

Examining the Brachial Artery Reactivity Curve Measured by B-Mode Ultrasound in the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) Pilot Study

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ABSTRACT Brachial artery reactivity was assessed in the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) Pilot Study using B-mode ultrasound. Carotid artery intima-media thickness (CIMT), a known subclinical predictor of cardiovascular disease, also was examined in relation to brachial artery reactivity. A continuous scan was performed on the artery for 8 min (1 min of baseline, 4 min of cuff inflation at 40 mmHg greater than systolic pressure, 3 min after cuff release).

The sample for analysis ($n = 78$; 43 men, 35 women) consisted of active-duty police officers from a larger sample in the BCOPS pilot study. Means and standard deviations (SDs) stratified by gender were calculated, along with Pearson's correlations between brachial variables, and with CIMT. Arterial diameters (baseline, pre-cuff release, peak) were significantly different ($p < 0.001$) between men and women. Peak arterial dilation occurred at 50.77 ± 21.97 sec (49.67 ± 20.22 cardiac cycles) after cuff deflation in men, and 44.66 ± 24.07 sec (44.57 ± 20.36 cardiac cycles) after cuff deflation in women. Mean common carotid artery IMT and mean maximum IMT of all carotid sites were significantly correlated ($p < 0.01$) in men ($r = 0.691$) and women ($r = 0.450$). Brachial reactivity measures were inversely correlated with CIMT in women, and in contrast, positively correlated in men.

Introduction

An effective subclinical means of assessing endothelial function, in a noninvasive manner, is through the examination of brachial artery vasodilation.¹⁻⁴ It also has been demonstrated that assessment of the endothelial function of peripheral arteries (such as the brachial artery) may provide important information about the condition of the coronary arteries and may be an independent predictor of the risk of future cardiovascular disease (CVD) events.⁵⁻⁷

Because of the differing methods used in the study of brachial artery reactivity, there is further need for developing a standardized method for assessing brachial artery vasodilation. This method would need to

demonstrate consistency, reliability, and validity if it is to be used as a research and clinical tool.^{8,9} Endothelial dysfunction, which is an early subclinical marker of CVD, can be assessed by measuring the vasodilatory capacity of the artery.^{1,4}

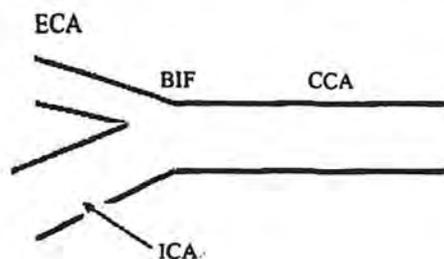
Brachial artery reactivity, used as a measure of endothelial function, is conducted through the use of B-mode ultrasound to observe changes in the artery diameter after the use of an occlusive pressure on the artery (blood pressure cuff inflated on the forearm for a specified duration of time), causing reactive hyperemia in the vessel and arterial dilation upon deflation of the cuff. Flow-mediated dilation (FMD) assesses endothelium-dependent reactivity (functional changes) of the artery. Some measures of vasodilatory response that can be obtained using brachial artery reactivity studies are dilation measures (such as the peak diameter of the artery after cuff deflation, and the percentage change in arterial diameter at peak compared with baseline diameter) and time taken to reach this diameter. However, to obtain these data, researchers have manipulated factors, such as levels of occlusion pressure, duration of occlusion, duration of scan after cuff deflation, the position of occlusion pressure on the arm (upper versus lower arm), and choice of intermittent or continuous scans.

Studies that measured the maximum (peak) diam-

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ECA – External Carotid Artery

BIF – Bifurcation

ICA – Internal Carotid Artery

CCA – Common Carotid Artery

Figure 1

Diagram of the carotid artery system, identifying the common carotid, the bifurcation, and the internal and external carotid branches.

eter of the brachial artery documented that this increase took place after 60 sec of cuff release or 45–60 sec of reactive hyperemia.^{10,11} However, it should be noted that these estimates were made by taking readings at designated intervals after cuff deflation (without actually measuring the time to peak diameter) and without the use of a continuous scan, thus making this determination an “estimate” rather than a true measure of the time to peak diameter of the brachial artery.

