

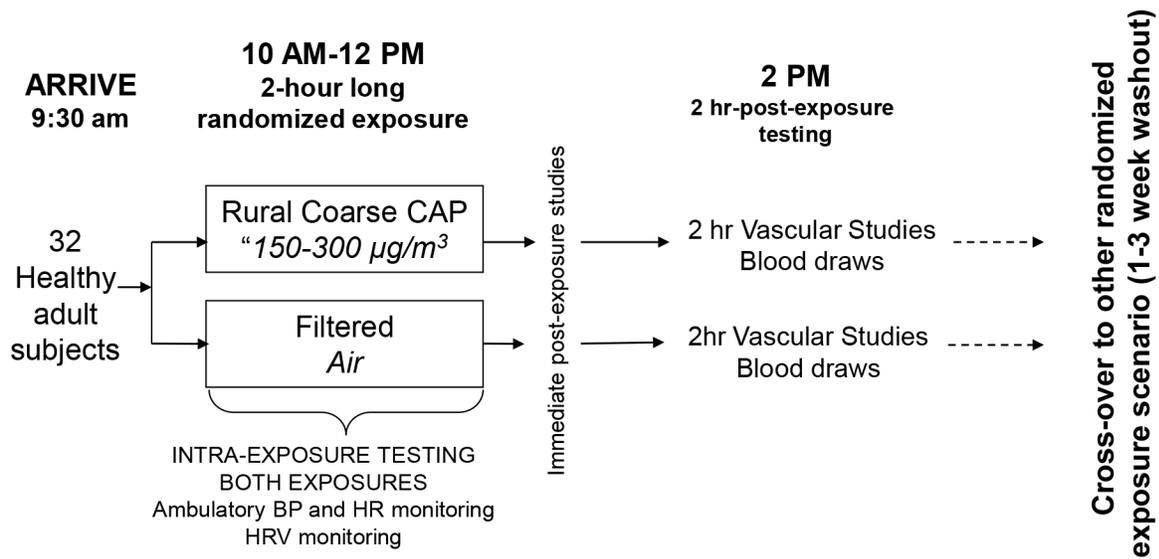
Supplemental Material

Hemodynamic, Autonomic, and Vascular Effects of Exposure to Coarse Particulate Matter Air Pollution from a Rural Location

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Figure S1. Study Flow Outline.



CAP, concentrated ambient coarse particles; BP, blood pressure; HR, heart rate; HRV, heart rate variability

AirCARE-2 Exposure Facility

The mobile facility was constructed within a 16.2 m semitrailer. It contains an electrical power system, heating, and air conditioning. There are 3 rooms (37 m² of total space): a controlled-exposure area, a subject exam/testing room, and an air pollution/exposure measurement laboratory. All rooms, as well as the human exposure chamber itself, are temperature-controlled. A PM₁₀-size selective air flow inlet is mounted approximately 1.5 m on top of the roof of the facility. This leads to stainless-steel ducts that enter the facility from the roof and connect to the 2-stage Harvard virtual impactor coarse concentrator system. Coarse CAP leaves the system in a stainless-steel pipe and enters the air-tight human chamber from the top and delivers air flow via plastic tubing and a facemask at a final rate of 25-28 L/min. A series of pumps (initial intake flow rate of 5000 L/min) and connecting tubing are contained in a trailer outside the facility.

Mixed Models Controlling for Ambient and Chamber Temperature

We performed additional mixed models (using models 1 and model 2) after controlling for ambient and chamber temperatures (included as a covariate in the models):

In this scenario we are interested to see if ambient or intra-chamber temperature is a confounder to the effect of exposure-type (CAP versus FA) on the health responses during exposures.

Results for BP outcomes are the change per 10 minutes of exposure of CAP vs. FA exposures.

Results for heart rate are the mean differences throughout the CAP versus FA exposure period.

