Interrelationships of hemodynamics and activity rhythms

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Abstract

In determining the time structure (circadian rhythm) of blood pressure (BP), heart rate (HR), and activity (ZCM) and how they are related, 20 healthy subjects were examined. BP/HR were measured every 30 minutes and activity was measured every minute, all for 6 to 7 days. Activity was later averaged over consecutive 30-minute intervals to match BP/HR data. Auto- and cross-correlation functions and least squares spectra were computed. A statistically significant circadian rhythm was invariably demonstrated. Phase-weighted averages obtained by the population-mean cosinor also detected both the 24- and 12-hour components (P<0.001). Whereas no difference in 24- or 12-hour acrophase was found between ZCM and systolic (S) BP, both components differ drastically in terms of their amplitude, which is much larger for ZCM than for SBP (P<0.001). On the average, in this sample of clinically healthy students, the circadian variation of SBP and ZCM showed great similarity and no phase difference between the two variables. Although activity is known to influence BP, it is not the determinant of the circadian rhythm in BP.

Introduction

The circadian rhythm in BP was long thought to be a direct response to activity. Circadian rhythms are known today to be partly endogenous. [1]

Studies of BP measured during continued bedrest show persistence of the circadian rhythm, albeit with a smaller amplitude [2].

During normal, quiet daily activities, an inverse relationship is usually observed between BP and HR, reflecting the short-term role of the baroreceptors. When BP rises, HR falls. These fluctuations in HR reflect changes in the sympathetic and parasympathetic outflow from the medullary cardiovascular centers, in response to the degree of baroreceptors stretch [3].

On the circadian scale, BP and HR are lower during rest and higher during the active part of the day.

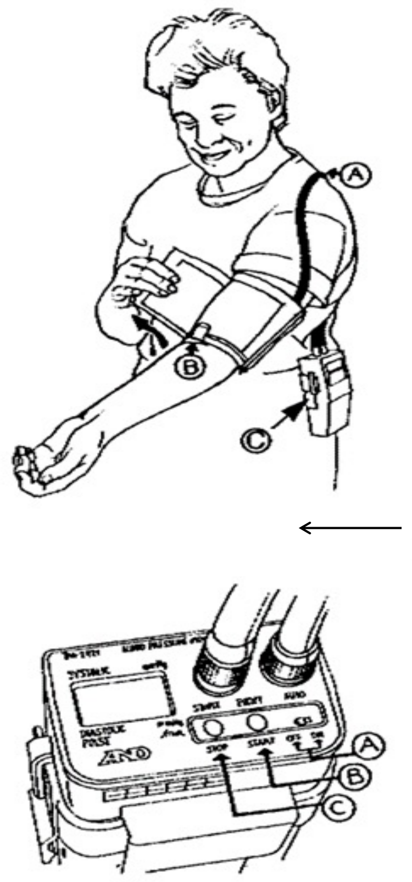


Figure 1: BP Monitoring.

Figure 2: Blood Pressure Cuff

Figure 3: Activity Watch

Materials and Methods

- 20 healthy subjects (mostly young adults).
- Locomotor activity determined by automated records of ZCM (zero crossing mode) and HPIM (proportional integral mode) of wrist actigraphy.
- BP/HR: measured every 30-minutes for 6 or 7 days (TM-2430 from A&D, Tokyo, Japan).
- Activity: measured every minute for 6 to 7 days (MicroMotion Logger, AMI, Ardsley, NY).
- Activity averaged over consecutive 30-minute intervals to match BP/HR data.
- Auto- and cross-correlation functions and least squares spectra computed for each subject and averaged across subjects, the latter by population-mean cosinor [4, 5].

Results

A statistically significant circadian rhythm was invariably demonstrated. Average phase-unweighted spectra indicate the prominence of the circadian rhythm and its second harmonic term with a period of 12 hours contributing to defining the circadian waveform of ZCM and SBP (charts 1-4).

