

# Abnormal blood pressure patterns in cardiac patients and duration of monitoring

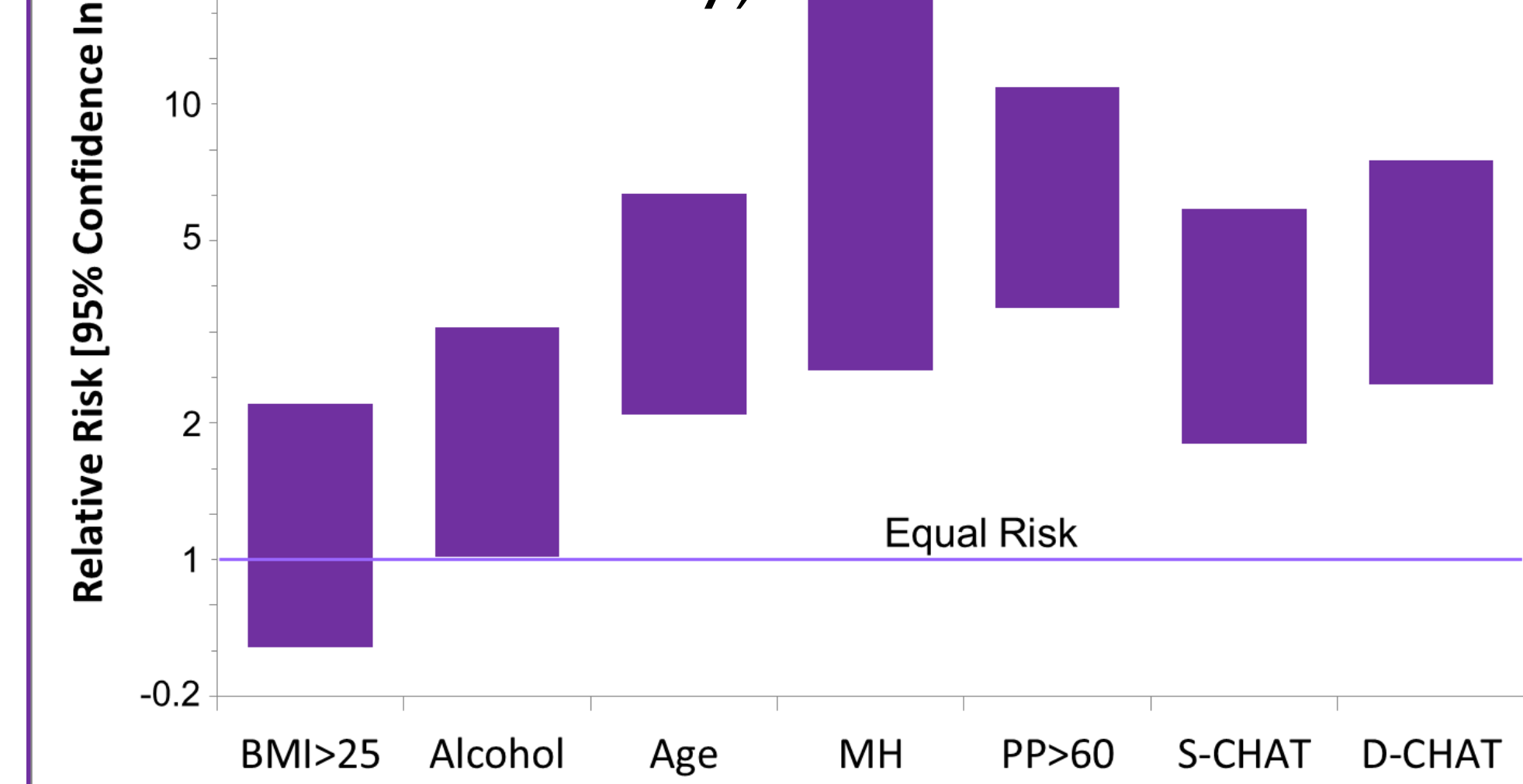
