Chapter 11
Analysis of HRV during the Menstrual Cycle and Postmenopause

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ABSTRACT
Every woman experiences an extensive fluctuation in HRV during her menstrual cycle and even after menopause. A woman who lives long enough will experience menopause as a normal physiologic event. The study of the influence of premenopausal and postmenopausal symptoms on HRV has not been adequate. During this period, health management is an important factor to be considered as it affects the entire quality of women life. Many women having diverse physical, behavioural as well as psychological symptoms at the time of menopause and even after the menopause. Thus, HRV analysis is an appropriate tool to examine the physiological effects of the menstrual cycle in young healthy women and the postmenopause in old women. This chapter intends to study the influence of the menstrual cycle, and postmenopause on autonomic modulation of heart with a perspective of signal processing approach.

INTRODUCTION
The measure of fluctuation in the time interval between heart beats is termed as Heart Rate Variability (HRV). In other words, the regularity of heart beats is monitored by HRV: smaller regularity implies higher HRV and vice versa. Regularity of heart beats is measured from the time elapsed between the consecutive heart beats, i.e., RR intervals in millisecond (ms). The HRV signal is obtained from the Electrocardiogram (ECG) signal by taking time interval between consecutive R peaks of the ECG signal.

HRV analysis provides valuable information regarding the functions of the heart and autonomic control through sympathetic and parasympathetic regulation. Higher HRV indicates healthy Autonomic Nervous System (ANS) while lower HRV is associated with poor health and stress. Studying HRV variations gives valuable information regarding stress level, pain, other emotional disturbances, etc. of women throughout the menstrual cycle (Sato and Miyake, 2004) and after the menopause (Fu et al., 2008; Neves et al., 2007; Ribeiro et al., 2001). The influence and impact of biomedical signals on modern society is tremendous, and signal processing is now a critical component in science and technology. Recording and analyzing HRV signals is continued for several decades but still continue to excite physicians and engineers. Presently variety of tools available for HRV measurement (Acharya et al., 2006; Camm et al., 1996) and assessment but existing techniques are not considered to be accurate analysis method (Mansier et al., 1996; Litvack et al., 1995; Masek et al., 2009). So, decoding HRV variations using signal processing techniques during the menstrual cycle proves to be crucial in determining the health conditions of women and also necessary to decide course of action for treatment of diseases related regularity and irregularity of cycles. In order to gain a deeper insight into the functioning of heart, various physiological maneuvers such as physical activity or postural variation have been used. There is also a strong impact of physical activity on the HRV during the menstrual cycle and the postmenopause. This chapter intends to study the influence of the menstrual cycle, and post menopause on autonomic modulation of heart with a perspective of signal processing approach. For this purpose, it is necessary to evaluate the existing signal processing methods for quantifying the HRV variations during the menstrual cycle (premenopause) and after the menopause (postmenopause) in the lying postures.

The first phase of this chapter is dedicated to application of linear HRV analysis methods for detecting the HRV variations during the menstrual cycle phases in the lying postures. In time domain methods such as (nn50) number of pairs of adjacent NN intervals differing by more than 50ms), and (TINN) Triangular Interpolation of NN intervals are analyzed and implemented on preprocessed menstrual cycle HRV dataset of 74 young women in the menstrual, follicular and luteal phases. nn50 and TINN are used to examine the effects of the menstrual, follicular and luteal phases of the menstrual cycle.

In the second phase of this chapter, the linear time domain methods such as nn50, and TINN are applied on HRV dataset comprising 20 postmenopausal women in the lying postures. Further, a comparative study was made between 74 premenopausal women in the follicular phase of the menstrual cycle and 20 postmenopausal women.

BACKGROUND

Various studies have investigated the effects of menstrual cycle on HRV using linear methods of HRV. Mckinley et al. (2009), Sato et al. (1995), Saeki et al. (1997), Guasti et al. (1999), Yildirir et al. (2002) and Ghildiyal et al. (2011) reported that sympathetic activities were lower in the follicular phase in comparison with the luteal phase. The increase in LF/HF ratio in the luteal phase as compared to the follicular phase was also reported by Sheema et al. (2014). Baker et al. (2008) analyzed that parasympathetic activity was decreased in the late luteal phase of women with premenstrual symptoms as compared to the follicular phase. Ageing effects on HRV in the menstrual cycle was also demonstrated by Bindiya et al. (2011). Some studies such as Nakagawa et al. (2006) and Vishrutha et al. (2012) reported that time domain methods were not able to differentiate the HRV variations between different phases of the menstrual cycle.