



Association Between Personal Levels of PM_{2.5} and Heart Rate Variability

UW/EPA NW Research Center for
Particulate Air Pollution and
Health

Why Study Heart Rate Variability?



- Measure of sub-clinical effects
- Non-invasive
- Insight into potential pathophysiologic mechanism
- Predictor of cardiac mortality



Definition of Heart Rate Variability

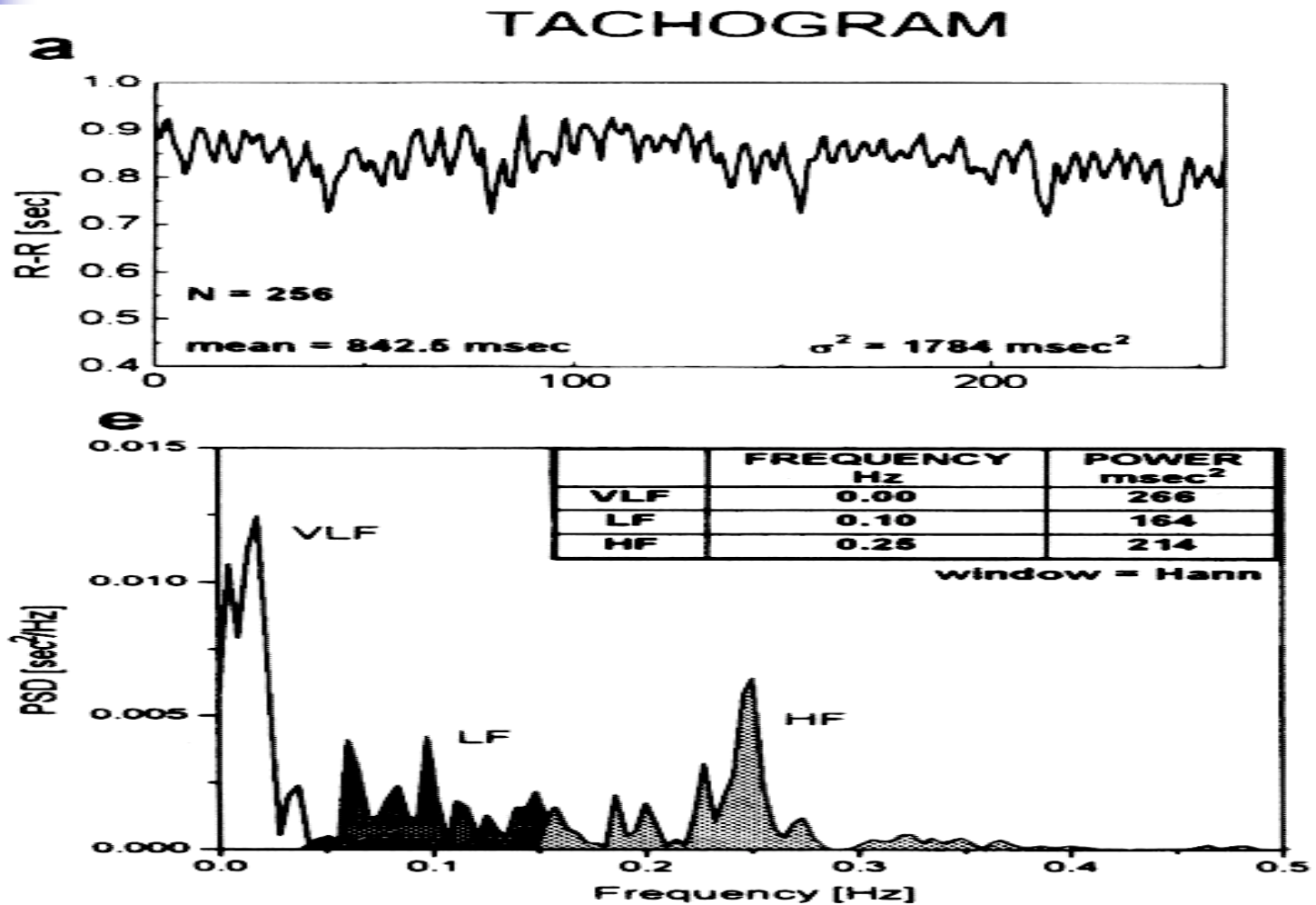
- Heart rate variability (HRV) is the oscillation between consecutive heart rates. HRV is used to describe variations of both instantaneous heart rate and RR intervals." -
 - Consensus statement from the North American and European Task Force on the Standardization of Heart Rate Variability, Circulation 1996.