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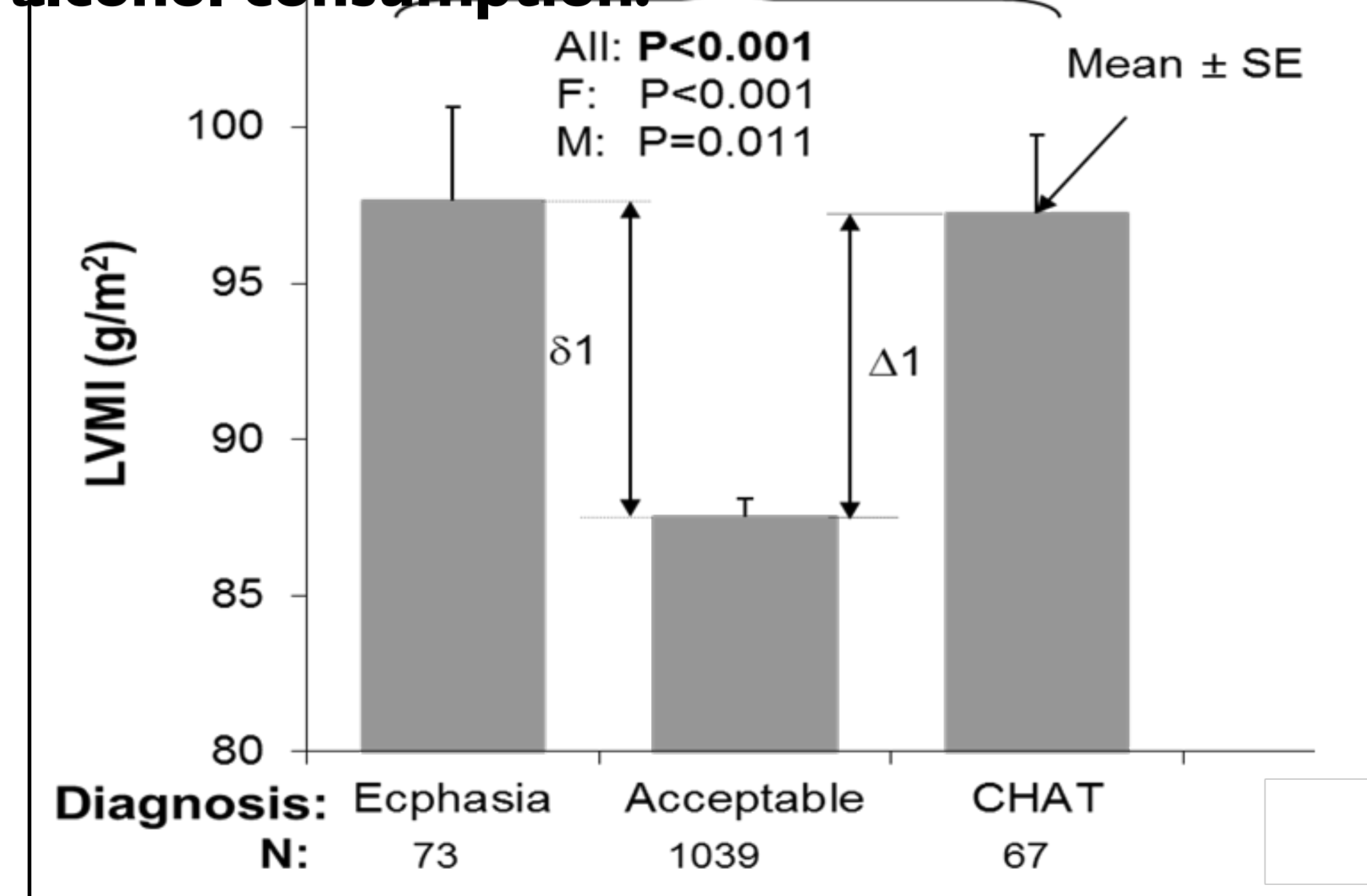
## Aim