To use brachial artery FMD as an early subclinical marker of CVD, there first needs to be documentation of successful reproducibility of such studies and the establishment of standardized techniques. In summary, brachial artery reactivity studies conducted thus far have lacked standardization in many regards. It is unclear, however, the extent to which modifications of any one or all of these factors could affect the accuracy as well as the significance of the results obtained.

Brachial Artery Reactivity Curve

It is possible to analyze the entire brachial reactivity curve when continuous scanning is used throughout the brachial study. This enables us to better understand the process of the reactive mechanism and then analyze the significant portions of the curve with the entire time sequence available for analysis. However, it also should be emphasized that even with the entire curve available, the “noise” within the various points on the graph still makes it difficult to visually ascertain the time of peak diameter unless statistical methods are used to smooth this curve. Analysis of trends in the reactivity curve enable us to determine which aspects of this curve (such as time to peak, peak dilation, percent dilation from baseline, percent dilation from pre-cuff release diameter) contribute the most useful information to assess the existence of subclinical disease.

Carotid Artery Intima-Media Thickness

Carotid artery intima-media thickness (CIMT), as obtained by B-mode ultrasound, has been demonstrated to be a useful tool in predicting cardiovascular disease outcomes, clinical coronary outcomes, and in

monitoring the progression of arterial wall thickness over the course of time.^{12–17} Locations along the artery that are primarily studied are the common carotid artery (CCA), at the bifurcation of the artery into the internal and external carotid and in the internal carotid artery (Figure 1). On the ultrasound screen, the combined intimal and medial layers are visualized as a “double line” pattern on the inner lumen of the vessel. Median CIMT values are in the range of 0.4 to 1.0mm; and the rates of progression of IMT thickness are between 0.01 and 0.3 mm per year determined from the Atherosclerosis Risk in Communities Study (ARIC).^{14,18} Therefore, there has been recent interest in assessing these 2 subclinical markers simultaneously—CIMT (mean CCA IMT and maximum IMT) with brachial artery reactivity, where an inverse relationship has been observed between CIMT and brachial artery reactivity.^{19–22} The availability of both brachial reactivity and CIMT data in the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) Pilot Study enabled assessment of the brachial reactivity curve and its relationship with CIMT.



Figure 2

Image of the brachial artery, showing tracings drawn with ImagePro Plus software to delineate the media-adventitia boundaries on the near and far walls. Arterial diameter (CT1) is the average distance between the two horizontal tracings (T3 and T4); which, in this example, is equal to 5.291 mm.

