

# Blood Pressure Response to Orthostatic and Mental Challenge in African-American Women Taking Oral Contraceptives

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**BACKGROUND.** Contraceptive use among women with an elevated risk of cardiovascular disease and stroke has generated little concern among primary care physicians. African Americans in the southeastern region of the United States are particularly vulnerable to hypertension but are often neglected in research studies of cardiovascular disease. The current study examines the effect of oral contraceptive use by African-American women on blood pressure response to orthostatic and mental challenges.

**METHODS.** One hundred African-American women between the ages of 19 and 29 years were recruited from the student populations of Meharry Medical College and Fisk University in Tennessee for a study of oral contraceptive use and blood pressure. Of 95 subjects on whom complete data were collected, 31 were taking oral contraceptives (OCs). As a measure of orthostatic challenge, each subject's blood pressure was monitored by a Dinamap automated instrument while she moved from a supine to sitting to standing position. To test blood pressure reactivity to mental challenge, a subset of 34 subjects (10 OC users and 24 nonusers) were monitored while they attempted to perform a frustrating cognitive task on a computer.

**RESULTS.** There were no differences between users and nonusers of oral contraceptives with respect to the amount of change in blood pressure associated with either the orthostatic or mental challenge. Levels of systolic blood pressure and mean arterial pressure, however, were consistently higher in subjects using oral contraceptives ( $P < .05$ ) under both testing conditions. Systolic blood pressure levels were 6.7 mm Hg to 9.7 mm Hg higher in OC users during each of the three conditions of orthostatic challenge and 4.4 mm Hg to 7.4 mm Hg higher during each of the four periods of mental challenge. Among OC users, mean arterial pressure levels were 2.9 mm Hg to 4.7 mm Hg higher during orthostatic challenge and 5.0 mm Hg to 8.3 mm Hg higher during mental challenge.

**CONCLUSIONS.** While absolute levels of systolic blood pressure never exceeded 126 mm Hg under either testing condition, the difference in blood pressure levels between the OC users and nonusers warrants concern about the long-term effects of oral contraceptive use among African-American women. Although all OC users in this study were taking low-dose formulations, OC use did not eliminate the risk of elevated blood pressure in this population. Our findings suggest that caution is warranted and that alternative birth control methods should be advised for African-American women who have additional risk factors for cardiovascular disease.

**KEY WORDS.** Blood pressure; hypertension; contraceptives, oral; blacks; cardiovascular diseases; cerebrovascular disorders. (*J Fam Pract* 1997; 45:237-242)

**T**he disproportionate prevalence of hypertension in the African-American population is well documented,<sup>1</sup> and there has been a corresponding interest in identifying factors contributing to this higher

prevalence. The effect of oral contraceptives (OCs) on blood pressure is one factor that has been studied extensively.<sup>2,8</sup>

In one of the earliest and most frequently quoted studies, a prospective investigation of 83 women in Scotland found increases in systolic blood pressure of 8 mm Hg to 14 mm Hg following OC initiation.<sup>2</sup> In a more recent study of Brazilian women, OC users had systolic blood pressures averaging 2.6 mm Hg higher than nonusers.<sup>7</sup> In the quarter century between these two studies, there have been consistent reports that OC use has been associated with a

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difference in systolic blood pressure of between 6 mm Hg and 9 mm Hg.<sup>7</sup> The vast majority of these studies have been performed in the white population. Very few have included African Americans, despite the disproportionate frequency of hypertension and stroke in African-American women, particularly those living in the "stroke belt" in the Southeast United States.<sup>9</sup>

In a study of OC use among young African-American women, Blumenstein et al<sup>6</sup> were unable to find differences in systolic and diastolic blood pressure levels between OC users and nonusers.<sup>6</sup> The current investigation focused on blood pressure levels and dynamics in African-American women living in the "stroke belt" region. We hypothesized that OC use would affect both the levels and, perhaps to an even greater extent, the dynamics of blood pressure change in response to orthostatic and mental challenges.

## METHODS

### SUBJECTS

One hundred African-American women between the ages of 19 and 29 years (mean  $22.7 \pm 0.34$  standard error of the mean [SEM]) were recruited from the student populations of Meharry Medical College and Fisk University in Nashville, Tennessee. Of 95 subjects on whom complete data were collected, 31 were taking OCs. All 95 were tested for blood pressure response to orthostatic challenge. Of these, 34 were also tested for blood pressure reactivity to mental challenge. Only five subjects in the total sample reported tobacco use.