To analyze ambulatory blood pressure monitoring (ABPM) records from patients admitted at the cardiology clinic in Almaty (Kazakhstan) and from residents of Tosa City (Japan) for comparison with chronobiological reference values and to relate the incidence of abnormal patterns of blood pressure (BP) and/or heart rate (HR) to the record length.

Abnormalities in the circadian patterns of BP and HR (known as Vascular Variability Anomalies, VVAs) have been associated with an increased cardiovascular disease risk, beyond the risk of an elevated BP in several outcome studies. In addition to MESOR-hypertension (elevated rhythm-adjusted 24h mean of BP), these VVAs include too large a circadian amplitude of BP (CHAT, Circadian Hyper-Amplitude-Tension), an odd timing of the circadian BP rhythm (ecphasia), an excessive pulse pressure (PP>60mmHg), and too small a standard deviation of HR (DHRV, Deficient HR Variability).



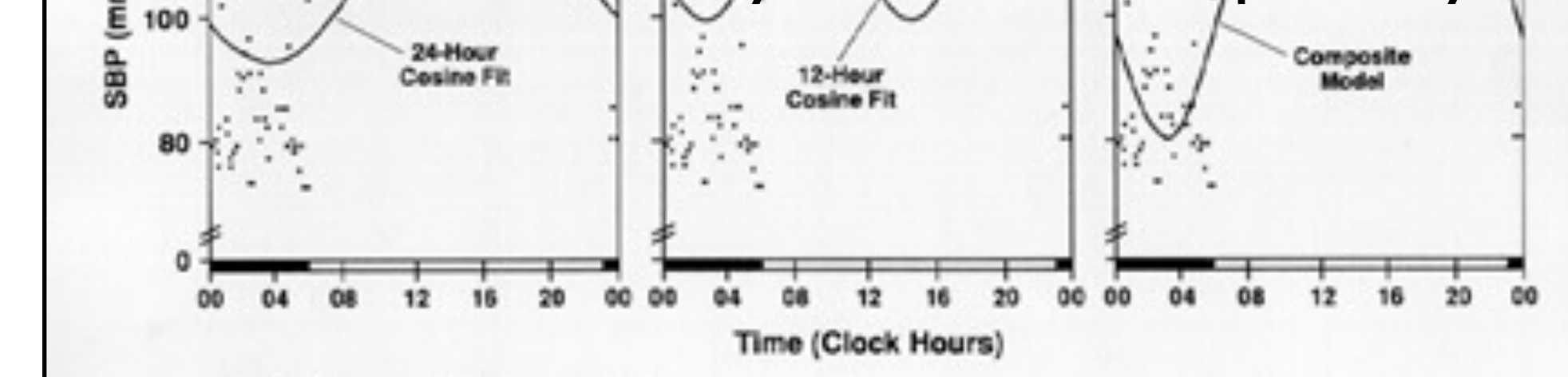
**Figure 1: An elevated BP, too large a circadian amplitude of BP and an excessive pulse pressure are associated with an increased cardiovascular disease risk., as well as age and alcohol consumption.**