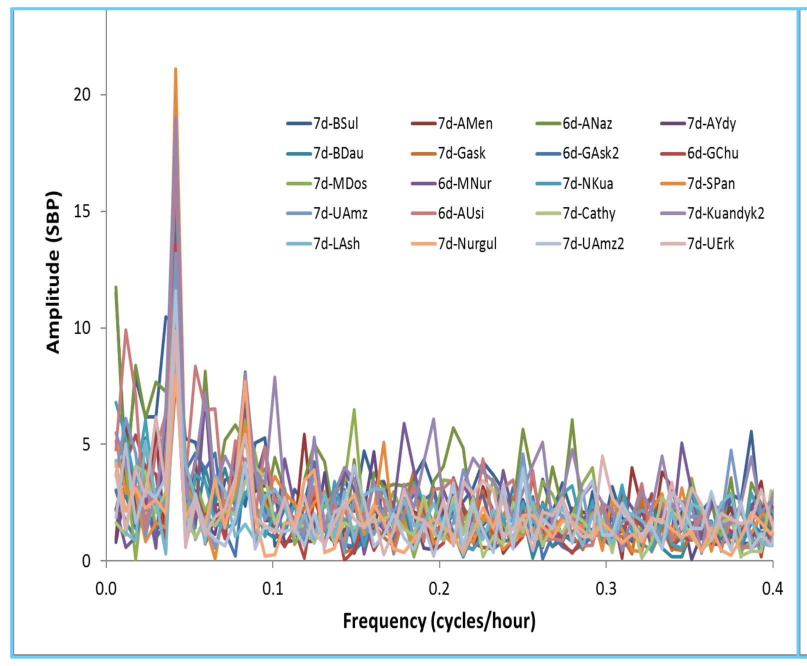


Chart 1: Spectra of SBP of 20 subjects

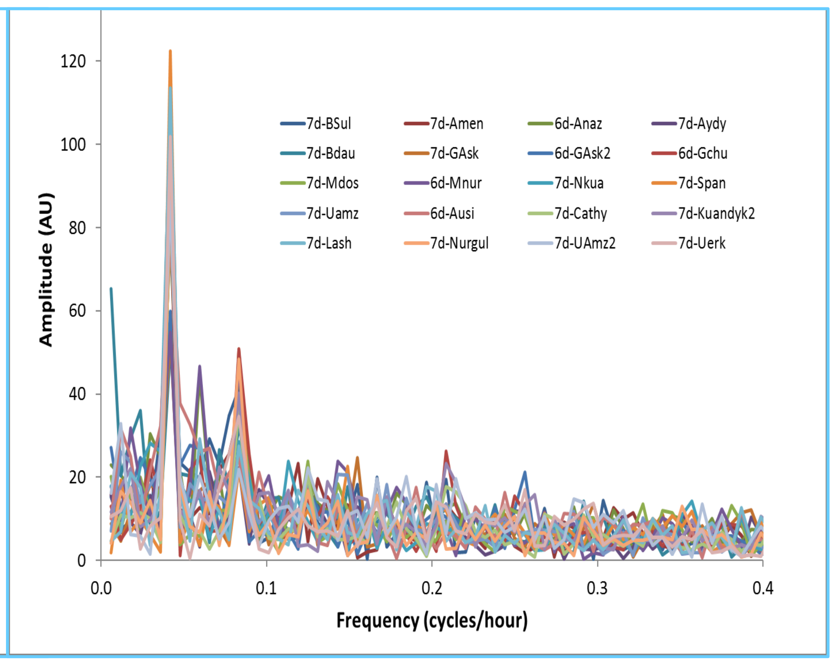