Ambient temperature during period of exposures

Systolic BP 0.32 (0.14 standard error [SE]), p=0.020

Diastolic BP 0.27 (0.14), p=0.049

Heart rate 4.41 (0.56), p<0.0001

Intra-chamber temperature during period of exposures

Systolic BP 0.32 (0.14), p=0.020

Diastolic BP 0.27 (0.14), p=0.050

Heart rate 4.56 (0.55), p<0.0001

Mixed Models for Effect Modification by Ambient PM

Ambient PM_{2.5} levels were obtained from the local monitoring station at the Dexter site. Values were averaged for the 24-hour period prior to each subjects' CAP and FA exposures. We evaluated if ambient fine PM levels that subjects were exposed to during the prior 24 hours affect the subjects' responses to controlled exposures. In other words, do subjects have greater or lesser BP or heart rates responses to CAP exposures depending upon their previous day-long exposures

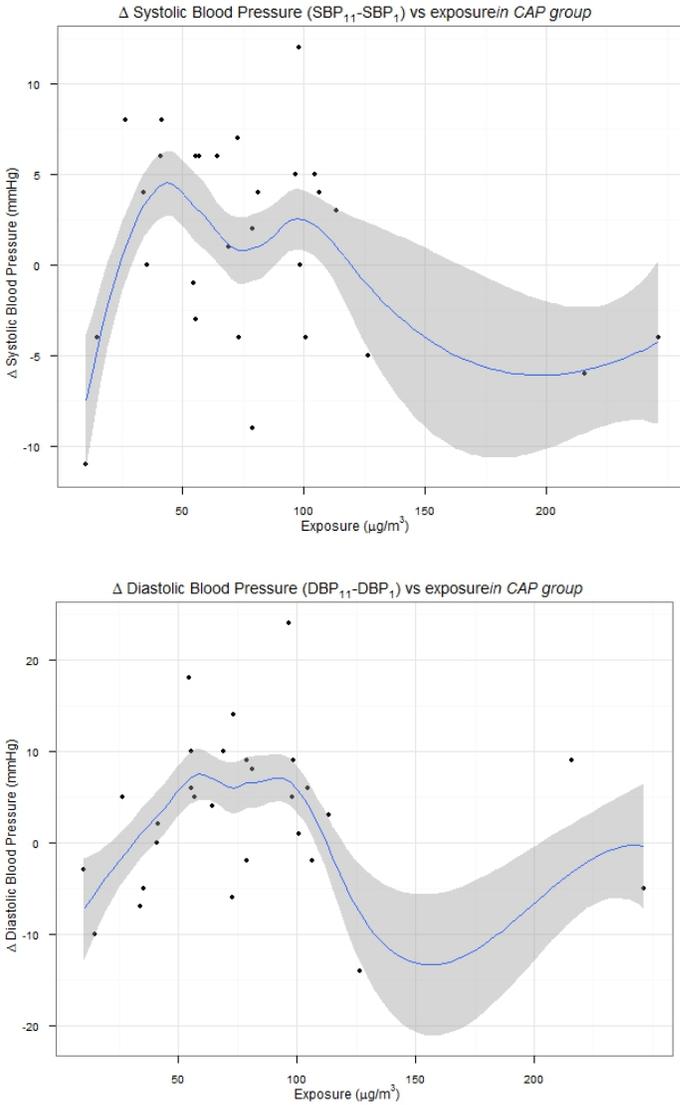
to ambient PM_{2.5}. In this scenario, there is no time-varying potential confounding with ambient PM_{2.5} (like there might be with temperature), therefore we are not treating it as a covariate (or confounder) in the model. The results are the interaction terms in model 1 for systolic and diastolic BP (time x exposure type x ambient PM_{2.5}) or model 2 for heart rate (exposure x ambient PM_{2.5}). The units of PM_{2.5} are per 1 μm^3