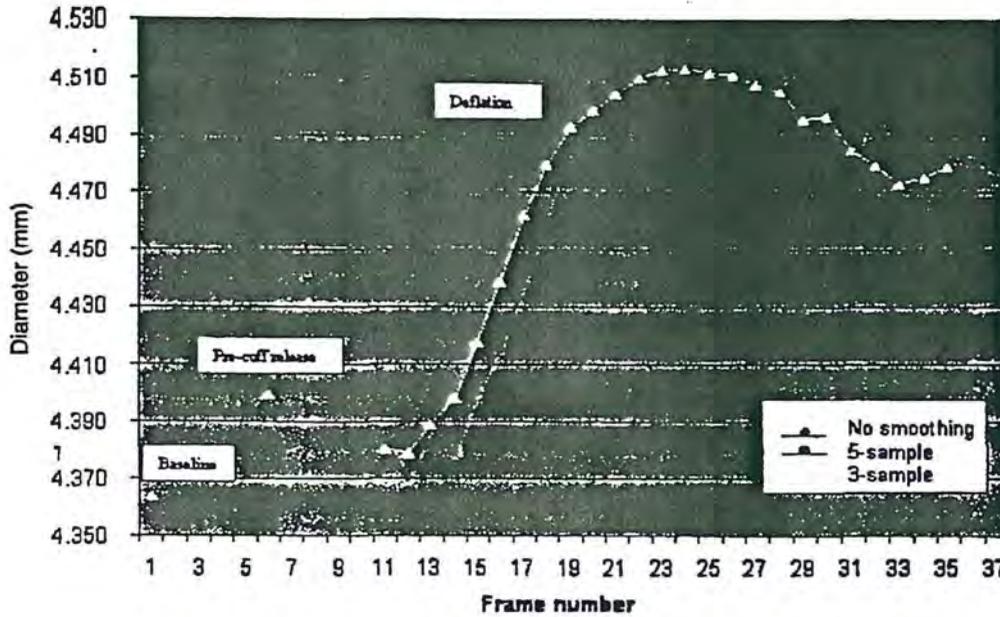


Figure 3

Depiction of the brachial reactivity curve for 78 participants in the BCOPS pilot study over the 1-min baseline, 4-min inflation, and 3-min of cuff deflation. The single baseline value represents an average of 5 frames obtained during the 1-min baseline. The pre-cuff release value represents an average of 5 frames obtained during the last 30 sec of the 4-min inflation phase of the scan. Post-cuff release values were obtained during the 3-min period of cuff deflation, 3 cardiac cycles apart. The figure also demonstrates the impact of using smoothing techniques on the reactivity curve using 3-sample and 5-sample moving averages.

Materials and Methods

The BCOPS pilot study was designed to establish a working methodology and protocol for a larger police study to be conducted in Buffalo, New York. The ultrasound components of this study that were used to measure both brachial artery reactivity and CIMT were adopted from the protocol used at the Center for Medical Ultrasound, at Wake Forest University School of Medicine in North Carolina.²³ Sonographers conducting the scans were trained and certified by the Ultrasound Center at the Bowman Gray School of Medicine at Wake Forest University on this standardized protocol. Ultrasound scans were performed using the Biosound Esaote AU5 ultrasound imaging machine (Indianapolis, IN) with 10-MHz (brachial) and 7.5-MHz (CIMT) transducers and were read at a central reading site at Wake Forest University.

The pilot study was composed of 100 active-duty police officers in the Buffalo Police Department, with the baseline visit having taken place in the year 2000. The ultrasound component (CIMT and brachial artery reactivity) was conducted during the second on-site visit between November 2001 and April 2003. The sample consisted of officers who ranged in age from 29 to 64 years (at baseline visit). There were 57 men and 42 women in the ultrasound component of the study. A total of 99 officers were scanned, with 94 receiving both CIMT and brachial scans and 5 receiving the CIMT scan only (because of exclusion criteria, detailed within). All officers signed

University at Buffalo Health Sciences Institutional Review Board-approved informed consent forms for participation in the study before any testing was performed.

To be eligible for the CIMT scan, the officers had to be free of history of heart attack, stroke, bypass surgery, carotid artery endarterectomy, transient ischemic attack (TIA), and doctor-diagnosed coronary artery disease (CAD). In addition, for the brachial artery reactivity portion of the scan, participants

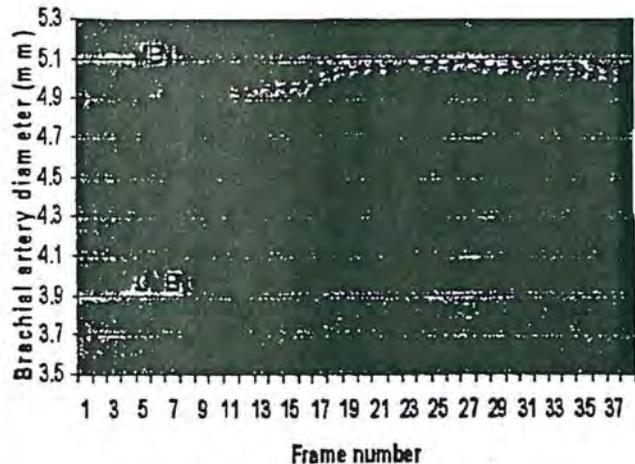


Figure 4

Comparison of the brachial artery reactivity curves between men and women in the BCOPS pilot study.

