Day-to-day variability in circadian BP characteristics & effects of exercise

Lee Gierke C[1], Siegelova J[2], Hvelkova A[2], Dusek J[2], Cornelissen G[1]

[1] University of Minnesota, Minneapolis, MN, USA; [2] Massaryk University, Brno, Czech Republic

Introduction

Hypertension is a powerful and independent risk factor for cardiovascular disease and renal disease. The *2014 Evidence-Based Guideline for the Management of High Blood Pressure in Adults* names hypertension the most common condition seen in primary care. Despite effective drug treatment options, however, blood pressure is not well controlled in 44% of those with hypertension -- half of whom are receiving drug treatment. Proper diagnosis and effective treatment of high blood pressure (BP) require accurate assessment of BP and BP variability, including circadian as well as day-to-day variation.

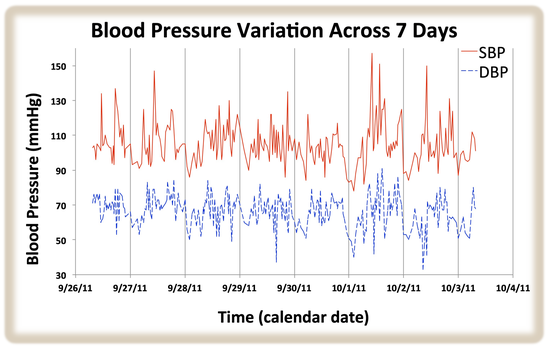

Figure 1: SBP MESOR=103.5, SD=12; double amplitude = 14.

Aim

To assess the extent of day-to-day variation in the estimate of the circadian MESOR (rhythm-adjusted mean) and amplitude of systolic blood pressure (SBP) of clinically healthy men and women who exercised twice a week.

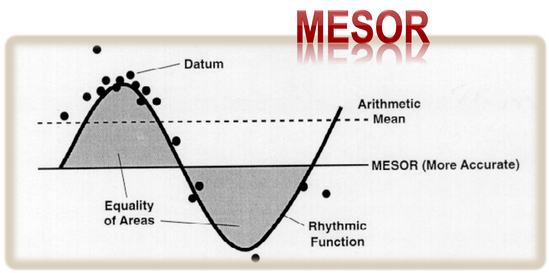

Figure 2: MESOR reflects model midline vs mean of raw data.

MESOR: The Midline Estimating Statistic of Rhythm is a rhythm adjusted mean, measuring the area under the cosinor fitted curve.

Amplitude: The extent of predictable magnitude above/below the MESOR, as assessed by cosinor model.

Methods

Forty-two subjects (22 men and 20 women), 20-41 years of age, participated in the study. Each provided data at 30-min intervals for 7 days (with occasional interruptions). On 2 of the 7 days, they exercised for 1 hour at a fixed load (M: 120 W; F: 80 W). For each individual, data were analyzed overall and separately for each day to estimate the MESOR (SBP-M) and 24-hour amplitude (SBP-A) of SBP circadian rhythm. These measurements were obtained by cosinor analysis using software from the Halberg Chronobiolgy Center.

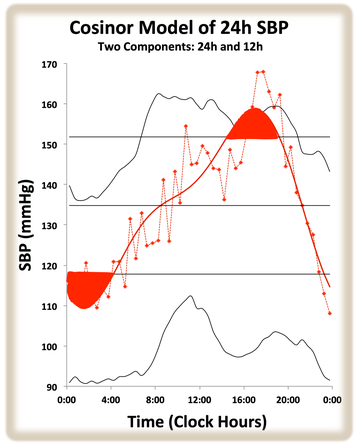

Figure 3: Seven day plot of SBP, stacked into 24 hours. Upper and lower lines reflect the age appropriate peer reference group high and low. Light red line is raw data. Solid red line is cosinor model, from which MESOR and Amplitude are computed. Solid red is excessive A.

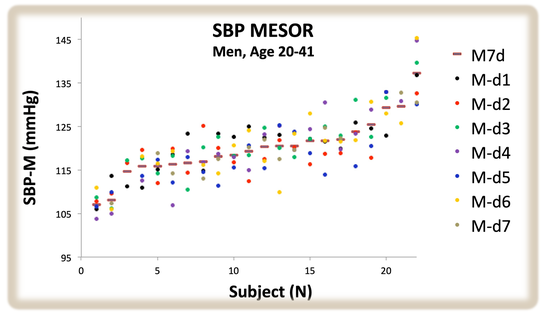

Figure 4: Daily MESORs, ranging from 104 – 145 mmHg (males). Seven day MESOR (M7d) shown by a red dash.

The Bland-Altman plot was adapted to estimate the bias, precision and limits of agreement for a comparison of daily estimates of SBP-M and SBP-A on days with or without exercise versus estimates from the 7-day record. Similarly, Bland-Altman was carried out comparing SBP-M and SBP-A between days with and without exercise. Analyses were carried out separately for men and women.

Results

The bias on SBP-M was small, ranging from -0.2 to 0.5 mmHg, and not significant (P>0.50). The precision, however, was consistently around 4 mmHg. Hence, limits of agreement were approximately ± 8 mmHg.