Systolic BP -0.045 (0.036), p=0.22

Diastolic BP 0.032 (0.037), p=0.38

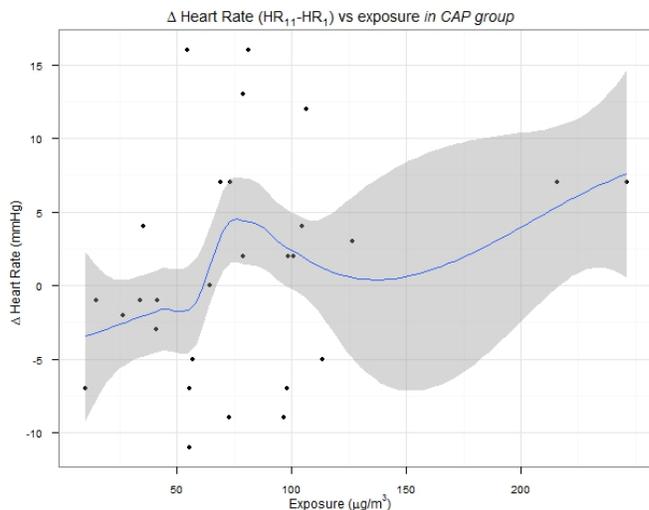
Heart rate -0.33 (0.045), p<0.082

Figure S2. Association of systolic and diastolic blood pressure changes with coarse particle mass concentration during particle exposures.



The figure presents the association of the intra-individual changes in blood pressure (values at time 110 minutes minus values at time 10 minutes of exposure) with the coarse particle mass (average level throughout the 2-hour long CAP exposures). The nonparametric regression curve was estimated using local regression (loess) models, with shading representing the 95% confidence intervals.

Figure S3. Association of heart rate changes with coarse particle mass concentration during particle exposures.



The figure presents the association of the intra-individual changes in heart rate (values at time 110 minutes minus values at time 10 minutes of exposure) with the coarse particle mass (average level throughout the 2-hour long CAP exposures). The nonparametric regression curve was estimated using local regression (loess) models, with shading representing the 95% confidence intervals.

The nature of the dose-response relationship cannot be fully-explored given the relatively small size of the study and that fact that we did not achieve the anticipated concentration of coarse CAP in many of our exposures; hence, relatively few patients were exposed to values >100 μg/m³. The precise nature of the full dose-response curve will require additional investigations. Nonetheless, we believe that the available results suggest that there may be a threshold concentration (between 30-60 μg/m³ where responses became significantly [> 0 change in the biological outcome in the figures]) required to mediate the BP- and heart rate-raising effects of PM_{2.5-10}. BP levels tended to increase thereafter by a greater amount in association with higher

coarse PM concentrations until a plateau was reached ($\sim 100 \mu\text{g}/\text{m}^3$) for the BP responses. On the other hand, a clear plateau of effect was not apparent in regards to the heart rate increases. However, there were few exposures $> 100 \mu\text{g}/\text{m}^3$ and therefore whether or not a real plateau of effect for BP changes is present will require follow-up coarse CAP exposures studies.

Table S1. Mean ambient particulate matter levels during the day prior to controlled exposures.

Controlled exposure	Number of observations	Mean \pm SD ($\mu\text{g}/\text{m}^3$)
PM_{2.5}		
CAP	31	8.2 \pm 5.3
Filtered air	31	7.8 \pm 3.7
PM₁₀		
CAP	17	14.9 \pm 8.0
Filtered air	18	15.0 \pm 8.2

Concentrations are the particle mean and standard deviation ($\mu\text{g}/\text{m}^3$) levels measured by TEOM.

The PM levels represent ambient concentrations during the 24-hour day prior to controlled exposures (lag day = 1). These were the exposures that could have had an impact on basal cardiovascular outcomes prior to exposures (pre-exposure values) and could have modified the biological responses to controlled exposures.