Student *t* tests for independent samples revealed that weight and body mass index did not differ significantly between the two groups ( $P > .05$ ), but there was a slight and statistically significant difference in age ( $P < .05$ ; means  $\pm$  SEM,  $24.0 \pm 0.69$  for OC users vs  $22.0 \pm 0.37$  for nonusers). There were no statistically significant correlations between age and cardiovascular measures, with the exception of diastolic blood pressure while standing ( $P < .05$ ).

### INSTRUMENTATION

Blood pressure (systolic, diastolic, and mean arterial) and heart rate were monitored with an automated blood pressure device (Dinamap, model No. 1846 SX-P, Criticon, Inc, Tampa, Fla) commonly employed in cardiovascular research. The instrument uses an

oscillometric method for the determination of blood pressure and has an output terminal designed to interface with a personal computer for capturing and storing data.

### ORTHOSTATIC AND MENTAL CHALLENGE TESTS

**Test for Orthostatic Challenge.** To test for blood pressure response to orthostatic challenge, subjects were seated in a recliner chair, and using the Dinamap automated instrument, a blood pressure cuff was secured to the left arm. Subjects were then placed in a supine position for 10 minutes, in a sitting position for 5 minutes, and a standing position for 5 minutes. Blood pressure measurements were obtained at the end of each of the three periods. This protocol has been used in a large number of studies to investigate neurogenic reflex control of circulation.<sup>10</sup>

**Task for Mental Challenge.** To test for blood pressure response to mental challenge, a modified Stroop test was used to establish a standardized method of assessing cardiovascular reactivity to stress.<sup>11-12</sup> Excessive cardiovascular reactivity was defined as either large changes in blood pressure from baseline to task or as the failure of blood pressure to "habituate" across the three repeated trials of the mental task. Failure to habituate, which was defined as a lack of decrease in the amount of blood pressure change with repeated trials of the mental task, was analyzed by an examination of the interaction effect in a repeated-measures multivariate analysis of variance (MANOVA). In previous research, we have found that normotensive young African Americans with parental histories of hypertension<sup>11</sup> and low dietary calcium<sup>12</sup> reveal relative failure to habituate when their levels of systolic blood pressure are analyzed from baseline levels through three repeated mental challenges against the same pattern of reactivity in a group of control subjects.

The Stroop task used for the mental challenge is one in which words are presented on a computer monitor while the subject is seated in a recliner chair. The subject is asked to read the word aloud if it is printed in black or identify the color of the word if it is printed in red, blue, or green. The difficulty of the task is that the word stimuli are the names of colors, ie, "red," "blue," "green." A correct response to the word "red" printed in black, for example, is to say the word "red." If the word "red" appears in blue,

TABLE 1

**Cardiovascular Responses to Orthostatic Challenge Among Oral Contraceptive Users and Nonusers**

Orthostatic Position	Systolic BP (mean±SEM)	Diastolic BP (mean±SEM)	MAP (mean±SEM)	Heart Rate (mean±SEM)
All positions				
OC+	113.0±1.4	70.3±0.9	86.7±1.0	78.0±1.0
OC-	107.8±0.8	67.7±0.6	83.1±0.7	77.0±0.8
Supine				
OC+	112.3±2.3	66.7±1.4	83.4±1.6	73.4±1.4
OC-	107.1±1.4	64.8±1.0	80.5±1.2	72.9±1.3
Sitting				
OC+	111.9±2.3	69.4±1.4	85.6±1.6	74.7±1.4
OC-	107.4±1.4	67.0±0.9	82.2±1.1	74.0±1.1
Standing				
OC+	114.7±2.8	74.9±1.3	91.2±1.5	85.8±1.7
OC-	109.0±1.5	71.4±1.0	86.5±1.2	84.1±1.4

BP denotes blood pressure; MAP, mean arterial pressure; OC+, oral contraceptive user; OC-, oral contraceptive nonuser.

however, the correct response would be "blue." If the word "green" appears in black, the correct response is "green," but if it appears in red, the correct response is "red," and so on. The task is made somewhat more challenging by presenting words at a rate of one every 2 seconds, a pace that subjects are encouraged to sustain. Moreover, subjects are required to wear headphones through which they hear prerecorded repetitions of the words "red," "blue," "green" in random order. The testing protocol is controlled by a computer program and begins with a 5-minute resting baseline period. Instructions are given immediately there-

after during a 4-minute period. Word stimuli are presented for three 3-minute periods (90 stimuli per period) separated by 2-minute rest intervals. A 5-minute recovery period concludes the test protocol.

