

THE RELATIONSHIP BETWEEN CIRCADIAN BLOOD PRESSURE VARIATION AND AGE ANALYSED FROM 7-DAY MONITORING

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Abstract

The relationship between age and circadian blood pressure (BP) variation was the aim of the present study. One hundred and eighty-seven subjects (130 males, 57 females), 20-77 years old, were recruited for seven-day BP monitoring. Colin medical instruments (Komaki, Japan) were used for ambulatory BP monitoring (oscillation method, 30-minute interval between measurements). A sinusoidal curve was fitted (minimum square method) and the mean value and amplitude of the curve (double amplitude corresponds to the night-day difference) were evaluated on every day of monitoring. The average 7-day values of the mean (M) and of double amplitude (2A) for systolic BP (SBP), diastolic BP (DBP), and heart rate (HR) were determined in each subject. The mean values of M (\pm SD) for the whole group were: SBP- 127 \pm 8, DBP - 79 \pm 6 mmHg, HR - 70 \pm 6 bpm; of 2A: SBP - 21 \pm 7, DBP - 15 \pm 5 mmHg, HR - 15 \pm 6 bpm. A linear relationship between M of SBP and age ($r=0.341$, $p<0.001$) and DBP and age ($r=0.384$, $p<0.001$) was found (difference between 20 and 77 years: SBP - 16, DBP - 12 mmHg). 2A of SBP and DBP was increasing with age up to 35 years, then the curve remained relatively flat up to 55 years (maximum at 45 years), and then it decreased again (difference between 45 and 77 years: SBP - 13mmHg, DBP - 12 mmHg). Heart rate M and 2A were age-independent. The mean values of SBP and DBP were increasing with age up to 75 years, but the night-day difference of SBP and DBP reached its maximum value at 45 years and then decreased.

Key words

Circadian blood pressure, 7-day blood pressure monitoring, Blood pressure and age

INTRODUCTION

Franz Halberg, Germaine Cornélissen, and BIOCOS scientific group provided strong evidence for the need to account for day-to-day changes in blood pressure and heart rate variables in the similar way as a circadian assessment considers the hour-to-hour variability (1-5). The evidence led to the recommendation of

around-the-clock monitoring for 7 days at the outset (6, 7), to be continued whenever needed, until monitoring for a lifetime becomes more readily feasible.

By 1988, major findings had been summarized in a volume of annotated illustrations (8). Methodology had developed concomitantly under Halberg chronobiology center leadership in Minnesota University. In particular, the “sphygmochron” (9) was introduced.

The sphygmochron is a computer summary of results from chronobiological analyses performed on BP and HR data collected around the clock by ambulatory monitoring. Two approaches are possible, one parametric (model-dependent), the other non-parametric (model-independent). The parametric approach entails the least-squares fit of a two-component model consisting of cosine curves with periods of 24 and 12 hours. Estimates are obtained for the MESOR (midline-estimating statistic of rhythm), a rhythm-adjusted mean, and for the amplitude and (acro)phase of each component, measures of (half) the extent of predictable change within a cycle, and of the timing of overall high values recurring in each cycle, respectively.

The relationship between age and circadian blood pressure (BP) variation was the aim of the present study.

METHODS

One hundred and eighty-seven subjects (130 males, 57 females), twenty years to seventy-seven years old, were recruited for seven-day BP monitoring. Colin medical instruments (Komaki, Japan) were used for ambulatory BP monitoring (oscillation method, 30-minute interval between measurements). A sinusoidal curve was fitted (minimum square method) and the mean value and amplitude of the curve (double amplitude corresponds to the night-day difference) were evaluated every day of monitoring. Average 7-day values of the mean (M) and of double amplitude (2A) for systolic BP (SBP), diastolic BP (DBP), and heart rate (HR) were determined for each subject.

RESULTS

Mean values of MESOR (\pm SD) for the whole group of healthy people were: SBP- 127 ± 8 mmHg, DBP - 79 ± 6 mmHg, HR - 70 ± 6 bpm (Figs. 1, 2). Mean values of double circadian amplitude were: SBP - 21 ± 7 mmHg, DBP - 15 ± 5 mmHg, HR - 15 ± 6 bpm. A linear relationship between MESOR of SBP and age ($r=0.341$, $p<0.001$) and DBP and age ($r=0.384$, $p<0.001$) was found (difference between the age of twenty years and seventy-seven years: SBP - 16, DBP-12 mmHg). Double circadian amplitude of SBP and DBP was increasing with age up to 35 years, then the curve remained relatively flat up to 55 years (maximum at 45 years), and then decreased again (difference between 45 and 77 years: SBP- 13 mmHg, DBP-12 mmHg); the results are shown in Figs. 4, 5. Heart rate MESOR and double circadian amplitude were age-independent (Figs. 3, 6).