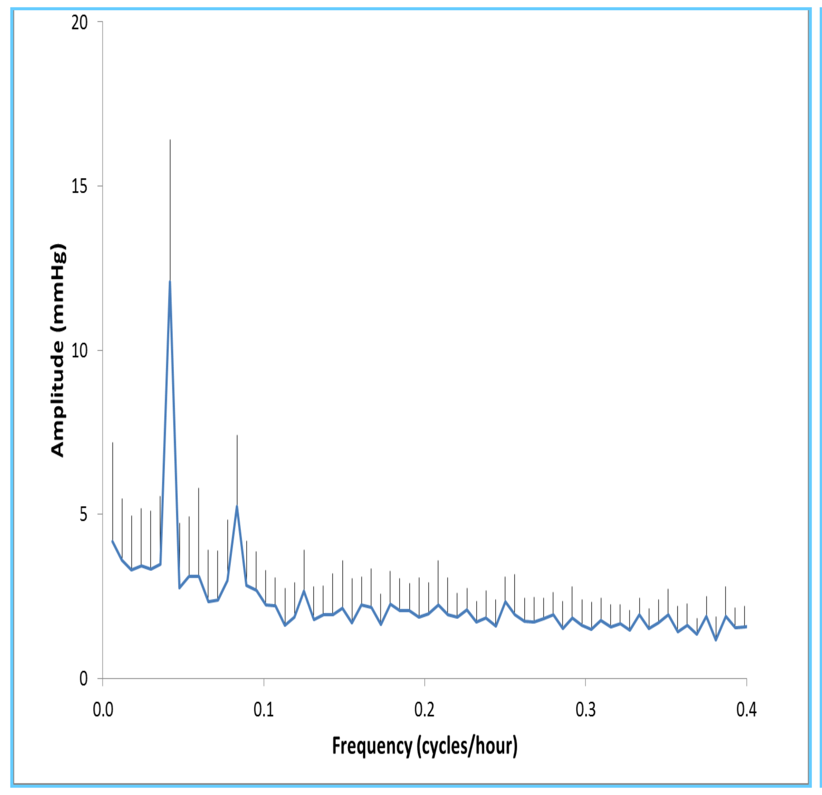
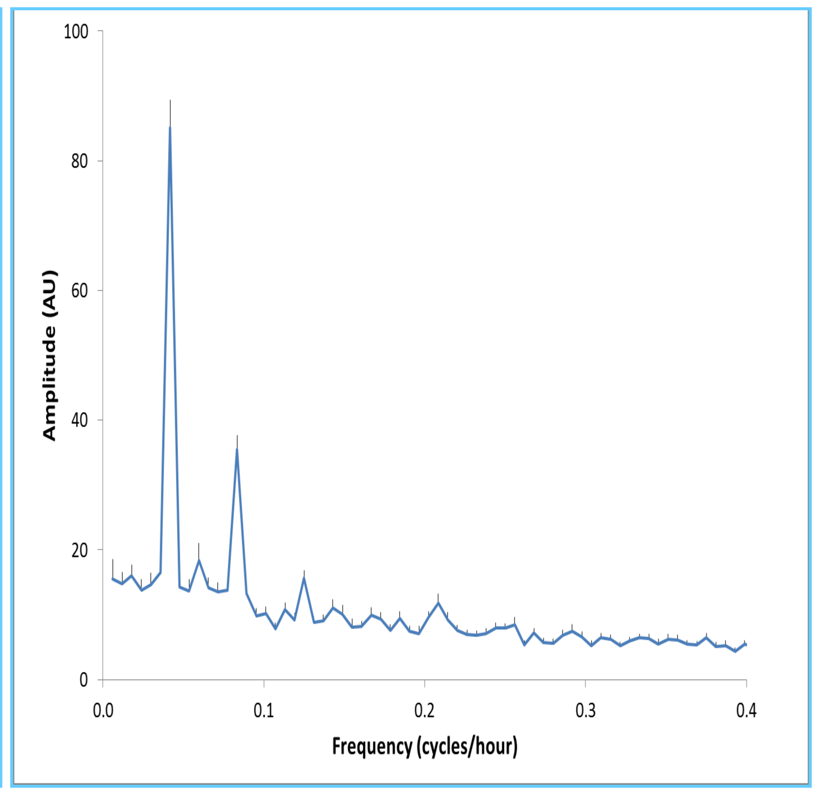


