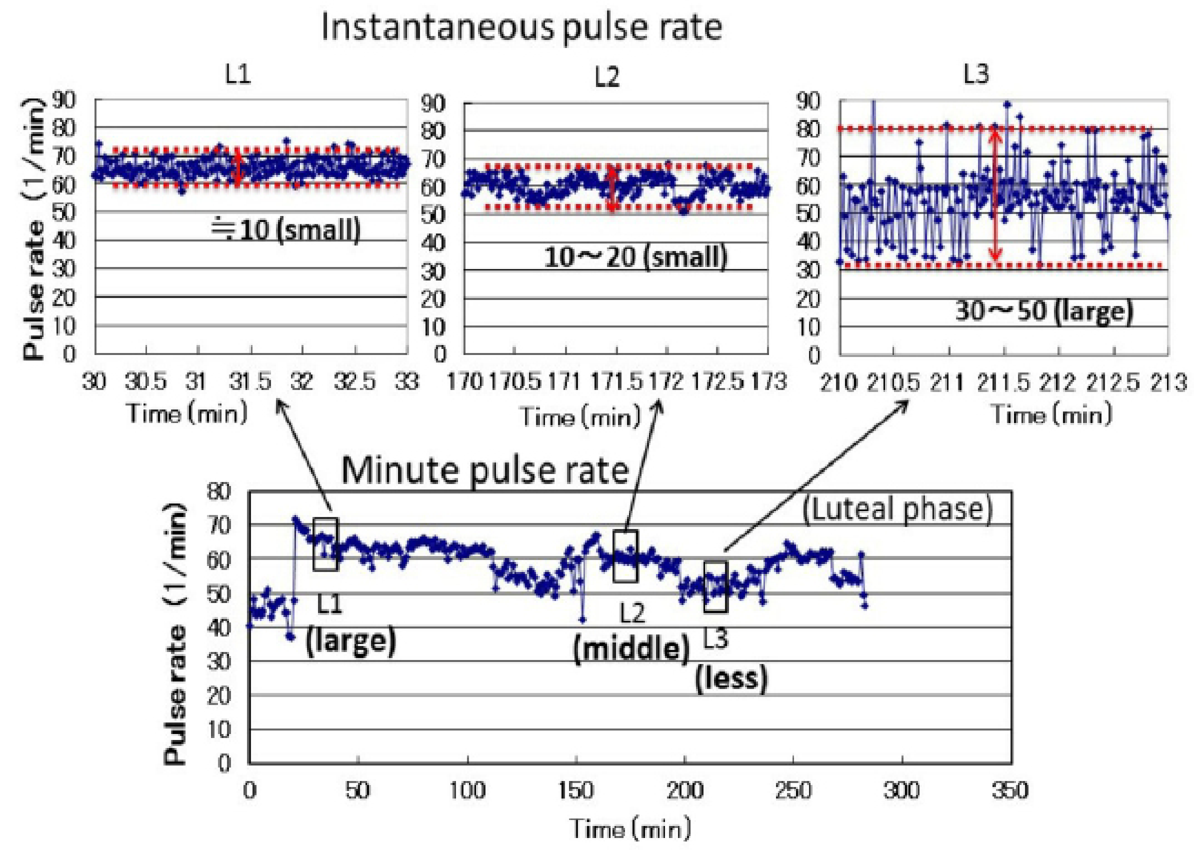
To study further of PR behavior, instantaneous PR was adopted to investigate. Figure 5(a) shows an example of the transition of PR in follicular phase. In the figure, the portions marked by F1, F2, and F3 were selected from the viewpoint of less, middle and large level to examine instantaneous PR as shown in the lower panels extracted from three portions. As a result, the magnitudes of fluctuations, viz., amplitude of instantaneous PR train, of the portions F1 and F2 were small within 5 - 10 and small within 10 - 15, respectively, whereas that of F3 was rather large up to 30.

In the next, PR behavior for the luteal phase was shown in figure 5(b). Portions of large level L1, middle level L2 and less level L3 were selected in the same way as above. As a result, the magnitudes of fluctuations of L1 and L2 were small within 5~10 and 10 - 20, whereas that of L3 was rather large up to 50.

Consequently, it was found that the magnitude of fluctuations occurred at F1 and F2 in follicular phase of minute PR of around 50 were rather small, however, that at L3 in luteal phase was lager even though their minute PR took almost same level. In contrast, that at F3 of minute PR of a little less than 60 showed larger, however, those at L1 and L2 of minute PR of 60 or more showed small level.



(a) Minute PR and portions of F1, F2 and F3 for the follicular phase.



(b) Minute PR and portions of L1, L2 and L3 for the luteal phase.

Figure 5: *(a) and (b) Transition of minute PR over the course of a night and instantaneous PR at typical portions of three levels for the follicular phase and the luteal phase.*

Discussion

At the present study, since the amount of measurement data is for only five subjects, the discussion maybe not enough. However, the detected data itself for each subject has a transition throughout more than two or three months and was checked, whereas data amount for the aroma and music referred later, obtained separately with the current study, at this section to discuss variation of PR depending on phase was sufficient. For this reason, the reliability at this discussion here will be acceptable.

It is known that BBT for the menstrual cycle shows biphasic variation of high and low temperature, however, such tendency did not always occur as shown in table 1, i.e. three of five subjects had biphasic variation and two did not. Whereas the transition of PR for all of five subjects showed biphasic variation. Since PR is also one of the expression of activities of ANS which is closely related in secretion of hormone [3], it is considered that, in PR, the decrease in the phase from luteal to follicular and the increase in the phase from follicular to luteal, were influenced by secretion of estrogen and progesterone, respectively.