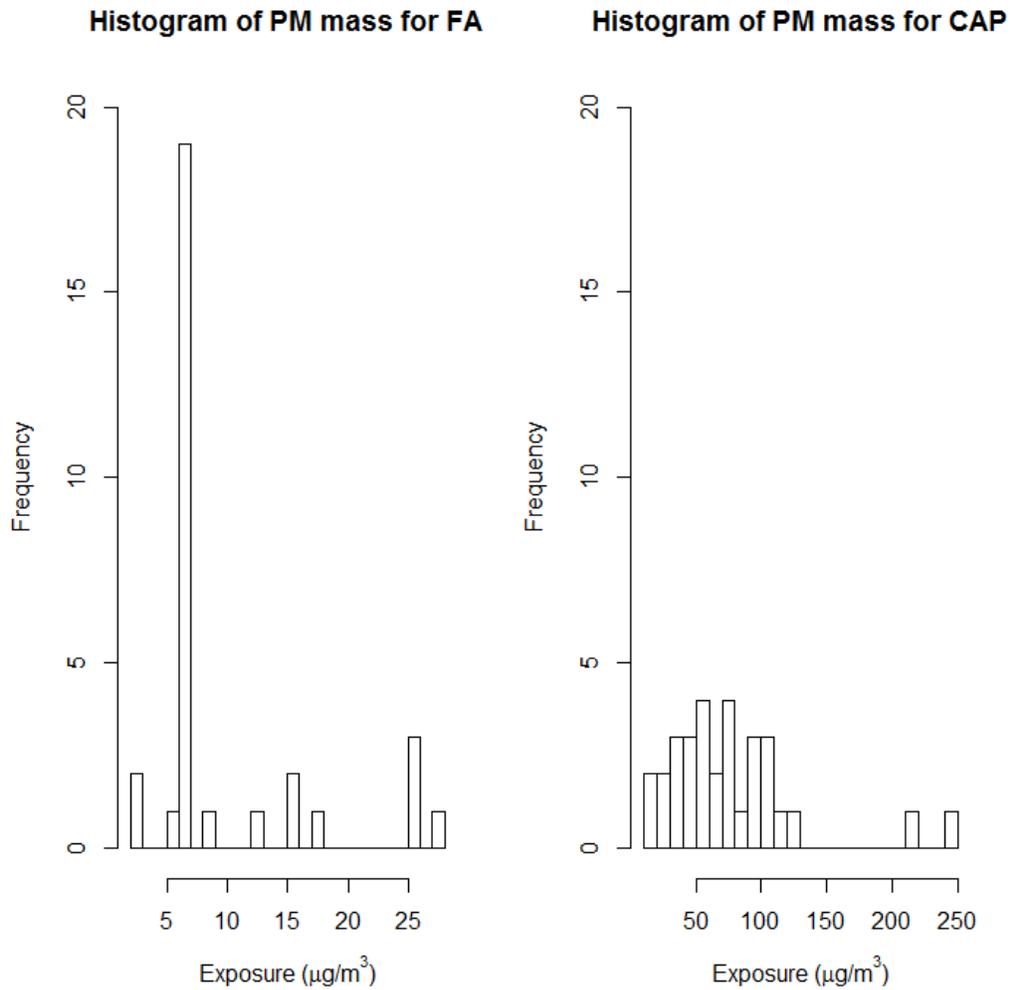
Comparisons of means between the 2 days are $p = 0.072$ and $p = 0.95$ for PM_{2.5} and PM₁₀ respectively by 2 sample t-tests.

Table S2. Coarse PM levels for each subject during exposure types.

Subject ID	CAP ($\mu\text{g}/\text{m}^3$)	FA ($\mu\text{g}/\text{m}^3$)
1	64.3	6.8
2	100.7	
3	33.9	6.8
4	10.3	6.8
5	216.1	25.6
6	54.4	8.2
7	68.9	6.8
8	73	12.6
9	113.7	6.8
10	55.7	25.1
11	73.5	17.2
12	98.1	25.7
13	98.7	6.8
14	39.1	6.8
15	246.5	15.2
16	35.2	6.8
17	104.7	6.8
18	56.7	27.4
20	26.7	6.8
21		6.8
22	81.1	2.6
23	44.5	6.8
24	126.4	6.8
25	96.7	6.8
26	55.3	6.8
27	106.6	6.8
28	78.8	2.7
29	79	6.8
30	40.8	6.8
33	26.3	15.7
35	14.8	6.8
37	41.7	5.2

The results are the 2-hour average PM mass levels during the individual exposures for each subject. On all exposure occasions, the PM mass was higher in the CAP compared to the FA exposures for each individual subject.