Table 1

Characteristics of the Sample of Police Officers in the BCOPS Pilot Study: The Sample Includes Only Those Officers for Whom Both Brachial Reactivity and CIMT Data Were Available (n = 78)

	Total (n = 78)	Men (n = 43)	Women (n = 35)	P Values
Age (years)	44.09 (SD 7.53)	44.14 (SD 9.07)	44.03 (SD 5.89)	NS
Race				
White	61 (78.21%)	35 (81.40%)	26 (74.29%)	p < 0.05
African-American	13 (16.67%)	4 (9.30%)	9 (25.71%)	
Hispanic	4 (5.13%)	4 (9.30%)	0 (0.0%)	
Education				
High school	11 (14.10%)	6 (13.95%)	5 (14.28%)	NS
GED	1 (1.18%)	0 (0.00%)	1 (2.85%)	
Some college	22 (28.21%)	11 (25.58%)	11 (31.43%)	
Assoc. degree	19 (24.36%)	13 (30.23%)	6 (17.14%)	
Bachelor's degree	21 (26.92%)	11 (25.58%)	10 (28.57%)	
Graduate	4 (5.13%)	2 (4.65%)	2 (5.71%)	
Rank				
Police officer	27 (34.62%)	19 (44.19%)	18 (51.43%)	NS
Sergeant	1 (1.28%)	1 (2.33%)	0 (0.00%)	
Lieutenant	14 (17.95%)	8 (18.60%)	6 (17.14%)	
Captain	7 (8.97%)	5 (11.63%)	2 (5.71%)	
Detective	12 (15.38%)	8 (18.60%)	4 (11.43%)	
Other	7 (8.97%)	2 (4.65%)	5 (14.29%)	
Physical measures				
Height (cm)	173.66 (9.52)	179.60 (7.44)	166.37 (6.11)	p < 0.001
Weight (kg)	84.85 (15.80)	92.24 (12.46)	75.77 (14.74)	p < 0.001
BMI (kg/m ²)	28.03 (4.25)	28.58 (3.44)	27.37 (5.05)	NS
Percent body fat (%)	27.09 (7.25)	23.09 (4.82)	31.88 (6.78)	p < 0.001
Systolic BP (mmHg)	118.06 (13.84)	121.81 (13.26)	113.46 (13.31)	p = 0.007
Diastolic BP (mmHg)	77.03 (8.28)	79.91 (6.66)	73.49 (8.78)	p < 0.001
Total cholesterol (mg/dL)*	191.03 (38.88)	195.47 (37.97)	185.40 (39.93)	NS
Glucose (mg/dL)*	93.69 (13.98)	97.95 (16.13)	88.30 (8.15)	p = 0.004

*n = 68, data obtained at visit 1 (baseline visit); men = 38, women = 30.

were excluded if they had a previous history of mastectomy, removal of lymph nodes, Raynaud's syndrome, diabetes with insulin pump, kidney dialysis, use of blood thinners, taking high doses of aspirin/NSAIDs, and any other heart condition or circulatory disorder.

