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A CASE OF MILD HYPERTENSION

WHAT CAN WE LEARN FROM OVER 900 DAYS OF DATA RECORDS?

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Abstract: *Over 900 days of data records for blood pressure (systolic, diastolic) and heart rate for a single subject with mild hypertension were analyzed. From the data the Mean Arterial Pressure (MAP) was calculated. Linear regression over the entire time revealed a slight trend to higher MAP and lower heart rates. A clear circadian behaviour and a difference between work days (Mon-Fri) and weekends for the MAP data was detected.*

Keywords: *Hypertension, Mean Arterial Pressure, Heart Rate, Weekly and Circadian Variations.*

Introduction

Hypertension or high blood pressure is a chronic medical condition in which the blood pressure in the arteries is elevated. This requires the heart to work harder than normal to circulate blood through the blood vessels. Blood pressure is summarised by two measurements, systolic and diastolic, which depend on whether the heart muscle is contracting (systole) or relaxed between beats (diastole). Normal blood pressure at rest is within the range of 100-140 mmHg systolic (top reading) and 60-90 mmHg diastolic (bottom reading). Mild hypertension is said to be present if it is persistently at or above 140/90 mmHg. This is the case in our data. In the diagnosis of hypertension the blood pressure is measured for a few days. With the availability of 24-hour ambulatory blood pressure monitors the possible circadian changes in pressure can be detected and wrong diagnosis avoided. Still, the question remains whether the 24-hour variation of the blood pressure is caused by sleep or is based on an internal controlled process. There are controversial statements about it in reference [1, 2]. No measurements were taken during sleep. Is there a 24-hour blood pressure variation detectable in our data?

There are practical no long-term data records of blood pressure and heart rate in the scientific literature. The here presented data analysis for Mean Arterial Pressure (MAP) and Heart Rate (HR) is a first tiny step to fill this gap. Furthermore, in the most published studies [2, 3] data are measured under strict controlled conditions in a hospital environment. But, what happens to people with hypertension outside the controlled conditions? The long-term impact of everyday life with work and family stress on MAP and HR should be an import topic in biomedical research and will contribute to a better understanding of hypertension.

Methods

Data were recorded from a 54 year old female using an automatic wrist-based blood pressure monitor "SBC23" for more than 900 days. The date, clock time, systolic and diastolic blood pressure, and heart rate were stored in an excel file. In addition, the labels 'medication (yes/no) and 'work days' or 'vacation days' were assigned to the data records. Measurements took place several times during the day, with some higher occurrence in the morning and in the evening.

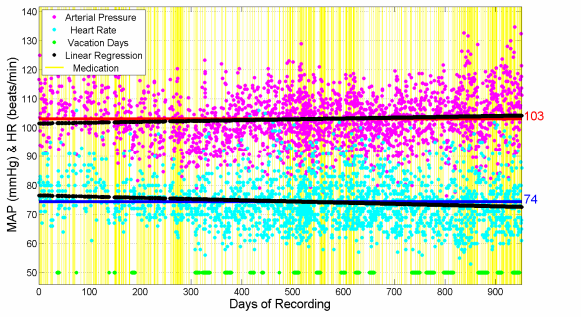

Figure 1: Mean Arterial Pressure (MAP) and Heart Rate (HR) as function of recorded day. Vertical yellow lines mean blood pressure medication was taken; lower green dots display vacation days.

From the Systolic Pressure (SP) and Diastolic Pressure (DP) the Mean Arterial Pressure (MAP) was calculated using equation (1).

$$MAP = (2*DP + SP)/3 \qquad (1)$$

All data points of MAP (mmHg) and HR (beats per minute) together with overall means and linear regressions are displayed in figure 1 as function of date and clock time. The variation of MAP and HR over the course of the day is shown in figure 2 using a nonlinear regression of higher order. The impact of work days

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compared to free days on MAP and HR is presented in figure 3. The different perspective of the data analysis using these selected time scales give a really good overview about the development of the hypertension of our single subject.