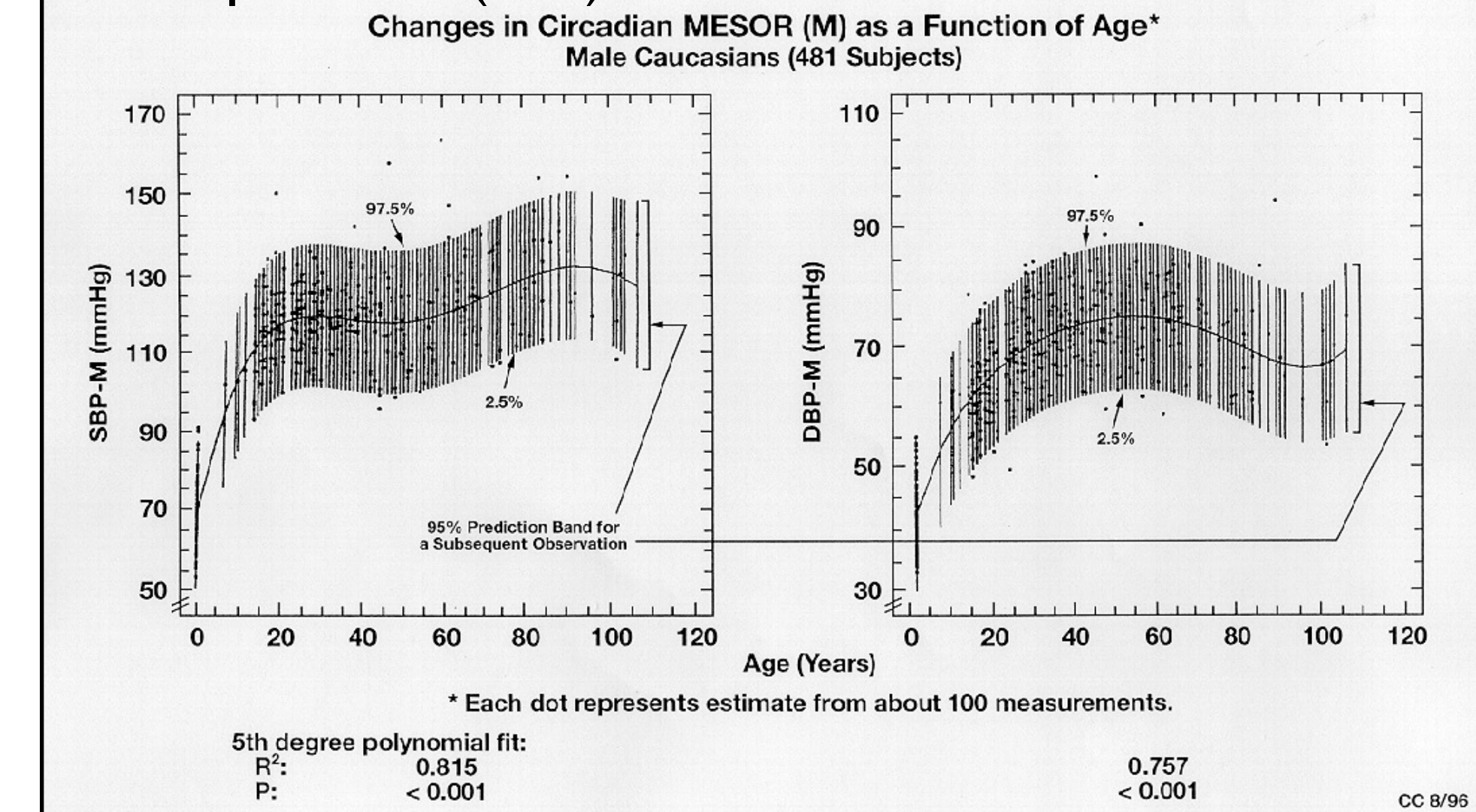
**Figure 2: Abnormal circadian amplitude and phase of DBP are associated with an elevated LVMI (N>1,000).**

## Subjects and Methods

In Almaty, 24h ABPM records were obtained from 360 patients of a specialized cardiology clinic in Almaty, Kazakhstan. In Tosa City, Japan, 7-day ABPM records from 26 residents served to examine any influence of the duration of monitoring on the incidence of VVAs. Each record was fitted by least squares with a model consisting of cosine curves with periods of 24h and 12h, used to approximate the circadian waveform of systolic (S), diastolic (D) BP and HR. Parameter estimates were compared to 90% prediction limits derived from clinically healthy peers matched by gender and age to identify any VVAs. Records from Tosa City were analyzed overall and for each day considered separately.