To measure brachial artery reactivity, a continuous scan was performed on the artery during baseline (1

min), during the occlusion period (4 min), and after occlusion (3 min). Brachial artery diameter has been defined for this study as the maximum distance between the "trailing edge" of the adventitia-media interface of the near wall and the "leading edge" of the media-adventitia interface of the far wall (Figure 2). This specific definition is used for all measurements to ensure standardization of all readings. The level of

Table 2

Brachial Artery Reactivity and CIMT Variables in the BCOPS Pilot Study

Variable	Total (n = 78) Mean (SD)	Men (n = 43) Mean (SD)	Women (n = 35) Mean (SD)
Baseline diameter (mm)*	4.36 (0.77)	4.89 (0.51)	3.71 (0.49)
Pre-cuff release diameter (mm)*	4.55 (0.79)	4.95 (0.51)	3.72 (0.51)
Maximum diameter, post-cuff release (mm)*	4.40 (0.79)	5.10 (0.50)	3.87 (0.51)
Cardiac cycle at maximum diameter, post-deflation	47.38 (20.31)	49.67 (20.22)	44.57 (20.36)
Heart rate (beats/min)	60.81 (7.90)	59.74 (8.41)	62.11 (7.14)
Time to peak (sec)	48.02 (22.99)	50.77 (21.97)	44.66 (24.07)
Absolute dilation from baseline (mm)	0.19 (0.14)	0.21 (0.16)	0.16 (0.12)
Percent dilation from baseline (%)	4.41 (3.40)	4.41 (3.41)	4.42 (3.45)
Absolute dilation from pre-cuff release diameter (mm)	0.15 (0.11)	0.16 (0.12)	0.15 (0.11)
Percent dilation from pre-cuff release diameter (%)	3.53 (2.75)	3.24 (2.48)	4.16 (3.01)
Mean CCA IMT (mm)	0.65 (0.11)	0.66 (0.12)	0.63 (0.09)
Mean maximum IMT (mm)	0.86 (0.16)	0.87 (0.16)	0.84 (0.16)

*p < 0.001 (independent samples t-test for gender differences).

occlusive pressure chosen for the BCOPS pilot study was a cuff inflation of 40 mm greater than the participant's resting systolic blood pressure, with an upper limit of 230 mmHg. In this study, cuff inflation pressure ranged from 132 mmHg to 201 mmHg (mean cuff inflation of 166.51 mmHg in men, 153.83 mmHg in women). Even though there is a range of cuff inflation used, the standardized component of the protocol is that the level of cuff inflation is consistent for each participant relative to the systolic blood pressure obtained prior to the scan. Additionally, the brachial reactivity scan was performed after the carotid scan, to measure CIMT. Therefore, all participants were resting for approximately 30 min before the start of the brachial scan.

To obtain CIMT measures, scans were performed on the right and left sides of the extracranial carotid artery, with images obtained for 1-cm segments of the near and far walls of the CCA, bifurcation (BIF), and internal (ICA) carotid arteries at 3 different angles on each side of the neck (total of 36 images: 2 sides \times 3 angles \times 6 images per angle). For analysis, CIMT variables used are the mean CCA IMT (average of the IMT measures from the near and far wall of the common carotid) and mean maximum IMT (average of the maximum IMT obtained from all sites).

Also obtained during the clinic visit were demographic information, cortisol measures (from saliva), body composition/bone density measures (using dual energy x-ray absorptiometry), anthropometric measures (height/weight, abdominal height, waist circumference, resting pulse, systolic and diastolic blood pressure, physical activity (Stanford Activity questionnaire²⁴), alcohol and dietary consumption, and smoking history.

Statistical Methods

Descriptive information available for the analysis includes variables such as age, gender, race, height, weight, body mass index, body fat percent, blood pressure, total cholesterol, and glucose. Descriptive analysis was conducted and presented in tabulated form with corresponding means and standard deviations.

Data from the brachial artery scans were used to calculate estimates of peak dilation of the artery (difference between both baseline and pre-cuff release diameters compared with peak diameter), percentage change in arterial diameter (compared with baseline and pre-cuff release diameters), and the time to peak dilation of the artery (estimated by the cardiac cycle at maximum diameter). Pearson's correlation also was used to determine the correlation between brachial variables.