Figure S4. Distribution of coarse PM levels during CAP and FA exposures.



The results in Figure S4 represent the distribution of PM mass levels in the individual CAP and FA exposures for all exposures performed. The majority of values were $<10 \mu\text{g}\cdot\text{m}^{-3}$ during FA exposures. The figure shows an overall higher distribution of PM mass values during CAP exposures.

Table S3. Study outcomes and differences measured post-exposures.

Outcome	Coarse CAP: Immediate-post	Coarse CAP: 2 hours-post	Filtered Air: Immediate-post	Filtered Air: 2 hours-post	p^a	p^b	Difference between CAP and FA Immediate-post	Difference between CAP and FA 2 hours-post
Brachial SBP (mm Hg)	109 (101, 114)	108 (101, 113)	110 (99.5, 118)	107 (102.5, 117)	0.66	0.65	0.63 (-2.28, 3.55)	-0.60 (-3.23, 2.03)
Brachial DBP (mm Hg)	71.0 (66.0, 79.5)	67.0 (61.0, 75.5)	71.0 (64.5, 79.0)	66.0 (62.5, 73.0)	0.72	0.61	0.50 (-2.30, 3.30)	-0.57 (-2.80, 1.67)
Heart Rate (beats/min)	62.0 (57.0, 68.5)	64.0 (61.0, 71.5)	60.0 (55.0, 66.5)	61.0 (55.5, 67.0)	0.12	0.03	2.33 (-0.53, 5.20)	3.57 (0.45, 6.68)
Aortic SBP (mm Hg)	98.0 (88.5, 102.5)	94 (86, 101)	98 (87, 104)	92 (88, 101)	0.94	0.49	-0.10 (-2.90, 2.70)	-0.83 (-3.28, 1.61)
AP (mm Hg)	3 (1, 5)	2 (1, 4.75)	4 (1, 6)	2 (-1, 5.5)	0.63	0.26	-0.24 (-1.25, 0.77)	-0.62 (-1.72, 0.48)
AIx@75 (%)	8 (-1.75, 14.75)	1 (-4.50, 10.25)	9 (-1.5, 13.0)	2 (-14, 15)	0.80	0.94	0.41 (-2.82, 3.65)	-0.14 (-3.93, 3.65)
PWV (m/sec ²)	6.60 (5.55, 7.85)	6.50 (5.55, 7.15)	6.35 (5.60, 7.40)	6.00 (5.50, 7.85)	0.96	0.19	-0.08 (-0.45, 0.43)	-0.33 (-0.66, 0.14)
BAD (cm)	3.45 (3.32, 3.77)	3.50 (3.32, 3.81)	3.54 (3.38, 3.88)	3.48 (3.34, 3.95)	0.12	0.15	-0.07 (-0.16, 0.02)	-0.06 (-0.15, 0.02)
FMD-peak (%)		9.3 (6.3, 12.1)		8.2 (6.2, 10.9)		0.68		0.35 (-1.34, 2.03)
RHI		2.1 (1.8, 2.2)		2.0 (1.7, 2.4)		0.57		0.08 (-0.15, 0.32)

Results are presented as median (interquartile range).

Differences are the (CAP-FA difference) presented as the mean (95% confidence interval)

^ap values are comparisons of immediate-post exposures (CAP vs. FA); ^bp values are comparisons of 2 hours-post exposures (CAP vs. FA).

Paired t-tests were used for all statistical comparisons except for FMD and RHI (Wilcoxon Ranked Sum Tests).