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DISTURBANCE OF CIRCADIAN RHYTHM IN BLOOD PRESSURE BY LACK OF DARKNESS AT NIGHT

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A b s t r a c t

The aim of the study was to verify whether exposure to light at night was associated with disturbances of circadian variability of blood pressure in comparison to usual dark at night in healthy subjects.

Nine subjects were recruited for 48-h ambulatory blood pressure monitoring. Systolic and diastolic blood pressure was measured three times per hour during the day and one time per hour at night. During the first night the subjects slept in darkness, during the second night the bedroom was illuminated.

Our result shows that the illumination of bedroom at night increases systolic blood pressure by about 11 mmHg.

Long lasting increase of systolic blood pressure could be connected with an increase of risk of cardiovascular diseases like stroke and myocardial infarction.

K e y w o r d s

Circadian rhythm, Blood pressure, Light at night as a risk of cardiovascular disease

INTRODUCTION

In the history the consciousness – sleep cycle had always been synchronized with light in the day and dark in the night cycle. In living subjects including man the most important for endogenous biological rhythms is the environmental light-dark cycle, which is connected with the circadian biological rhythm (*1,2*). The alteration of the day and night circadian cycle is a very important regulator of a wide variety of physiological rhythms in living organisms, including humans (*3*). Due to the introduction of electricity and artificial light about hundred years ago the pattern and duration of human exposure to light has changed dramatically. Light at night allowed to work at night and increasing light exposure at night became a sign of a modern lifestyle. In modern cities the illumination during the night is sometimes so high that the night darkness is not valid any more. With the use of usual artificial light sources during the normal dark period, humans could readily manipulate the light-dark cycle allowing for light during the dark period; however, not all of the resulting

changes have served the human population well. The physiological consequences of excessive light exposure appear not to be trivial (*4*). The ability to maintain a lighted environment after sunset has encouraged humans to stay awake later into the night. In the United States estimated 45 million people are sleep-deprived nightly. Sleep deprivation is very costly in terms of reduced work efficiency as well as the development of disease and mortality, e.g. falling asleep while driving. Additionally, inadvertent manipulation of intrinsic physiological processes, such as suppression of endogenous melatonin production, alters a variety of cellular functions, which may lead to a disease (*4*).

The issues related to the excessive use of artificial light have become a major concern. As a result, a number of international organizations have been formed to combat what now is conventionally referred to as "light pollution" (*4*).

The circadian variation of cardiovascular variables is inborn, genetically coded, and connected with the day-night natural changes. Many blood pressure alterations can lead to hypertension, which is not only a disease, but also a risk factor of cardiovascular diseases (*5–12*). Following cardiovascular parameters, heart rate and blood pressure, over a period of 24 hours is possible using ambulatory blood pressure monitoring.

The investigation of disturbance of 24-hour blood pressure cycle under the influence of illumination during the night was the aim of the present study.

METHODS

Nine healthy subjects (4 females and 5 males) were recruited for 48-hour ambulatory blood pressure monitoring (Colins, AD Japan, oscillatory method). The medical examination excluded the presence of a disease, the subjects signed informed consent, and the study was approved by the local ethical committee. The subjects performed their usual daily activities, worked during the daytime, and slept in their own bedrooms at night. We measured systolic (SBP) and diastolic blood pressure (DBP) three times per hour during the day (6:00 to 22:00) and once during the night (22:00 to 6:00). During the first night the subjects slept in darkness, during the second night the bedroom was illuminated (illumination of faces ranged from units to tens of lux). The 24-hour blood pressure profiles of SBP and DBP during the first day and during the second day of monitoring were compared (*Figs. 1, 2*).

RESULTS

The original records of blood pressure profiles in two different subjects can be seen in *Fig. 1* and *Fig. 2*. We evaluated the mean systolic and diastolic blood pressure in every hour and the results are presented as a mean (SD) in *Fig. 3*. SBP increased during the second night (illumination in the bedroom) between 1:00 and 3:00 o'clock at night. The difference at 3:00 o'clock at night is statistically significant (Wilcoxon test, $p < 0.05$). The difference in mean SBP values between the first and the second night is 11 mmHg for the interval from 1:00 to 3:00. We also observed a statistically significant difference in DBP at 3:00 o'clock at night only. From our results we can conclude that illumination in bedroom at night increases systolic blood pressure by about 11 mmHg and diastolic blood pressure by 3 mmHg at 3:00 o'clock at night.

DISCUSSION

To have the environmental conditions equal in our small group of subjects, we did not use the crossover design of the study (one half of the subjects exposed to illumination in the first night and to darkness in the second night and the second half of the subjects subjected to the opposite time course), but we do not see this as a disadvantage because in 187 subjects with blood pressure monitoring lasting 7 days (*13,14*) we did not observe any increase of blood pressure during the second night of monitoring.