Because CIMT data also are available for this study sample, it was possible to examine the relationship between the brachial artery variables (discussed previously) and CIMT parameters (maximum IMT, mean maximum IMT of CCA/bifurcation/ICA segments) and to determine the level of correlation (using Pear-

son's correlation) between brachial and CIMT variables. Statistical significance was determined at the level of $\alpha < 0.05$ (2-tailed test).

Results

Clear readable data were available for 81 brachial reactivity and 98 carotid IMT scans in the BCOPS pilot study. A total of 13 brachial scans were not included in the analysis because the scans were difficult to read as the result of vessel movement or lacked clear EKG tracings to standardize image capture for reading. Additionally, because our interest was in examining brachial reactivity and CIMT together, the sample for data analysis was reduced to include only those participants for whom both brachial and CIMT data was available ($n = 78$).

The composite brachial curve (men and women) is presented in Figure 3. The brachial curves also are presented separately for men ($n = 43$) and women ($n = 35$) but are shown together on the same grid (Figure 4) to demonstrate the overall differences in the curves between men and women based on diameter differences in the brachial artery.

The characteristics of this sample ($n = 78$), both as a whole, and stratified by gender are shown in Table 1. Independent sample t-test and chi-square tests were used to evaluate the differences in these variables between men and women, and corresponding p values also are presented in Table 1. The overall age of this sample was 44.09 ± 7.53 years, average age of men was 44.14 ± 9.07 years, and women was 44.03 ± 5.89 years. A test for the interaction effect of gender on the relationship between brachial/CIMT variables and CVD risk factors also was conducted using a regression model, which was determined to be statistically significant ($p < 0.05$); all further analyses examined men and women separately.

Brachial Artery Reactivity

For data analysis of the brachial curve, the curves were smoothed by fitting a nonparametric regression model using the LOESS method implemented in SAS PROC LOESS.²⁵ The description of brachial and CIMT variables for men and women are summarized in Table 2. Brachial variables presented are the diameters of the brachial artery, cardiac cycle at maximum diameter (which is used as a measure of "time to peak"), heart rate, absolute and percent dilation of the artery from both baseline, and pre-cuff release diameters. All arterial diameter measures (baseline, pre-cuff release, and maximum diameter after cuff deflation) were significantly different between men and women ($p < 0.001$). Carotid IMT variables examined in the analysis were the mean CCA IMT and the mean maximum IMT of the carotid artery (Table 2). No significant ($p < 0.05$) differences in CIMT were observed between men and women.

As a means of examining the data from this study in relation to other studies that have selected a specific

Table 3

Correlations Between Brachial Artery Reactivity Variables and CIMT in Men in the BCOPS Pilot Study

Men (n = 43)	Baseline Mean Diameter (mm)	Pre-cuff Release Mean Diameter (mm)	Maximum Diameter (mm)	Cardiac Cycle at Maximum Diameter
Baseline mean diameter (mm)	1			
Pre-cuff release mean diameter (mm)	0.982†	1		
Maximum diameter (mm)	0.953†	0.975†	1	
Cardiac cycle at maximum diameter	0.104	0.096	0.053	1
Heart rate (beats/min.)	-0.137	-0.201	-0.224	0.021
Absolute dilation from baseline (mm)	-0.235	-0.107	0.072	-0.171
Percent dilation from baseline (%)	-0.352*	-0.226	-0.052	-0.187
Absolute dilation from pre-cuff release diameter (mm)	-0.269	-0.254	-0.031	-0.198
Percent dilation from pre-cuff release diameter (mm)	-0.385*	-0.375*	-0.159	-0.224
Mean CCA IMT (mm)	0.036	0.086	0.087	-0.144
Mean maximum IMT (mm)	-0.037	-0.001	0.057	-0.249

time to study peak (i.e., 60 sec after cuff deflation), there was interest in having an estimate of the "clock" time to peak, in seconds. Because data were available for heart rate (beats/min) and the cardiac cycle at maximum diameter, it was possible to calculate time to peak in seconds, which is equivalent to $[(1/\text{heart rate}) \times 60] \times (\text{cardiac cycle at maximum diameter})$. It is therefore estimated that peak dilation occurred at 50.77 ± 21.97 sec after cuff deflation in men and 44.66 ± 24.07 sec after cuff deflation in women ($p = 0.16$) (Table 2).