The protocol of employing a variation of the Stroop task is one of several that have been used to investigate whether excessive cardiovascular reactivity to mental stress can be established as a risk factor for heart disease.<sup>13</sup> It is essentially a replicable means by which stress and heart disease can be studied in a laboratory setting. Much like the cardiologist's use of the treadmill to investigate cardiovascular function under physical stress, the Stroop task permits a standardized method for investigating cardiovascular function during mental stress.

Because the protocols for orthostatic and mental challenge generate multiple measures across time, we interpreted these collective blood pressure levels as patterns of reactivity. Examining cardiovascular dynamics as opposed to a static blood pressure measure at one point in time permitted between-group comparisons using the repeated-measures MANOVA. The interaction factor of a repeated-measures MANOVA is uniquely sensitive to between-group differences in patterns of reactivity and can be expect-

ed to yield a significant *P* value if blood pressures of an experimental group habituate to repeated stimulation while a comparison group does not, or vice versa. We expected this "more dynamic" measure of cardiovascular activity to be especially sensitive to differences in our comparison groups.

## RESULTS

Repeated-measures MANOVAs were performed using the four cardiovascular measures (systolic, diastolic, and mean arterial blood pressures, and heart rate) as dependent variables and the three levels of orthostatic challenge (supine, sitting, standing) as one condition under which OC users and nonusers were compared using a 2 × 3 factorial design with repeated measures on the second factor. Identical analyses were performed on the four levels of mental challenge (baseline and each of the three repeated performances of the task) as an additional condition under which OC use was analyzed as the independent variable. These analyses utilized a 2 × 4 factorial design with repeated measures on the second factor. Statistically significant differences were found only for the *levels* of systolic blood pressure

TABLE 2

Cardiovascular Responses to Mental Challenge Among Oral Contraceptive Users and Nonusers

Levels of Mental Challenge	Systolic BP (mean±SEM)	Diastolic BP (mean±SEM)	MAP (mean±SEM)	Heart Rate (mean± SEM)
All levels				
OC+	119.0±1.9	73.9±1.4	92.2±1.7	82.3±2.2
OC-	110.7±1.3	69.2±1.0	85.2±1.0	77.3±1.2
Baseline				
OC+	111.9±2.6	69.3±2.4	85.4±3.0	75.7±3.6
OC-	105.8±1.7	65.3±1.8	80.4±1.7	70.7±2.2
Trial 1				
OC+	124.9±4.3	78.1±3.1	98.1±4.0	88.2±5.1
OC-	115.2±2.9	73.2±2.0	90.3±2.2	83.5±2.5
Trial 2				
OC+	119.4±4.3	75.3±2.2	93.6±3.0	83.3±3.9
OC-	111.0±2.9	69.6±1.9	85.3±2.1	79.0±2.1
Trial 3				
OC+	119.8±3.0	73.1±2.6	91.5 (2.6	82.0±4.3
OC-	110.9±2.1	68.9±1.9	84.8±1.9	75.9±2.0

BP denotes blood pressure; MAP, mean arterial pressure; OC+, oral contraceptive user; OC-, oral contraceptive nonuser.

and mean arterial pressure during both orthostatic and mental challenge (Tables 1 through 4). Significant repeated measures factors were considered trivial, since all cardiovascular measures will change as a subject moves from an inactive to an active state.

Systolic blood pressure levels were 4.5 mm Hg to 5.7 mm Hg higher in OC users during orthostatic challenge and 6.7 mm Hg to 9.7 mm Hg higher during mental challenge ( $P < .05$ ). Mean arterial pressure levels were 2.9 mm Hg to 4.7 mm Hg higher in OC users during orthostatic challenge and 5.0 mm Hg to 8.3 mm Hg higher during mental challenge ( $P < .05$ ). The analyses revealed no statistically significant differences in the *dynamics of blood pressure change* during either orthostatic or mental challenge for any of the blood pressure measures that would have been revealed in statistically significant interaction effects. No differences were found in the dynamics of change or levels of diastolic blood pressure or heart rate. When all observations are combined for each measure, however, highly significant differences are seen for all four cardiovascular measures. An examination of means and standard errors for the

freedom for groups and subjects rather than just subjects.