Menstrual phase meets a fast decrease of progesterone, whereby the descending speed of PR occurs in different manner among five subjects as shown in figure 3. For some subjects, PR decreased from the early menstrual phase, and for other subjects, PR kept high value in the early menstrual phase, and then decreased from the middle menstrual phase.

Then, a question occurred, that BBT is accurate information or not. In fact, the data of BBT was not accurate to reveal menstrual cycle in two of five subjects in the current study. One of the possible reasons of such low degree of accuracy is only information of just before waking up, i.e., at a moment information. Whereas PR value a day is an average of data related to state of body condition over the course of a night.

As to the transition of PR for one night as shown in figure 4, the one during luteal phase in the lower panel is larger than the other in the upper panel because of normal menstrual cycle. Whereas it was reported that, at the other study for the viewpoint of relaxation by music, aroma or other services with the BMW method, the value of PR or both PR and RR produced some decrease concretely enough to demonstrate relaxation effect [6-11]. For this reason, also at the present study under the condition that either music or aroma was not used, it can be considered that the state of body condition in the follicular phase was relatively more relaxed.

In the next, as to instantaneous pulse rate, Okawai., *et al*. reported that minute PR or both minute PR and minute RR varied with increase and decrease against time during sleep under the control of ANS to sleep well. Thus occurred maximum and minimum in the transition of minute PR, and at these moments, heart produced large fluctuation, as shown in the instantaneous pulse rate train to turn from increase to decrease, and to turn from decrease to increase [8-11]. The range between maximum and minimum of PR was named to be Minute Optimum Pulse Rate Range for Sleep (moPR-S) [9-11].

Thus, PR at F3 turned from increase to decrease, whereas the one at L3 turned from decrease to increase by means of large fluctuation. In this respect, moPR-S of approximately 48-55 in the follicular phase as shown in figure 5(a) shifted up to approximately 55 - 65 in the luteal phase as shown in figure 5(b).

As to sleeping quality, since music and aroma made PR decrease by relaxation effect and made moPR-S shift downward [9-11], it can be considered that the sleeping quality and body condition in follicular phase is rather well than that of luteal phase even though a subject is not aware.

Conclusion

Pulse rate and respiration rate during sleep over the course of night were detected for more than 46 days to reveal menstrual cycle with the body motion wave(BMW) detected with a dynamic air pressure sensor.

Pulse rate train showed cyclically variation with menstrual cycle for five of five subjects, i.e. it decreased in follicular phase and increased in the luteal phase. In addition, the data of especially pulse rate in the follicular phase showed good sleep quality rather than in the luteal phase. Therefore, pulse rate will be expected to be an indicator and the present method will be one of the nonrestrictive ones to detect the menstrual cycle with higher precision.

Acknowledgements

Authors would like to acknowledge subjects for producing data for more than 46 days.

Bibliography

1. Elizabeth A Lenton., *et al*. "Problems in using basal body temperature recordings in an infertility clinic". *British Medical Journal* 1.6064 (1977): 803-805.

2. Joan E Bauman. "Basal Body Temperature, Unreliable Method of Ovulation Detection". *Fertility and Sterility* 36.6 (1981): 729-733.

3. Fumihisa Miyauchi., *et al*. "Effects of night shift on plasma concentrations of melatonin, LH, FSH, and prolactin, and menstrual irregularity". *Sangyo igaku. Japanese Journal of Industrial Health* 34.6 (1992): 545-550.

4. Magdalena Seebauer., *et al*. "Changes of respiratory sinus arrhythmia during the menstrual cycle depend on average heart rate". *European Journal of Applied Physiology* 87.4-5 (2002): 309-314.

5. Massimiliano de Zambotti., *et al*. "Autonomic regulation across phases of the menstrual cycle and sleep stages in women with premenstrual syndrome and healthy controls". *Psychoneuroendocrinology* 38.11 (2013): 2618-2627.

6. Okawai H., *et al*. "Detection of influence of stimuli or services on the physical condition and satisfaction with unconscious response reflecting activities of autonomic nervous system". 5th Kuala Lumpur International Conference on Biomedical Engineering (2011): 420-423.

7. Okawai H., *et al*. "Entrusting the reply of satisfaction or physical condition for services to unconscious responses reflecting activities of autonomic nervous system". 4th International Conference on Applied Human Factors and Ergonomics, AHFE, San Francisco (2012): 911-920.

8. Okawai H., *et al*. "Detection of Satisfaction for the Services by Body Motion Wave Revealing Unconscious Responses Reflecting Activities of Autonomic Nervous System". In: Ahram T, Karwowski W, Marek T (Eds.), Proceedings of the 5th International Conference on Applied Human Factors and Ergonomics AHFE, Krakow, Poland (2014): 4297-4286.

9. Okawai H and Takashima M. "Physiological Detection of Satisfaction for Services by Body Motion Wave Revealing Unconscious Responses Reflecting Activities of Autonomic Nervous Systems". In: Sawatani Y., Spohrer J., Kwan S., Takenaka T. (eds) Serviceology for Smart Service System (2017): 279-286.

10. Hiroaki Okawai. "Entrusting Communication of Mental and Physical Satisfaction and Health State to Autonomic Nervous System". Patrick Bernard Owens (Ed.), Autonomic Nervous System (ANS): Clinical Features, Functions and Disorders, Nova Science Publishers Inc., NY, USA, (2016): 121-156.

11. Hiroaki Okawai and Mitsuru Takashima. "Physiological Study on the Relaxation Effect of Bedding Materials to Sleep Quality by Body Motion Wave Reflecting Activities of Autonomic Nervous System". *EC Pulmonology and Respiratory Medicine* 4.2 (2017): 29-40.

Volume 5 Issue 6 November 2017