The increase in blood pressure in highly developed countries is associated with obesity, physical inactivity, excessive alcohol use, and excessive salt intake. Increasing blood pressure is connected with sedentary lifestyle in young population and blood pressure rises again with age. Two thirds of people above the age of 65 years in UK and USA have hypertension (*1*0). Hypertension is an important risk factor for myocardial infarction, strokes, heart failure, and renal failure. The relationship between blood pressure level and risk is continuous and graded, and is steeper for systolic blood pressure than for diastolic blood pressure (*11*). These data are summarized from randomized, controlled clinical trials (JNC-1997). In our results the difference in SBP and DBP between night in the darkness and night in illuminated bedroom does not appear to be dramatic at first glance. However, a comparison with the curves of the relationship between SBP and DBP and the risk for cardiovascular disease demonstrates a relatively high increase of risk caused by illumination. By calculating the difference of 11 mmHg in SBP during the night for the whole 24-hour period, we obtain an increase of 2 mmHg.

The meta-analysis of the risk for stroke and for myocardial infarction suggests that the increase of 2 mmHg in SBP corresponds to an increase of risk of 9 % for stroke and 5 % for myocardial infarction (*11*).

The predicted risk can be taken as a relative value. In an individual subject, some physiological control mechanism like adaptation can appear and this can change SBP and DBP values during longer time intervals. The relation between risk and DBP is more complicated. The data from Framingham Heart Study suggest that DBP is the best predictor for coronary heart disease risk in people below fifty years of age, that both systolic and diastolic blood pressure are equally predictive in people at the age of fifty to sixty years, and after sixty years systolic blood pressure and pulse pressure become more significant (*21,22*). On the other hand, our results indicate that it would be worth studying the relationship between blood pressure and illumination during the night in more detail.

The impact of breast cancer on women across the world has been extensive and severe, exposure to light at night being suggested as a potential risk factor. In our study, we demonstrated the impact of night illumination on blood pressure.

This influence is mediated by the increased sympathetic nervous activity at night.

The altered autonomic nervous activity also influences immunological response by neuroimmunomodulation. Neuroimmunomodulation deals with 3-way interactions among the nervous, endocrine, and immune systems (*12*).

As early as in 1953, *Halberg* (*1*) published papers on immune function, which changes daily in a rhythmic fashion. Later with Cornélissen they introduced the term chrononeuroimmunomodulation, stressing the periodicity of neural, endocrine, and immune functions (*6,8,23,24,25*). The effect of alteration of chrononeuroimmunomodulation in man is not known but animal experiments suggest that this can be an additional risk factor for oncological diseases, for example in shift workers.

As the conclusion of our study, we can state that the increase in systolic blood pressure by about 11 mmHg during the night with illumination of the bedroom indicates that CNIM is altered by illumination during the night.

A c k n o w l e d g e m e n t

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PORUCHA CIRKADIÁNNÍHO RYTMU KREVNÍHO TLAKU ZPŮSOBENÁ NEDOSTATKEM TMY V NOCI

S o u h r n

Cílem studie bylo ověřit, zda vystavení zdravé osoby světlu ve spánku při elektrickém osvětlení vede ke změnám cirkadiánní variability krevního tlaku ve srovnání se spánkem ve tmě. Devět osob bylo vyšetřeno ambulantním monitorováním krevního tlaku v průběhu 48 hodin. Systolický a diastolický krevní tlak byl měřen 3 x za hodinu během dne a jedenkrát za hodinu v noci. První noc spaly osoby ve tmě, druhou noc byla ložnice osvětlena. Výsledky ukázaly, že osvětlení ložnice zvyšuje systolický krevní tlak asi o 11 mmHg. Dlouhodobý vzestup systolického krevního tlaku by mohl vést k zvýšení rizika kardiovaskulárních onemocnění, jako je cévní mozková příhoda a infarkt myokardu.