DISCUSSION

We have replicated the findings of many investigators concerning the adverse effect of OC use on blood pressure.<sup>28</sup> We are the first, however, to replicate the effect in a sample of African-American women. Since our subjects were young, well-educated college students, it is difficult to make a strong argument for the generalization of these findings to the larger population of African Americans. On the other hand, the demographics of our sample suggest that our finding has relevance to a large segment of the African-American population who are likely to use oral contraceptives during most of their child-bearing years. Another potential limitation of this study is our use of the mental challenge for cardiovascular reactivity testing. The mental challenge was perhaps less "stressful" to college students who are accustomed to difficult cognitive tasks. Perhaps we also would have found a difference in the dynamics of blood pressure change in a less educated sample.

categories labeled "All positions" in Table 1 and "All levels" in Table 2 reveal that the combined observations of each measure would easily generate statistical significance in between-group comparisons. Our findings, interpretations, and conclusions, however, are based on the more conservative analyses generated by MANOVA, which take into account that repeated measures are separated in time; that is, there are intervals of time between supine, sitting, and standing of the orthostatic challenge and between baseline, trial 1, trial 2, and trial 3 of the mental challenge. In other words, MANOVA compares overall (grand) means with consideration to degrees of

**TABLE 3**

**Summary of Multivariate Analysis of Variance Results Comparing Oral Contraceptive Users and Nonusers, by Cardiovascular Responses to Orthostatic Challenge**

Cardiovascular Response	F Test	df	P Value
Systolic blood pressure			
Levels	4.5	1, 93	<.05
Repeated measures	980.0	2, 186	<.05
Interaction	1.1	2, 186	NS
Diastolic blood pressure			
Levels	2.8	1, 93	NS
Repeated measures	77.2	2, 186	<.05
Interaction	0.9	2, 186	NS
Mean arterial pressure			
Levels	4.0	1, 93	<.05
Repeated measures	57.3	2, 186	<.05
Interaction	1.1	2, 186	NS
Heart rate			
Levels	0.3	1, 93	NS
Repeated measures	100.0	2, 186	<.05
Interaction	0.3	2, 186	NS

df denotes degree of freedom.

NOTE: Statistical significance was set at  $P < .05$ .

**TABLE 4**

**Summary of Multivariate Analysis of Variance Results Comparing Oral Contraceptive Users and Nonusers, by Cardiovascular Responses to Mental Challenge**

Cardiovascular Response	F Test	df	P Value
Systolic blood pressure			
Levels	4.2	1, 32	<.05
Repeated measures	17.32	3, 96	<.05
Interaction	0.5	3, 96	NS
Diastolic blood pressure			
Levels	2.2	1, 32	NS
Repeated measures	20.4	3, 96	<.05
Interaction	0.2	3, 96	NS
Mean arterial pressure			
Levels	4.3	1, 32	<.05
Repeated measures	23.8	3, 96	<.05
Interaction	0.6	3, 96	NS
Heart rate			
Levels	1.5	1, 32	NS
Repeated measures	37.4	3, 96	<.05
Interaction	0.2	3, 96	NS

df denotes degree of freedom.

NOTE: Statistical significance was set at  $P < .05$ .

It is interesting that we found no differential effect on the dynamics of blood pressure change during either orthostatic or mental challenge. Nonetheless, systolic and mean arterial blood pressures were 3 mm Hg to 7 mm Hg higher in OC users during either of the two conditions of testing. While absolute levels of systolic blood pressure never exceeded 126 mm Hg under either testing condition, the difference between the OC users and nonusers was sufficiently large to warrant concern about the long-term effects of oral contraceptive use from a population-wide perspective.<sup>7</sup> Yunis et al<sup>7</sup> also found a statistically significant positive trend between the *length of time* that oral contraceptives were taken and mean systolic blood pressure levels.

Our findings suggest that, since all of our subjects taking OCs were using a low-dose formulation, the development of these low-dose OCs has not eliminated the risk of elevated blood pressure in African-American women taking OCs. Epidemiologists have found that stroke risk increases in the population with every mm Hg increase in systolic blood pressure.<sup>14</sup> Because African-American women, particularly those in the southeastern region of the United States, are already at a disproportionately high risk of stroke, any other factor that further exacerbates their risk cannot be ignored. While it was recently reported that oral contraceptive use per se did not appreciably increase risk of stroke in women of childbearing age, data from their report suggest strong interactive effects with other risk factors.<sup>15</sup> Moreover, their data reconfirm a considerably higher risk of stroke in African-American women by virtue of race. Unfortunately, however, the study did not report the specific risk of OC use in the subset of African-American women.

Our findings suggest that some caution is warranted and alternative methods of birth control might be advisable for African-American women who have additional risk factors such as family history of hypertension, obesity, hyperlipidemia, and cigarette smoking. In our experience, combinations of these risk factors coexist in the vast majority of young African-American women.

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