Mean values of SBP and DBP were increasing with age up to 75 years, but night-day difference of SBP and DBP reached the maximum value at 45 years and then decreased.

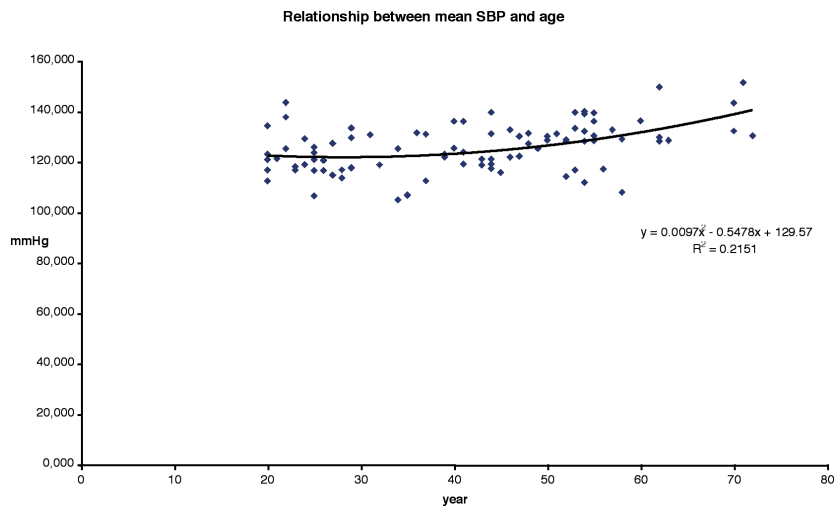


Fig. 1

Relationship between MESOR of systolic blood pressure (SBP, mmHg), measured by 7-day ambulatory blood pressure monitoring, and age (years) of the subjects

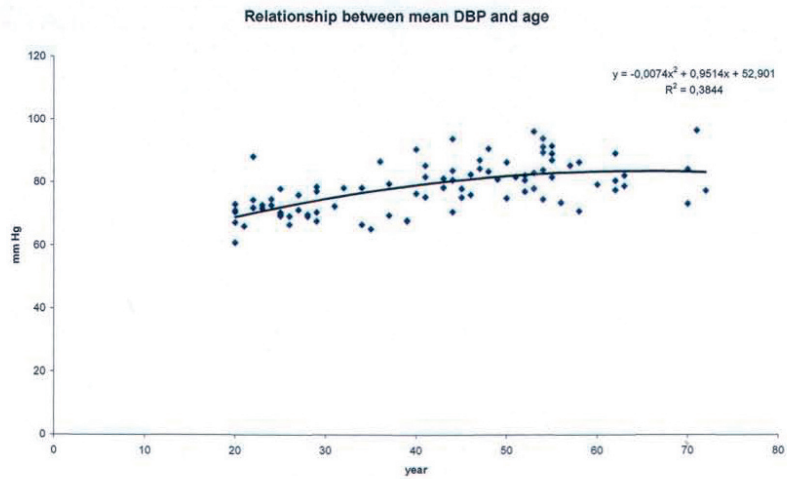


Fig. 2

Relationship between MESOR of diastolic blood pressure (DBP, mmHg), measured by 7-day ambulatory blood pressure monitoring, and age (years) of the subjects