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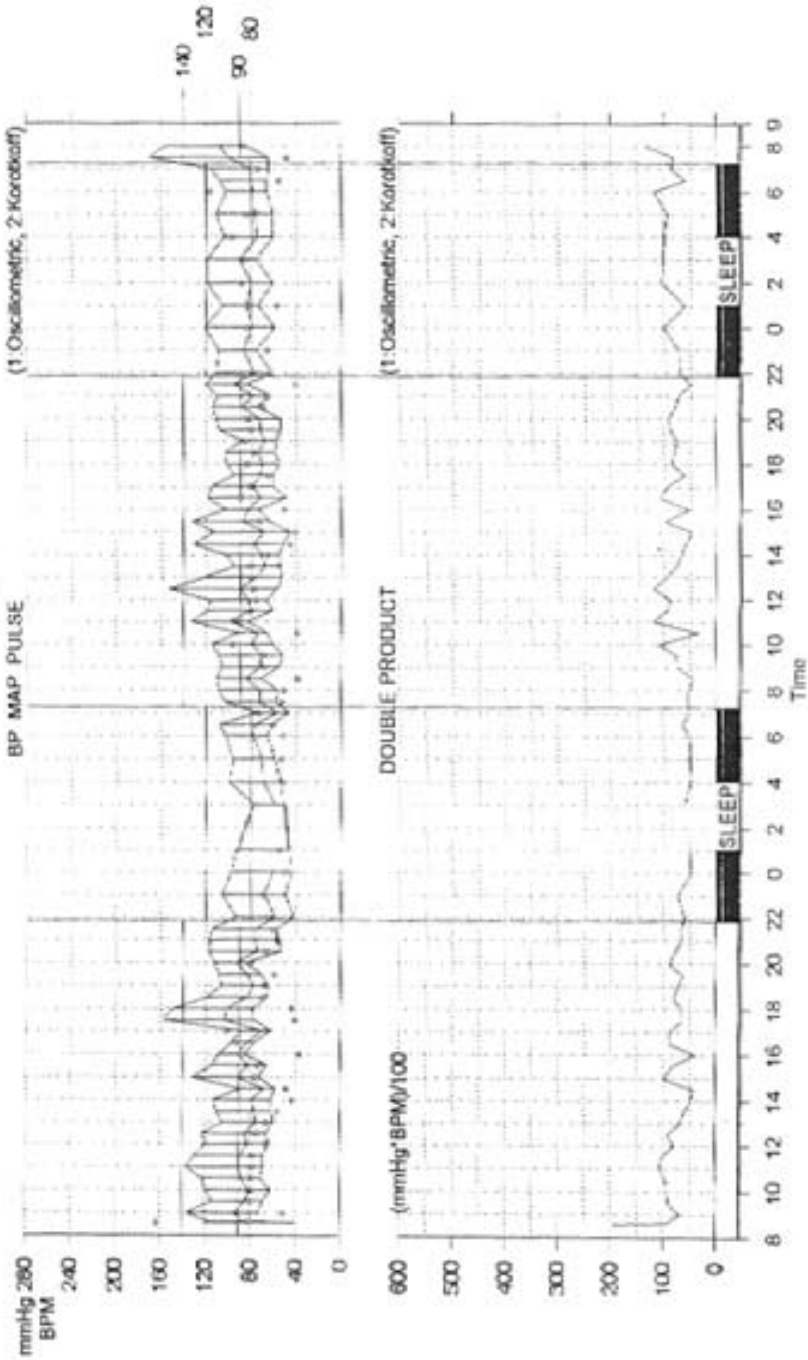

Fig. 1
The 48-hour profile of SBP and DBP monitoring during the first day with darkness in bedroom and during the second day with illumination in bedroom in one healthy subject (6)