Interaction of Sympathetic and Parasympathetic Nervous System on HRV

- Sino-atrial node innervation
 - Parasympathetic decreases heart rate and increases R-R intervals
 - Sympathetic increases heart rate and decreases R-R intervals

Frequency Domain Analysis of HRV





Predictive Value of HRV in Cardiac Disease

- HRV as a predictor of recurrent heart attack
 - A single short term measure of HRV predicted all cause mortality and arrhythmic death (Bigger, Circulation 1993).
 - Baseline HRV is associated with incident myocardial infarction (Liao, Am. J. Epidemiology 1997)



Air Pollution and HRV

- Increased PM₁₀ was associated with a decreased SDNN, and an increased RMS-SD in 7 elderly individuals in Utah (Pope, American Heart Journal 1999).
- HF component, LF component and SDNN were all inversely associated with PM 2.5 measures. (Liao, Environmental Health Perspectives 1999).
- An inter-quartile change in PM 2.5 (14.5 $\mu\text{g}/\text{m}^3$) was associated with a reduction in r-MSSD of 4ms for the resting period and 6ms during slow breathing (Gold, Circulation 2000).



Research Objectives

- Determine whether increased levels of $PM_{2.5}$ are associated with decreased heart rate variability (HRV) in susceptible populations.
 - High frequency power is most susceptible to effects of $PM_{2.5}$.
 - Those with compromised cardiac function will demonstrate decline in spectral power.



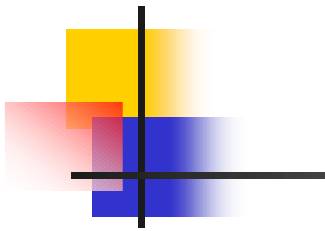
Methods

- Residence Level Measures
- Paced Breathing Protocol
- Exclusion Criteria:
 - Atrial arrhythmias, conduction blocks, paced rhythms and diabetes mellitus.



Results

- 357 HRV measures performed on 41 participants between 2/00 and 3/02.
- Editing and linkage to pollutant measures decreased our total to 285 measures on 34 participants.



Variable	Cardiovascular disease (n= 21) [%]	No CV disease (n= 13) [%]
Age (median, range)	77 (57-85)	78 (72-87)
Male gender	9(43%)	6 (46%)
Race (White)	20 (95%)	12 (92%)
History of MI	9 (43%)	0 (0%)
Angina (Current)	6 (29%)	0 (0%)
CHF (Current)	9 (36%)	0 (0%)
Hypertension	13 (54%)	6 (46%)
B-blockers	12 (57%)	0 (0%)
ACE-inhibitors	9 (43%)	4 (31%)
Calcium Channel	2 (10%)	2 (15%)