**Figure 3: Fit of 2-component model to systolic blood pressure (SBP) data.**

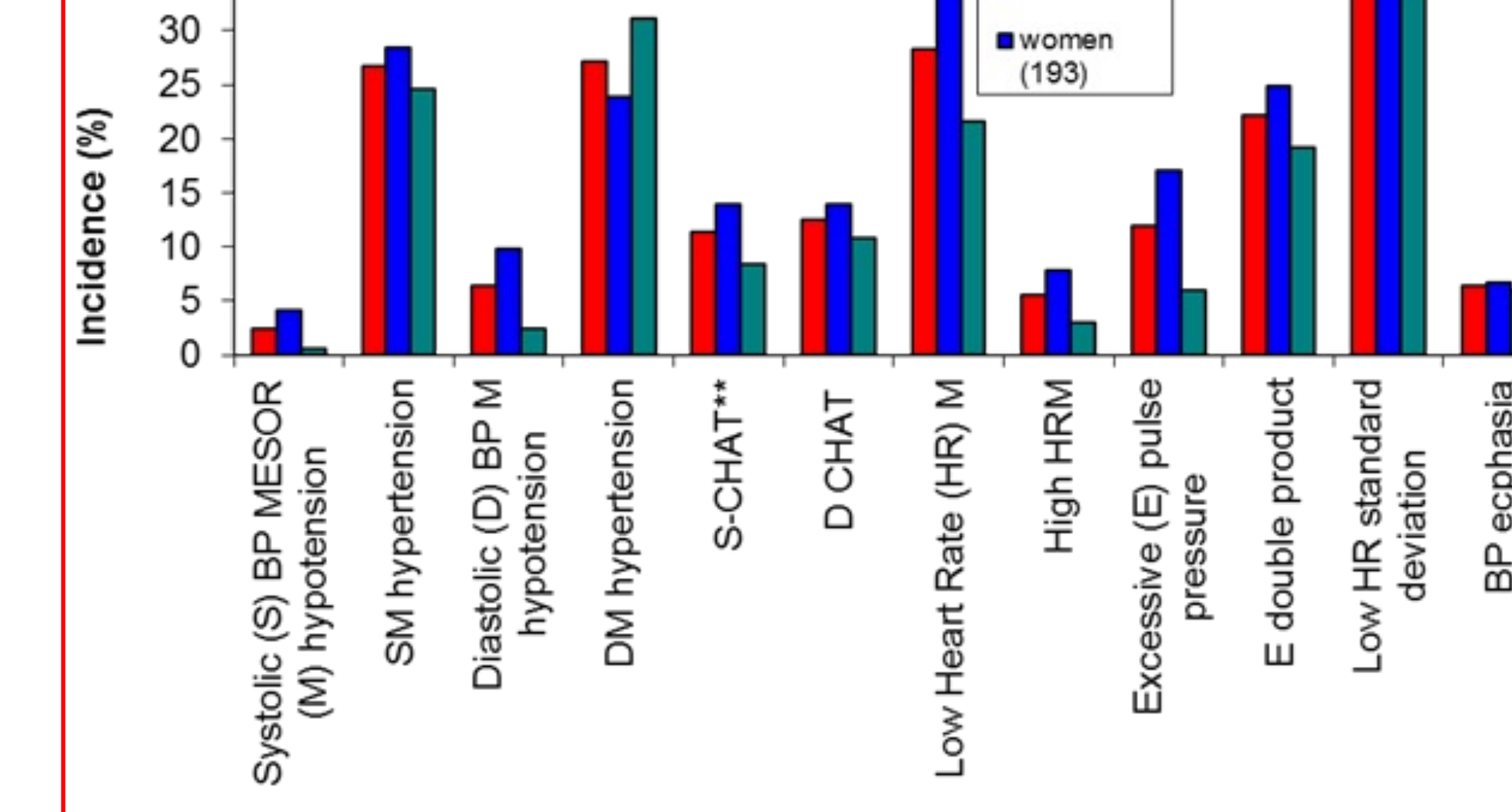


**Figure 4: Time-specified reference limits are determined from clinically healthy peers matched by gender and age. As seen here, the MESOR of SBP (left) and DBP (right) follow different trends as a function of age.**