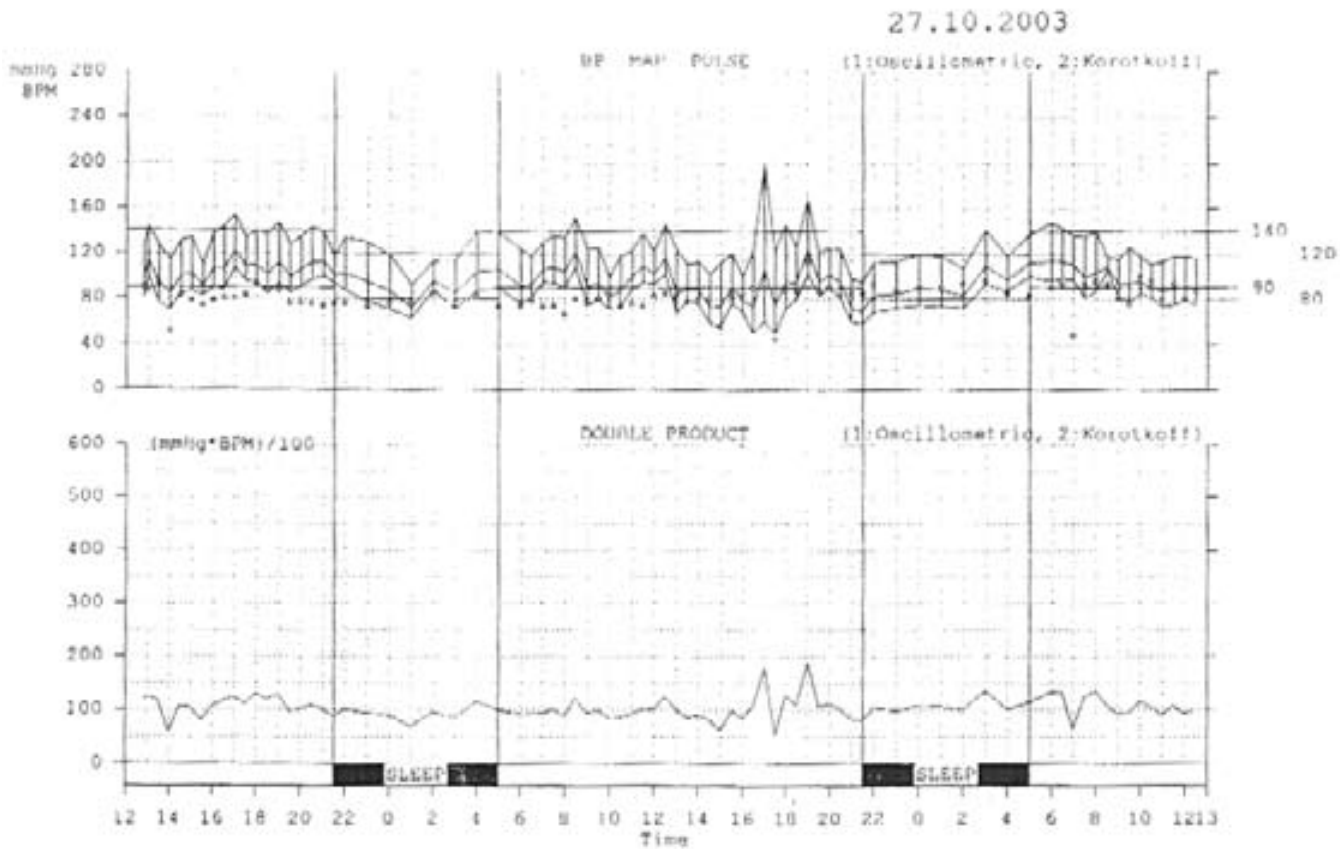

Fig. 2
The 48-hour profile of SBP and DBP monitoring during the first day with darkness in bedroom and during the second day with illumination in bedroom in another healthy subject (8)

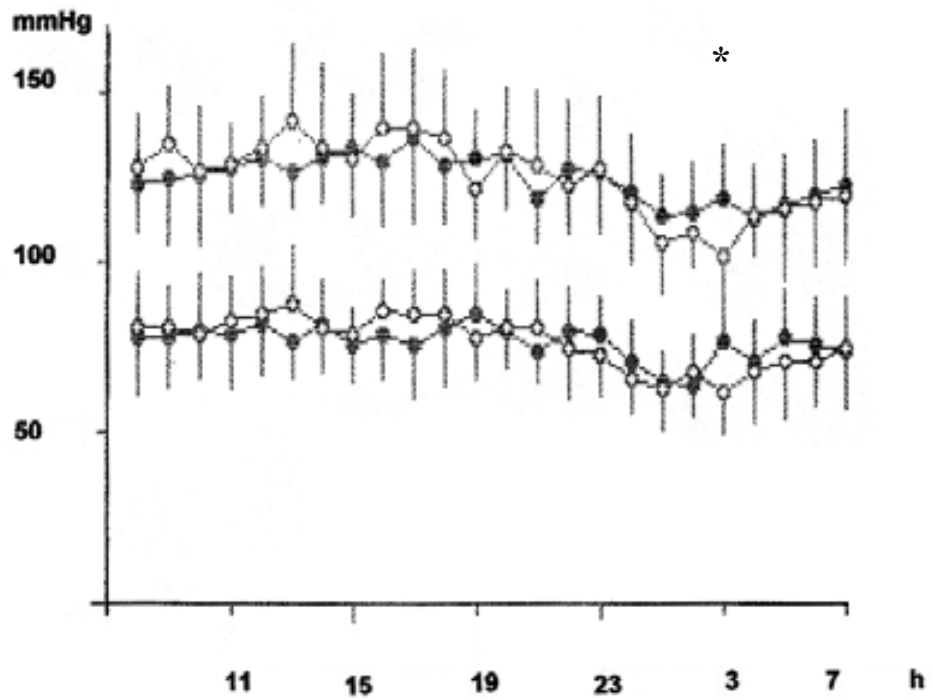

Fig. 3
Mean 24-hour blood pressure profile with darkness at night (open circles) and with illumination (full points) at night