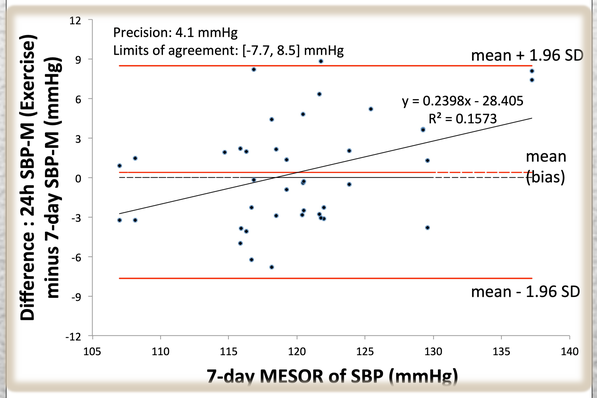

Figure 5: Bland-Altman for 22 men showing 24h SBP-M on exercise days minus 7-day SBP-M plotted versus 7 day SBP-M.

For the SBP-A, the bias of 24-hour versus the 7-day estimates was invariably positive (P<0.05), the SBP-A estimate being larger from 1-day than 7-day records. The precision was about 4.5 mmHg for men and 3.5 mmHg for women.

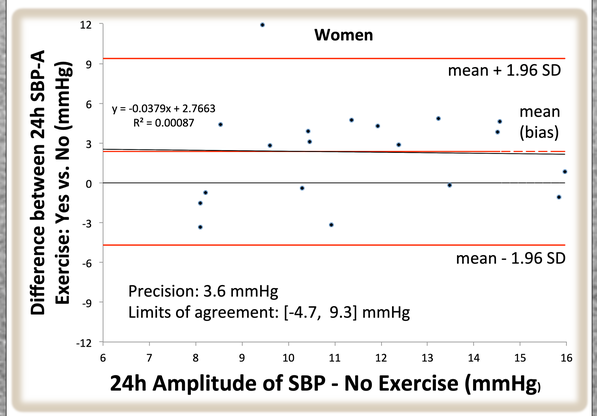

Figure 6: Bland-Altman for 20 women showing 24h SBP-A on exercise days vs non-exercise days, plotted against 7 day SBP-A. The bias of 2.3 mmHg was significant (P<.01).

Comparing days with exercise versus days without exercise, the bias was positive for both men and women. It was significant for women (2.3 mmHg, P<0.01), but not for men (0.4 mmHg, P>0.50). The precision was 3.9 mmHg for men and 3.6 mmHg for women.

Conclusion

Exercise and SBP Variability

	Bland-Altman	SD	N	LOA-	LOA	Bias	Paired-t	P
	MESOR							
M	No Ex vs 7d avg	3.7	95	-7.5	7.1	-0.2	0.490	0.625
M	Ex vs 7d avg	4.1	40	-7.7	8.5	0.4	0.593	0.557
M	Diff Ex vs No Ex	4.5	22	-8.5	9.0	0.2	0.249	0.805
F	No Ex vs 7d avg	3.7	99	-7.4	7.0	-0.2	0.436	0.664
F	Ex vs 7d avg	3.5	40	-6.6	7.2	0.3	0.537	0.594
F	Diff Ex vs No Ex	3.9	20	-7.1	8.0	0.5	0.560	0.583
	24-hour Amplitude							
M	No Ex vs 7d avg	4.9	95	-8.4	11.0	1.3	2.554	0.012
M	Ex vs 7d avg	4.2	40	-6.8	9.8	1.5	2.251	0.030
M	Diff Ex vs No Ex	3.9	22	-7.3	8.0	0.4	0.453	0.655
F	No Ex vs 7d avg	3.1	99	-5.5	6.8	0.6	2.008	0.048
F	Ex vs 7d avg	3.8	40	-4.5	10.4	3.0	4.965	0.000
F	Diff Ex vs No Ex	3.6	20	-4.7	9.4	2.3	2.920	0.009

Figure 7: Bland-Altman metrics. Difference in A was significant in all cases except difference between exercise and no-exercise days in men. No signficant differences in M were found.

- **BP variability within a day is quite large.**
  - In this study, **SBP** values varied in a range averaging about 100 mmHg and a 7-day SD of about 15 mmHg (**range: 70 – 130 mmHg**).
  - Even the **7-day SBP-2A** (double amplitude), which estimates the amount of variation that can be expected to occur predictably within a day, averaged 23 mmHg, **ranging from 11 to 37 mmHg** among the 42 study participants.
  - The **SBP-M** also, which represents an average of about 40 to 50 measurements per day was found to vary greatly from one day to another, as evident from the 4 **mmHg precision** derived by the Bland-Altman plots. Individual SDs of daily SBP-Ms also average 3.7 mmHg (range: 1.3 – 7.7 mmHg).
  - SBP-A gets smaller when record length increases
- **The resulting uncertainty from a single 24-hour record can make a large difference in terms of the diagnosis and the decision to treat.** Many factors contribute to the large day-to-day variability in BP, including exercise.
- **In this study, an effect of exercise was observed for the SBP-A of women but not men.** A 2.3 mmHg bias was significant (P<.01)
- **For the diagnosis of hypertension and other abnormalities in BP patterns, BP should be monitored around the clock for longer than 24-hour spans to obtain a reliable estimate of BP and BP variability.**