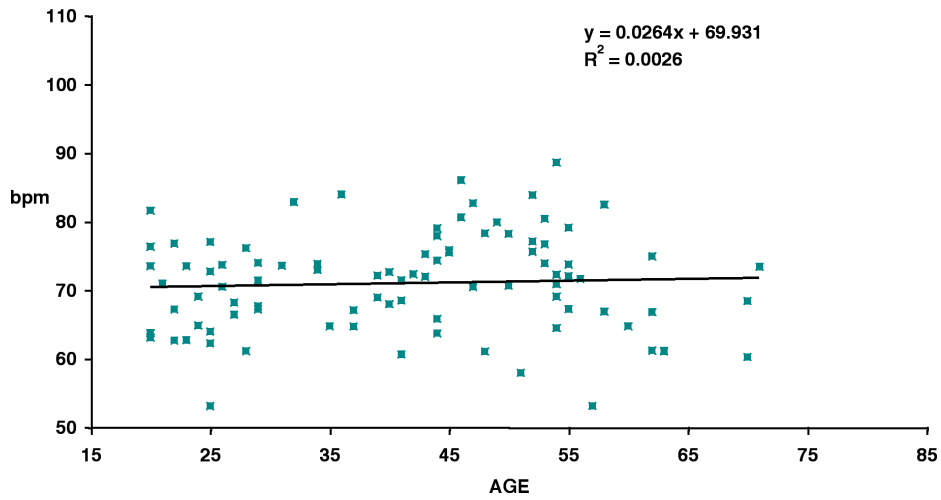


Fig. 3

Relationship between MESOR of heart rate (HR, bpm), measured by 7-day ambulatory blood pressure monitoring, and age (years) of the subjects

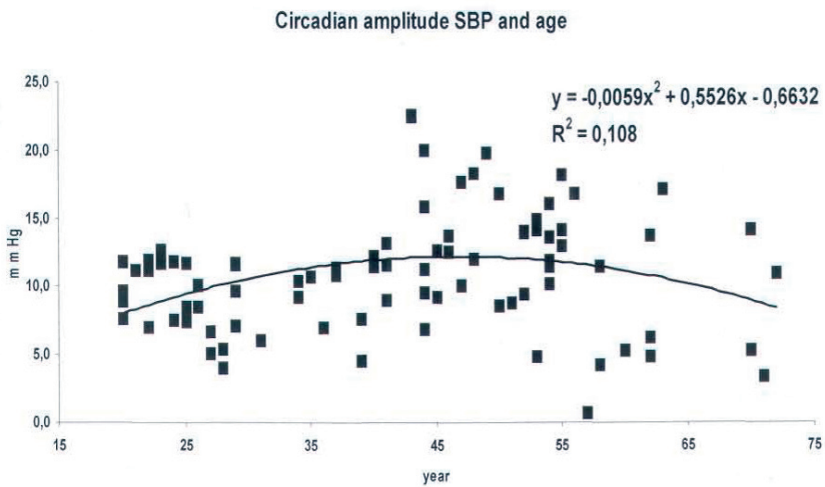


Fig. 4

Relationship between circadian amplitude of systolic blood pressure (SBP, mmHg), measured by 7-day ambulatory blood pressure monitoring, and age (years) of the subjects

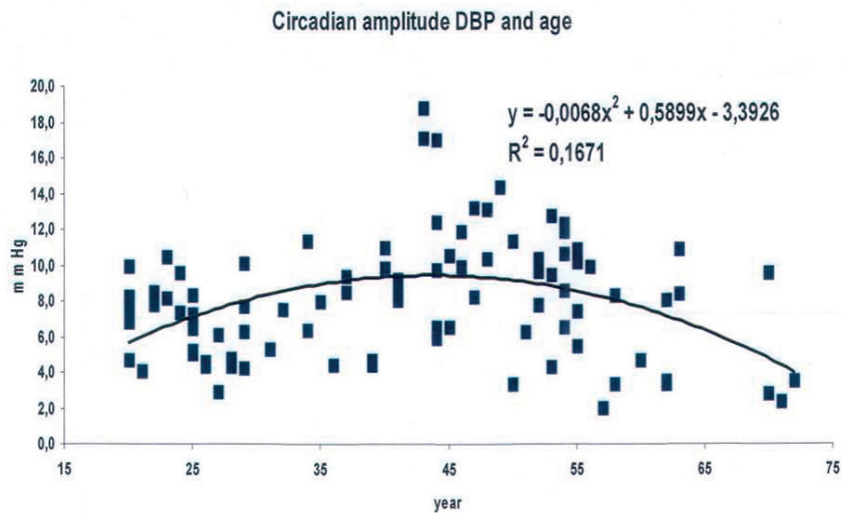


Fig. 5

Relationship between circadian amplitude of diastolic blood pressure (DBP, mmHg), measured by 7-day ambulatory blood pressure monitoring, and age (years) of the subjects