Correlations between brachial variables, stratified by gender are depicted in Table 3 and Table 4. In men, baseline artery diameter is significantly correlated with pre-cuff release diameter ($r = 0.982$), maximum diameter ($r = 0.953$), percent dilation from baseline ($r = -0.352$), and percent dilation from pre-cuff release diameter ($r = -0.385$). In women, baseline artery diameter also is significantly correlated with pre-cuff release diameter ($r = 0.987$), and maximum diameter ($r = 0.970$), whereas correlations between baseline diameter and percent dilation from both baseline and pre-cuff release diameters are of lower magnitude and not statistically significant.

CIMT and Brachial Artery Reactivity.

Mean CCA IMT and mean maximum IMT were significantly correlated ($p < 0.01$) in men ($r = 0.691$) and women ($r = 0.450$; Tables 3 and 4). In men, the mean maximum IMT was significantly correlated only with arterial dilation from baseline. The correlations of the mean maximum IMT with other absolute and percent brachial reactivity variables were not statistically significant; however, the trend appears to be positive. In contrast, these relationships were inversely correlated in women, and statistically significant ($p < 0.05$) for the correlation between mean maximum IMT and dilation (absolute and percent) from pre-cuff release diameter.

Discussion

The BCOPS pilot sample enabled us to analyze the brachial artery reactivity curve, and to examine separate components of this curve in relation to CIMT. In the past, studies have not had the complete data necessary to be able to analyze the reactivity curve in this manner.

Table 4

Correlations Between Brachial Artery Reactivity Variables and CIMT in Women in the BCOPS Pilot Study

Women (n = 35)	Baseline Mean Diameter (mm)	Pre-cuff Release Mean Diameter (mm)	Maximum Diameter (mm)	Cardiac Cycle at Maximum Diameter
Baseline mean diameter (mm)	1			
Pre-cuff release mean diameter (mm)	0.987†	1		
Maximum diameter (mm)	0.970†	0.979†	1	
Cardiac cycle at maximum diameter	-0.305	-0.248	-0.215	1
Heart rate (beats/min.)	0.039	0.015	-0.009	-0.449†
Absolute dilation from baseline (mm)	0.034	0.125	0.277	0.318
Percent dilation from baseline (%)	-0.091	0.002	0.153	0.314
Absolute dilation from pre-cuff release diameter (mm)	-0.109	-0.127	0.077	0.167
Percent dilation from pre-cuff release diameter (mm)	-0.275	-0.300	-0.102	0.163
Mean CCA IMT (mm)	-0.078	-0.029	-0.085	0.368*
Mean maximum IMT (mm)	0.215	0.217	0.144	-0.135

Table 3

Continued

Heart Rate (beat/min)	Absolute Dilation From Baseline (mm)	Percent Dilation From Baseline (%)	Absolute Dilation From Pre-cuff Release Diameter (%)	Percent Dilation From Pre-cuff Release Diameter (%)	Mean CCA IMT (mm)	Mean Maximum IMT (mm)
1						
-0.264	1					
-0.255	0.986†	1				
-0.069	0.785†	0.781†	1			
-0.042	0.753†	0.775†	0.985†	1		
-0.171	0.160	0.140	-0.010	-0.043	1	
-0.199	0.303*	0.295	0.241	0.228	0.691†	1

*Correlation is significant at the 0.05 level (2-tailed).

†Correlation is significant at the 0.01 level (2-tailed).