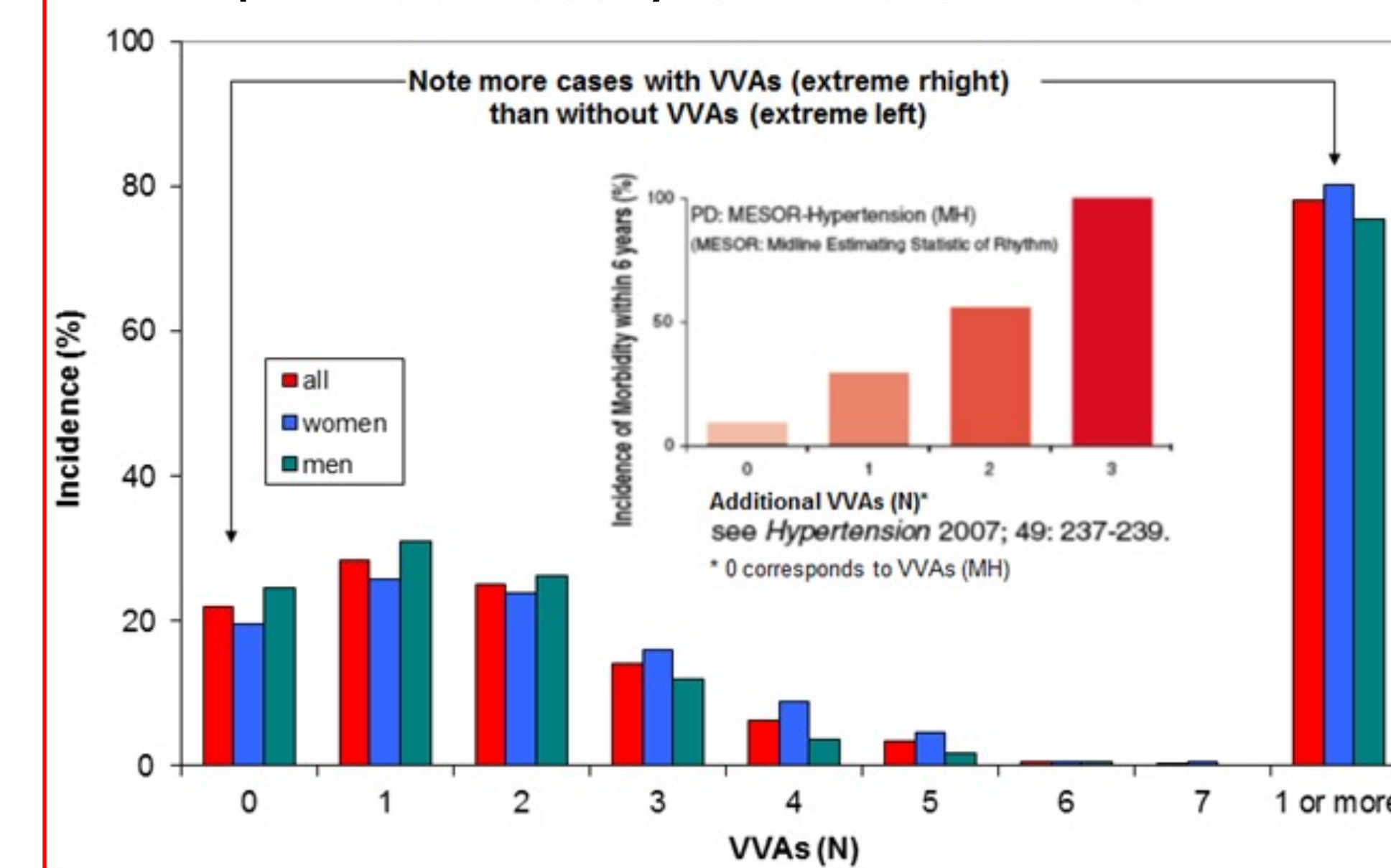
	N of cases		
	female	male	total
SM hypotensive	8	1	9
SM hypertensive	55	41	96
S-CHAT	28 (1 too low + 27 high)	21 (7 low + 14 high)	49
DM hypotensive	19	4	23
DM hypertensive	46	52	98
D-CHAT	32 (5 low + 27 high)	29 (11 low + 18 high)	61
Low HR M	66	36	102
High HR M	15	5	20
HR CHAT	15 (8 low + 7 high)	17 (9 low + 8 high)	32
PP >60	33	10	43
DP >100	48	32	80
SD of HR (<7.5)	69	56	125

## Results

One or more VVAs occurred in 78% of the cardiac patients in Almaty. More than one VVA was found in 50% of the patients, whereas 22% had no VVA despite the fact that these were patients treated for known cardiovascular disease.