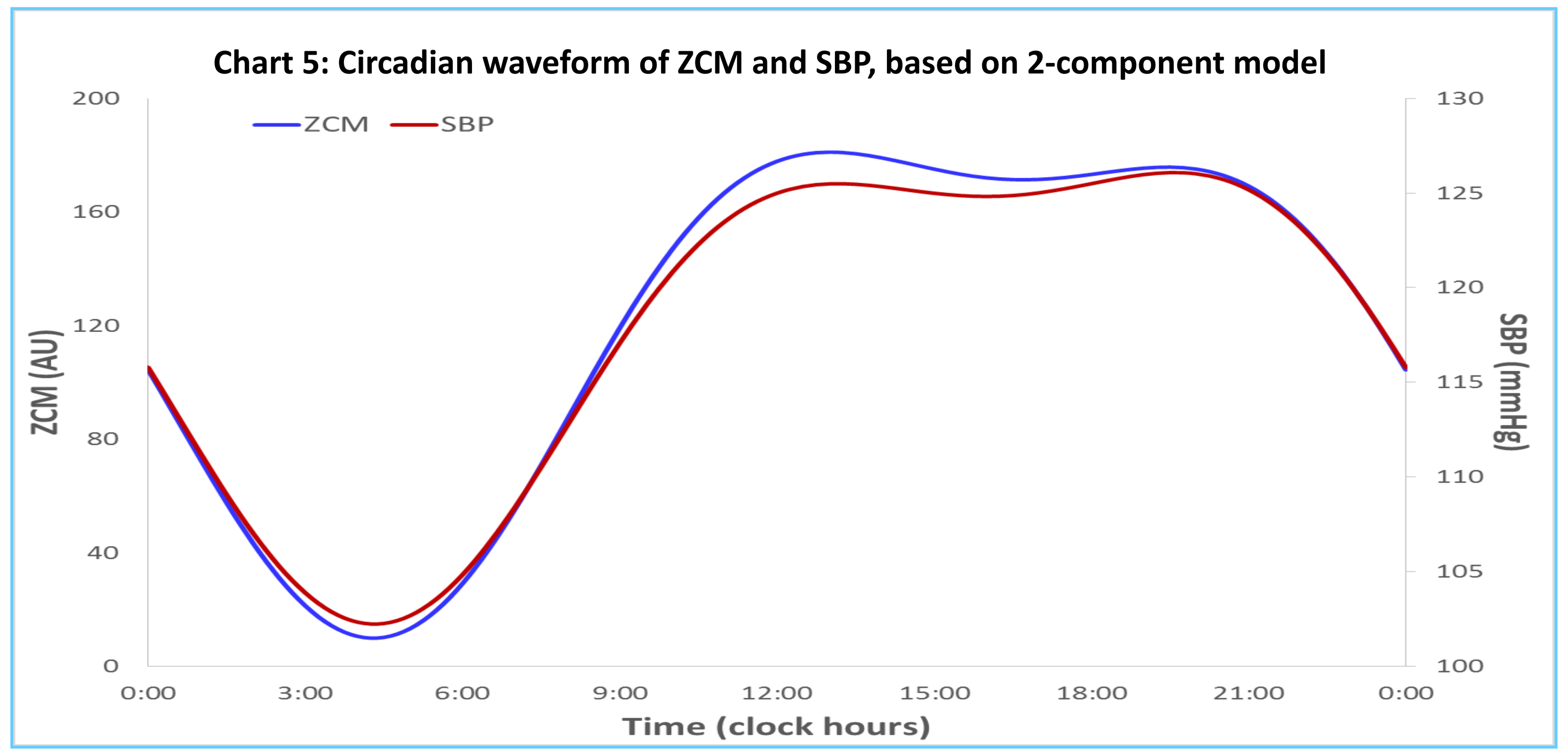
Chart 2: Spectra of ZCM of 20 subjects

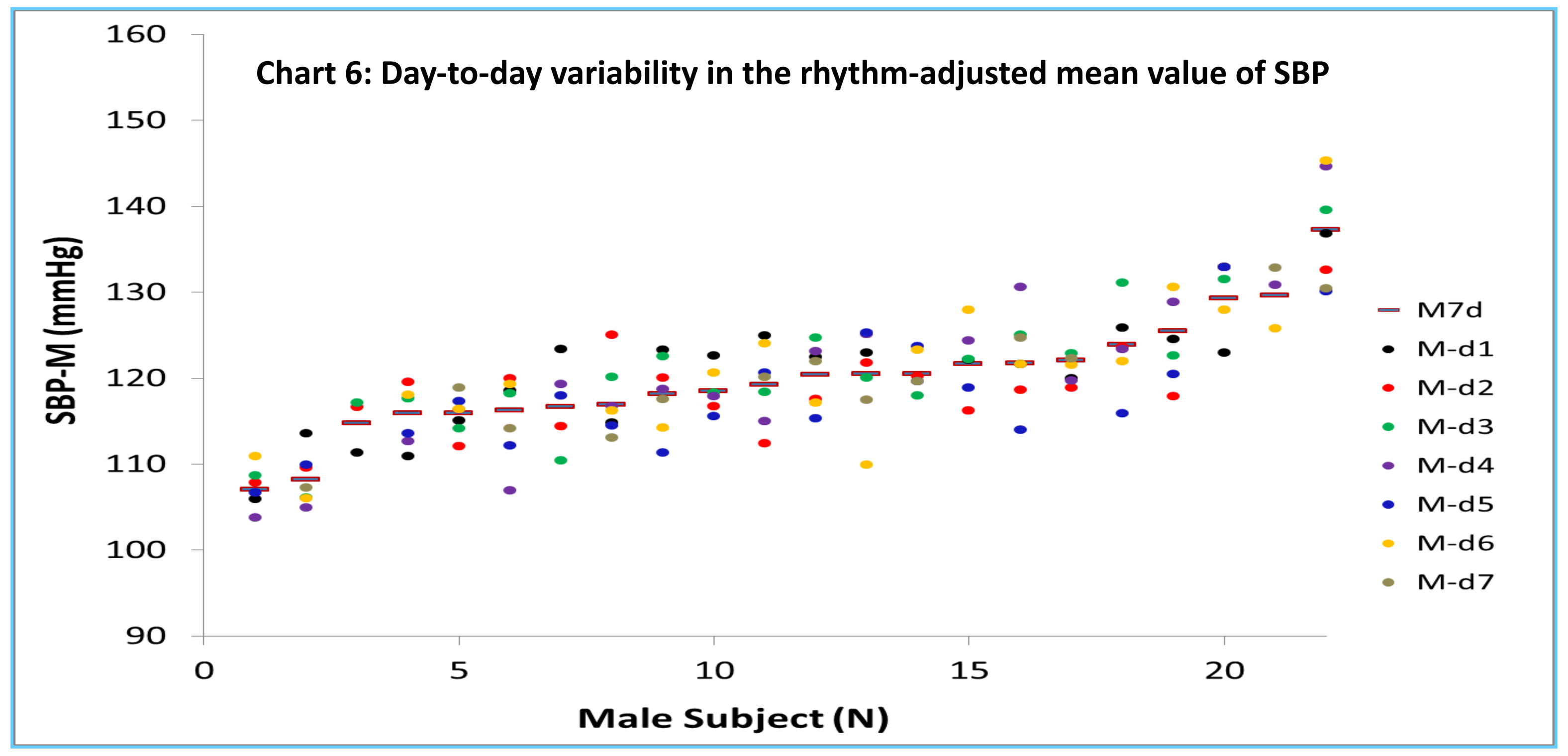




Charts 3 and 4: Average Least Squares Spectra of SBP (left) and ZCM (right).

BP, HR, and ZCM are all characterized by a prominent circadian variation. Their waveform differs from a cosine curve, as evidenced by the harmonic content. Phase-weighted averages obtained by the population-mean cosinor also detect both the 24- and 12-hour components (P<0.001). Whereas no difference in 24- or 12-hour acrophase is found between ZCM and SBP, both components differ drastically in terms of their amplitude, which is much larger for ZCM than for SBP (P<0.001). Based on the average spectral results, the circadian waveform of SBP and ZCM was reconstructed by modeling, chart 5, indicating great similarity between the two variables.





Discussion and Conclusion

As in other studies (chart6), our data also show large day-to-day variability in the circadian variation of BP and HR within the same record [6].

On the average, in this sample of clinically healthy students, the circadian variation of SBP and ZCM showed great similarity and no phase difference between the two variables.

Earlier work documented the persistence of a circadian rhythm in BP under conditions of bedrest [2]. BP was also shown to start increasing around mid-sleep, followed by a faster and larger increase upon awakening [7].

Although activity is known to influence BP, it is not the determinant of the circadian rhythm in BP.

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