There are significant differences in the components of brachial reactivity curve (baseline, pre-cuff release, and peak diameter) between men and women. This study also allowed us to further examine the pre-cuff release diameter measure, which is obtained during the last 30 sec of the 4-min period of cuff inflation. Because visually there appears to be a difference between baseline and pre-cuff release diameter on the brachial curve, it was of interest to examine whether these differences were in fact real. In analysis, it was possible to determine that there were highly significant correlations between the baseline diameter and this pre-cuff release diameter. Significant correlations in women between the pre-cuff release dilation percent variable and CIMT (the known subclinical CVD marker), suggests incorporation of this measure in studies of brachial reactivity, which has not been previously examined in the literature.

Previous studies have also used "clock time" as a means of determining the time of peak dilation of the artery.^{10,11,26} However, in only using "clock time" as the time to peak, what is eliminated is the individual

variation, because "clock time" does not take into account the number of cardiac cycles needed to elicit the dilatory response. We chose to consider the number of cardiac cycles to peak for the analysis and determined that this would be the best estimate of "time to peak" because it allows us to consider these changes at an individual level. It was observed that 49.67 ± 20.22 (men) and 44.57 ± 20.36 (women) cardiac cycles elapsed from the time of cuff deflation until the maximum diameter of the artery was reached. However, as mentioned earlier, although "clock" time is not the best estimate of time to peak, this measure was calculated using data for cardiac cycles to peak and the participants' heart rate as a means of comparing these data to previously published studies. It was determined that peak dilation occurred more than 10 sec before the typical 60-sec cutoff, suggesting that studies that use the diameter at 60 sec as the peak diameter could be missing the real peak diameter altogether, and possibly underestimating the magnitude of dilation because maximum dilation may occur earlier.

Table 4

Continued

Heart Rate (beat/min)	Absolute Dilation From Baseline (mm)	Percent Dilation From Baseline (%)	Absolute Dilation From Pre-cuff Release Diameter (%)	Percent Dilation From Pre-cuff Release Diameter (%)	Mean CCA IMT (mm)	Mean Maximum IMT (mm)
1						
-0.190	1					
-0.187	0.983†	1				
-0.117	0.741†	0.737†	1			
-0.097	0.663†	0.690†	0.976†	1		
-0.316	0.042	-0.085	-0.274	-0.319	1	
-0.081	-0.259	-0.306	-0.363*	-0.414*	0.450†	1

*Correlation is significant at the 0.05 level (2-tailed).

†Correlation is significant at the 0.01 level (2-tailed).

The data available also allowed us to examine brachial reactivity with CIMT. It was determined that mean CCA IMT and mean maximum IMT are significantly correlated ($r = 0.691$ in men, $r = 0.450$ in women). However, there is a positive correlation seen between CIMT and brachial dilation measures in men. The inverse correlations between mean maximum IMT and brachial reactivity variables obtained in women, are consistent with the results obtained in other studies.^{19,21} Although the inverse correlation would be an anticipated result (increased CIMT correlated with decreased brachial dilation), there is uncertainty as to the source of the contrasting correlations obtained between the sexes. It could be possible that these differences stem from absolute arterial diameter differences between men and women (therefore impacting the extent of dilation) or as a result of a more complex relationship between CIMT and brachial reactivity that deems further study.

In conclusion, the availability of continuous brachial artery reactivity data enabled us to obtain estimates of the maximum dilation of the artery, percentage change in arterial diameter, and the time to maximum (peak) dilation of the artery. These variables were then used to examine the relationship of brachial artery variables to CIMT outcomes; and examine which components of the brachial artery reactivity measures are most related to the CIMT outcomes.

The strengths of this study are the availability of both brachial and CIMT data for this sample, the use of a standardized protocol conducted by certified sonographers and readers, and high response rates for participation in the study. Additionally, the descriptive characteristics of this population are similar to those in the ARIC study, which was a large population-based sample.¹⁵ Its limitations are the choice of a unique healthy working population (police officers), therefore reducing its generalizability to the population at large; however, this sector represents a large component of the U.S. workforce. Even with these constraints, we have been able to demonstrate important aspects to consider in the study of brachial artery reactivity and for the further study of endothelial dysfunction.

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