**Figure 5: Above 90% of patients were hospitalized during the monitoring; \* CHAT, short for circadian hyper-amplitude-tension; Some vascular variability anomalies (VVAs) in ~24-hour (18-33 hour) records of cardiac patients in Almaty, Kazakhstan pathology**



**Figure 6: Multiple VVAs occurred in a large proportion of the patients in Almaty.**

In Tosa City, at least one VVA was found on at least one day in all subjects. Twelve subjects with no VVA overall had VVAs in 1 to 3 days. Among the other 14 residents with at least one VVA on 4 or more days, only one had no 7-day VVA.

Daily analyses	Disorder (VVD) on at least one day*													
	S-MH	D-MH	EPP	S-CHAT	D-CHAT	DHRV	anyVVD	S-MH	D-MH	EPP	S-CHAT	D-CHAT	DHRV	anyVVD
S81-0155	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S82-0186	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S83-0187	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S84-0188	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S85-0189	6	1	1	1	1	1	1	1	1	1	1	1	1	1
S86-0190	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S87-0191	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S88-0192	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S89-0193	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S10-0194	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S11-0195	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S12-0196	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S13-0197	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S14-0198	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S15-0199	6	1	1	1	1	1	1	1	1	1	1	1	1	1
S16-0200	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S17-0201	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S18-0202	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S19-0203	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S20-0204	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S21-0205	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S22-0206	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S23-0207	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S24-0208	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S25-0209	7	1	1	1	1	1	1	1	1	1	1	1	1	1
S26-0210	7	1	1	1	1	1	1	1	1	1	1	1	1	1

\* Abnormally on at least 1 day is found in each weeklong record, sometimes as more than a single VVD. The 3 subjects with abnormality on all 7 days also have an abnormal 7-day record. The number of abnormal days in a weeklong record as such does not tell.

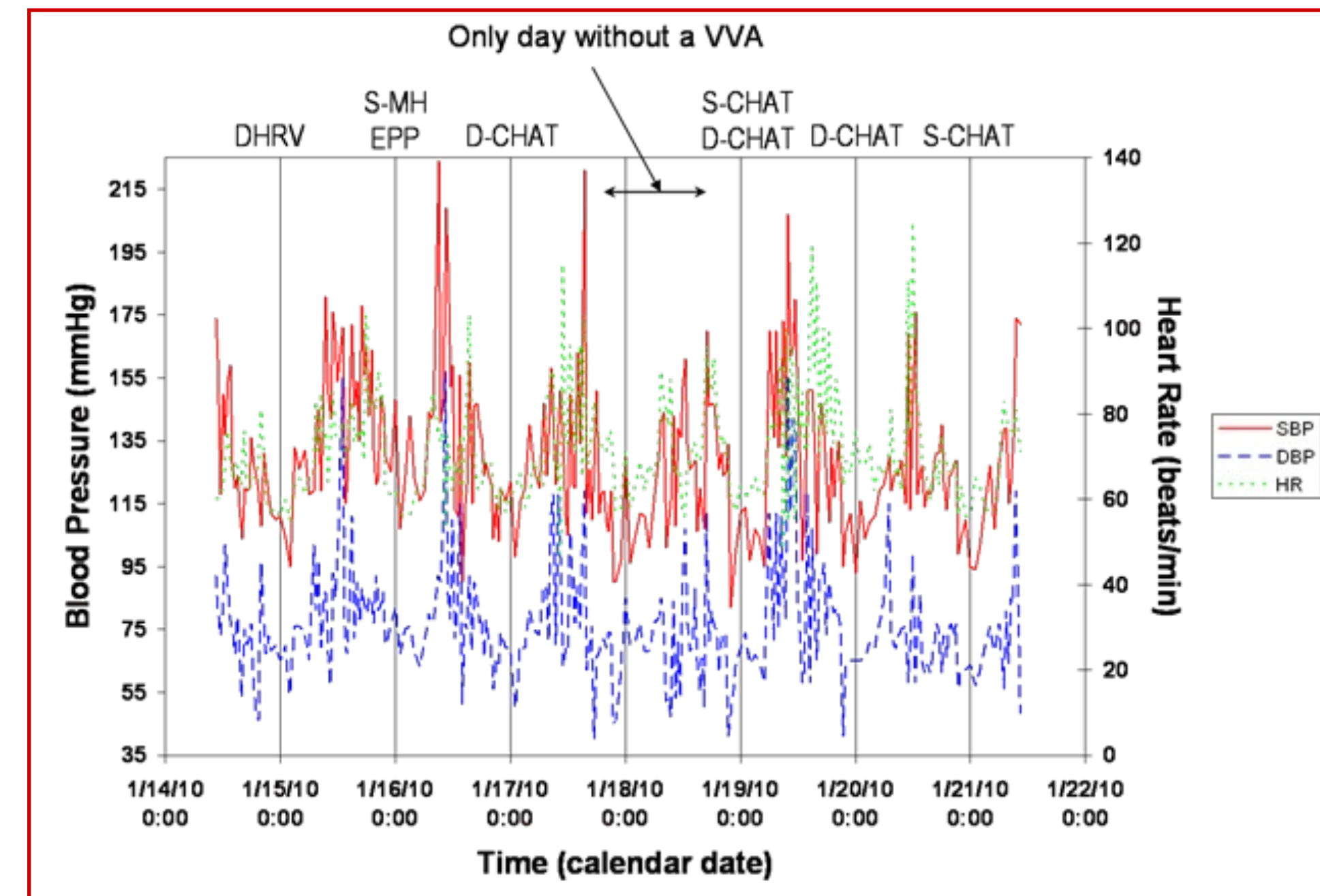
Number of days with at least one VVA will have to be complemented by the extent of severity of VVA(s) each day and overall \*