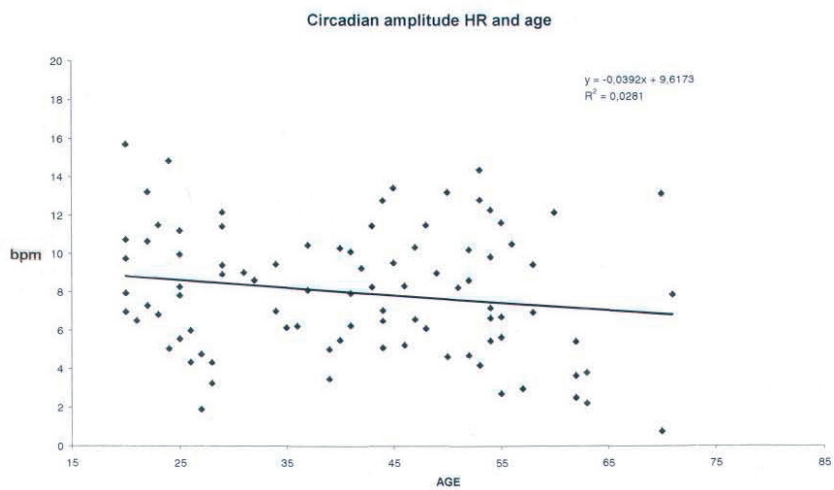


Fig. 6

Relationship between circadian amplitude of heart rate (bpm, HR), measured by 7-day ambulatory blood pressure monitoring, and age (years) of the subjects

DISCUSSION

There is a growing body of evidence suggesting that time structures in us and around us are intricately interwoven. Most if not all components of variation found in biota are also found in the environment, and vice versa (10). For instance, about-daily changes are seen in almost every biological variable under 24-hour synchronized conditions. It has also long been known that the phase of circadian rhythms can be manipulated by changing the phase of the environmental cycles (11). At least for the case of circadian rhythms, their genetic inheritance has been demonstrated on a molecular basis (12, 13), suggesting that the influence from the environment has been acquired genetically during the course of evolution.

The mapping of chromosomes should benefit our understanding of human health and disease in several ways. The study of human chromosomes can serve the derivation of refined reference values to better define health and to identify pre-disease, so that prophylactic interventions can be instituted as early as possible, preferably before disease sets in (14-16). The focus is thus put on prehabilitation, in the hope that the need for rehabilitation will thereby be reduced (17, 18, 19).

Several studies (20, 21) comparing the classification of patients based on single office measurements with that based on ambulatory monitoring for one to seven days suggest that the incidence of misdiagnosis is around 40 %, in keeping with the 48% response to placebo in the Australian Therapeutic Trial (22, 23). A comparison of circadian characteristics from day to day in records spanning at least two days further indicates the shortcomings of monitoring limited to a single 24-hour span (24, 25, 26). Prolonging the monitoring from one to two days reduces the uncertainty in the estimation of circadian parameters by about 35 % (27), whereas further information on the biological week (28-31) requires monitoring for at least 7 days, the current recommendation of BIOCOS for everybody at the outset (32). It is now widely accepted that prognosis of target organ damage is by far superior when it is based on around-the-clock monitoring than on single office measurements (33, 34, 35).

The mistaken impression that the circadian variation in blood pressure and heart rate is sufficiently stable to be approximated by a single 24-hour profile stems in large part from the use of statistical methods on groups of subjects rather than focusing on the individual patient. Correlation analyses applied to large groups of subjects with a wide range of average values emphasize similarity. Statistical analyses focusing on individual differences observed from one profile to another, however, yield information more likely to help the patient in need of treatment (24). Several case reports document this point (16, 36-39). Continued monitoring is the most logical solution.

An important distinction needs to be made between lessons learned from large clinical trials and their application for the individual patient. Differences and trends

uncovered in studies on groups, even when each subject provides only one or a few measurements, cannot be similarly assessed in medical practice when a decision needs to be made for treating the individual patient. In order to be able to reach an informed decision for the given patient, serial rather than single data should be collected. When time series are available, it becomes possible to assess risk elevation or the response to treatment for that particular patient.

Our study enabled not only confirmation of the increase of systolic and diastolic blood pressure with age but also description of the age dependence of the circadian amplitude. Mean values of SBP and DBP were increasing with age up to 75 years, but night-day difference of SBP and DBP reached the maximum value at 45 years and then decreased.

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