Results

The overall average of the MAP data is 103 mmHg and of the HR data is 74 beats per minute (figure 1). According to the blood pressure categorization used in [1] indicates the MAP value a mild case of hypertension. The trend over the recorded time scale is increasing despite the more frequent intake of blood pressure medication. It is interesting to notice that the MAP average on vacation days is reduced to 101 mmHg whereas the HR stays the same. In addition, a negative correlation between MAP and HR of -0.18 was detected. This correlation is significant (*).

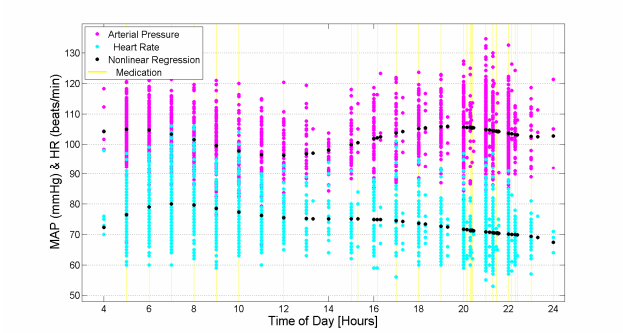

Figure **2**: Mean Arterial Pressure (MAP) and Heart Rate (HR) as function of time of day. Vertical yellow lines mean blood pressure medication was taken. The black dots are the result of a nonlinear regression analysis and indicate two maximums for MAP (morning and evening) and one maximum for HR (morning)

Data records are available between 04:00 and 23:00 during wake times of the subject. The distribution of MAP and HR during these clock times are displayed in figure 2. A nonlinear regression of the 7th order shows two maxima for the MAP data, the first one between 05:00 and 06:00 in the morning and a second one around 20:00 in the evening. The average MAP value during noon times is below the critical threshold of hypertension. The same regression yields for the HR a different time course with only one maximum around 07:00. A possible impact of daily work is presented in figure 3. During the normal work week (Mon-Fri), the average MAP value indicates a case of mild hypertension. On weekends, especially on Saturday our subject moves to the MAP category "normal". There is no difference between work week and weekend for the HR data.

Discussion

The data used in our investigation are from a single subject and were measured under everyday conditions with quite primitive equipment. Even under these circumstances, we demonstrated that long-term blood pressure and heart rate recordings are showing a remarkable depth of information. Overall the Mean Arterial Pressure is the more sensitive parameter compared to Heart Rate. General trends about the improvement or deterioration of the subject's health state can be recognized. Lower average HR seems to be linked to higher average MAP. The findings about this relationship in [2] point to the opposite.

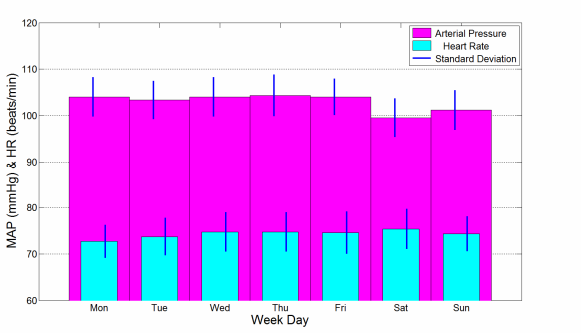

Figure **3**: Mean Arterial Pressure (MAP) and Heart Rate (HR) as function of weekday. Vertical blue lines display the standard variation. MAP is clearly reduced on weekends.

Another contradiction to the results in [2] was found regarding the 24-hour MAP variation. Our data show clear 24 hour and 12 hour periodic behaviour. These results are supported by the detailed discussion of the timing for the blood pressure in [4]. The state of mild hypertension of our subject seems mostly driven by work related issues. During vacation and on weekends the average MAP value is decreased, crossing the threshold to normal blood pressure values. Additional information about our subject would clearly reveal the main cause of the hypertension. From personal interviews it became obvious that a substantial differences in average sleep duration between work days and free days exist. It is well known that chronic sleep deprivation could be one possible cause of hypertension. More of these studies with more subjects are needed to test the general validity of our results especially regarding the 24 hour and 12 hour periodic variations of the MAP data.

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