Exposure Assessment

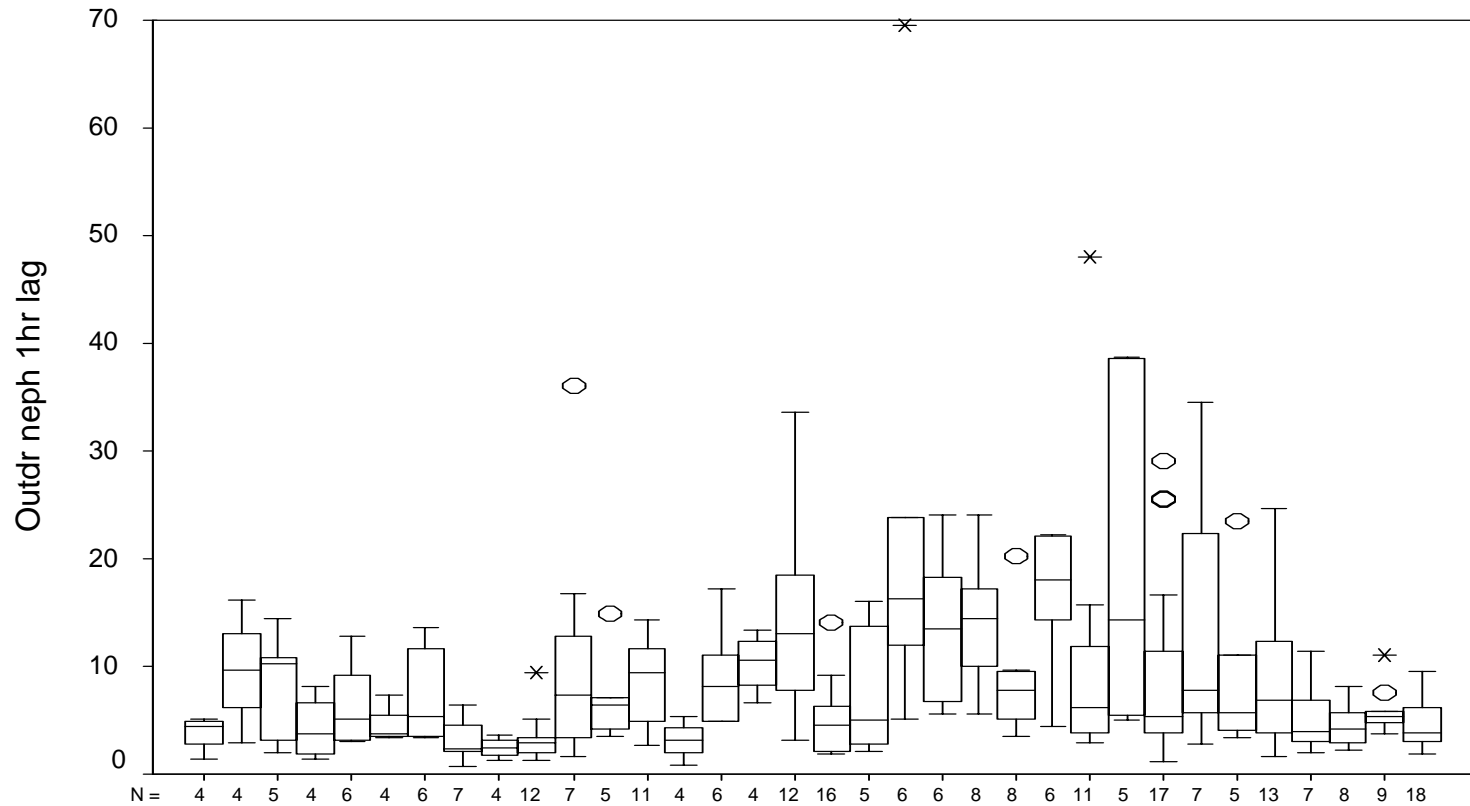
- Residential level nephelometry measures
 - Ten-minute resolution.
 - Analysis of 1-hour, 4-hour and 24-hour average
- Excursions in PM exposure in fall 2000-winter 2001.



**Summary of Exposure Variables 1-hour average
preceding HRV Measure.**

Variable (unit)	Min	25%	50%	75%	90%	Max
⁺ PM _{2.5} (µg/m ³)	3.3	8.0	10.7	15.6	20.9	40.3
CO (ppm)	0.63	0.99	1.22	1.51	1.81	2.50
NO ₂ (ppm)	0.006	0.017	0.021	0.026	0.029	0.046
Temperature	33.5	40.9	46.4	53.3	61.3	69.3
Relative Humidity	45.1	73.5	80.2	84.7	89.1	97.9

Summary of the within Individual Range of PM_{2.5} Exposure over the Study Sessions.





Comparison of Heart Rate and Frequency Domain HRV Measures by Presence or Absence of Known Cardiovascular Disease.

Variable	No CV dz	All CV disease	Prior MI	Current CHF
Heart rate (beats/ minute)	72 (10)	72 (12)	70 (9)	75 (8)
lnLF-HRV [ms²]	5.0 (1.2)	4.2 (1.3)	4.6 (1.3)	3.8 (1.7)
LnHF-HRV [ms²]	5.6 (1.1)	5.0 (1.2)	5.1 (1.2)	4.9 (1.2)

Heart rate is an average resting heart-rate at time of study.

Effect of a 10 microgram increase in fine PM on High Frequency HRV Measures

HRV Measures	Averaging time	CVD % change in median HRV (95%CI)	Non CVD % change in median HRV (95%CI)
CV (n= 21)	1-hr	3 (-19, 32)	-5 (-34, 36)
	4-hr	8 (-16, 38)	-7 (-36, 34)
	24-hr	8 (-19, 43)	-9 (-40, 40)
No CV disease (n= 13)	1-hr	-4 (-11, 4)	5 (-8, 20)
	4-hr	-5 (-12, 3)	7 (-6, 23)
	24-hr	-5 (-13, 3)	3 (-11, 21)



Discussion

- Unable to detect an association between elevated PM and HF-HRV.
- Potential reasons:
 - Range in exposure variability over study
 - Population studied
 - Method of HRV measure
 - PM Composition



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- Study Participants