N of days with a VVA	N of subjects	VVA in weeklong record?		Comments
		No	Yes	
0	0			
1	3	3	0	
2	7	7	0	
3	2	2	0	
4	6	4	2	1 VVA each (S-CHAT)
5	4	2	2	1 D-MH; 1 S-SD-CHAT
6	1	1	0	
7	3	0	3	1 S-CHAT; 2 with 3 VVAs**

\* One can have 6 days with a VVA and no abnormality in the overall record (row 7), a finding suggesting that the duration of a VVA is an incomplete measure, the extent of abnormality also in need of being assessed. Continuous recording with automatic analyses carried out both day-to-day and week-to-week is recommended in any event once a validated, unobtrusive monitor is miniaturized and rendered affordable in a chronobiologic system subservient to health monitoring, including mental and other strain assessment, with dividends for medical research and for monitoring effects of natural environmental factors, including solar activity.

\*\* 1 with S-MH, EPP and S-CHAT and 1 with S-MH, EPP and DHRV.

VVA: Vascular Variability Anomaly; S- (Systolic); D- (Diastolic); MH: MESOR-Hypertension; CHAT: Circadian Hyper-Amplitude-Tension; EPP: Excessive Pulse Pressure (>60mmHg); DHRV: Deficient Heart Rate Variability (standard deviation of HR <7.5 beats/minute).



**Figure 7: Day-to-day variability in BP and HR behavior. In this record, there is at least one VVA on 6 of 7 days. The overall summary shows all endpoints to be within acceptable.**

## Discussion and Conclusion

The large day-to-day variability in circadian characteristics of BP and HR and the associated presence or absence of any VVAs on a given day indicate the need to monitor for spans longer than 24 hours and to repeat the monitoring when a VVA is detected. Among the different factors known to affect BP, emotions have been shown to greatly affect the circadian amplitude of BP, as is the evening consumption of alcohol. Keeping a diary during monitoring may thus help with the interpretation of the results. Monitoring for 7 days at the outset has been recommended. One useful application has been for determining optimal circadian stages for the administration of anti-hypertensive medications, which can either increase or decrease the 24h BP amplitude depending on when it is taken.