Chemo- and baroresponses differ in African-Americans and Caucasians in sleep

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Crisostomo, Isabel, Adel Zayyad, David W. Carley, Jawed Abubaker, Ergun Onal, Edward J. Stepanski, Melvin Lopata, and Robert C. Basner. Chemo- and baroresponses differ in African-Americans and Caucasians in sleep. J. Appl. Physiol. 85(4): 1413–1420, 1998.—To determine sleep effects on baro- and ventilatory responses to transient chemo- and barostimulation in African-Americans and Caucasians, 26 nonobese normotensive young subjects (13 African-Americans and 13 Caucasians) were studied awake and in non-rapid-eye-movement (NREM) and rapid-eye-movement sleep during induced transient hypoxemia (N₃), hypertension (phenylephrine, PE), and concomitant hypoxemia and hypertension (N₂ + PE). Arterial blood pressure was recorded by plethysmographic volume clamp, minute ventilation by pneumotachograph, and arterial O₂ saturation by pulse oximeter. For all subjects, chronotropic baroreponse (Δpulse interval/Δsystolic blood pressure, where Δ is change) increased with NREM sleep (P = 0.007). Baroreponse slope was greater in Caucasians than in African-Americans (ANOVA, P = 0.02). Hypoxic ventilatory response (Δminute ventilation/Δarterial O₂ saturation) was greater in African-Americans than in Caucasians in NREM sleep (P = 0.01), as was hypoxicemic attenuation of baroreponse (N₂ + PE, P = 0.03). These data suggest sleep-related differences in arterial chemo- and baroresponse responses in normal young African-Americans and Caucasians, which may have implications concerning development of systemic hypertension.

hypertension; hypoxemia; blood pressure; arterial chemoreceptor; arterial baroreceptor

ARTERIAL BLOOD PRESSURE (BP), which reflects sympathetic outflow (24, 32, 33), is in part dependent on peripheral arterial chemoreceptor (22, 32, 33) and arterial baroreceptor (8, 31) afferent input. In awake normal humans the peripheral chemoreceptor reflex appears to be sympathoexcitatory (32, 33) and the arterial baroreceptor reflex sympathoinhibitory (34). A barostimulation-induced inhibition of the peripheral chemoreceptor and a chemo- and baroresponse inhibition of the baroreceptor have also been postulated (11, 34).

Sleep has been associated with increased arterial baroreceptor sensitivity (31) and decreased peripheral chemoreceptor sensitivity (2, 11). Each of these effects could contribute to normally observed decreases in sympathetic outflow (30, 32) and arterial BP during sleep (6, 30). However, normal responses of transient stimulation of these receptors during sleep have not been well studied in humans. Furthermore, although the increased prevalence of diurnal and nocturnal hypertension (17, 29a) as well as sleep-disordered breath-
Concomitant hypertensive and hypoxemic stimulation (N2 in 0.9% saline as a 0.5-ml bolus flushed with 2 ml of saline (1)). The hypertensive stimulus was 25–37.5 µg of phenylephrine (PE) suspended above the subject. Air leak was checked with a CO2 order, stimuli to induce transient hypoxemia, hypertension, and concomitant hypertensive and hypoxemic stimulation were administered. Hypoxemia was induced with three to eight breaths of pure N2 to titrate to cause a nadir between 75 and 89%. The gas was administered using a two-way valve fitted to a manifold to allow the inspirate to be selected from the N2-containing reservoir bag or from room air (13). The hypertensive stimulus was 25–37.5 µg of phenylephrine (PE) in 0.9% saline as a 0.5-ml bolus flushed with 2 ml of saline (1). Concomitant hypertensive and hypoxemic stimulation (N2 + PE) was achieved with N2 given immediately after the PE bolus and flush. A minimum of 3 min was required between stimuli. The goal was to obtain three stimulations each of N2, PE, and N2 + PE.

After wakefulness data were collected, the subject was allowed to rest quietly for 30 min. Then lights were turned off, and the subject was allowed to sleep. After a minimum of 5 min of consolidated sleep was achieved, stimuli were begun in random order, as for data collection during wakefulness. A minimum of 3 min of uninterrupted sleep was required between each stimulation. The goal was to obtain three collections, without arousal, of each stimulation in each of the following stages: non-rapid-eye-movement (NREM) stage 2, NREM stage 3/4, and rapid-eye-movement (REM) sleep. In all subjects, data were collected throughout the night.

Data analysis. For each stimulus (N2, PE, and N2 + PE), the 20 consecutive cardiac cycles preceding the stimulus were scored as the baseline segment, and the 40 consecutive cardiac cycles beginning at beat 21 after the administration of the stimulus were scored as the response segment. The decision to score and analyze cardiac cycles 20–60 after the stimulus as the response segment was made after inspection identified this region as the region invariably associated with the onset and resolution of measurable heart rate, BP, and ventilatory responses. BP, minute ventilation (V̇I), and SaO2, of each of these pre- and poststimulus cardiac beats were scored; however, only data measured during expiration were analyzed (12, 31). To correct for the lag of the SaO2 display in assigning SaO2 values for hypoxicemic stimuli (N2 and N2 + PE), the SaO2 curve was manually advanced such that the nadir of the curve was located directly below the area of maximal V̇I. All poststimulus data were normalized as change from the averaged 20 cardiac cycles preceding the stimulus. Baroresponses was calculated as the slope of arterial BP plotted against the pulse (R-R) interval of the subsequent cardiac cycle (Δpulse interval/ΔBP, in ms/mmHg, where Δ is change) (31). Systolic and mean BP were used for this analysis. There were no significant differences between results obtained with systolic BP and mean BP; results using systolic BP are reported. The slope of the ventilatory response was calculated as ΔV̇I/ΔSaO2, where SaO2 is the inspiratory time and Tİ is total respiratory cycle duration (5).

To calculate baroresponse slope, only data points associated with a ≥3-mmHg increase in systolic BP from prestimulus baseline were analyzed. Similarly, to calculate ventilatory response slope, only data points associated with a ≥1% decrease in SaO2 were analyzed. These stimulations were made before analysis of the data to ensure that we were measuring responses to physiologically significant baro- and chemostimuli. Exclusions for failure to minimally raise BP were made only during challenges with N2 alone; no data exclusions were necessary for challenges with PE alone and N2 + PE. Similarly, exclusions for failure to minimally decrease SaO2 were made only for PE alone; as expected, no significant changes in SaO2 occurred with PE alone.

Sleep was scored by a board-certified polysomnographer, who was blinded to the identity of the subject, according to standard criteria (28). Sleep data during or after transient arousals (3) were excluded from analysis, as were any data associated with movement of the hand. Data from challenges in which arousal occurred were included if they preceded EEG changes of arousal and ≥20 cardiac cycles of data were present before the arousal. Many data were excluded because of arousal, particularly during hypoxic challenges (N2 and N2 + PE), which tended to be alerting. This can be seen particularly in the paucity of data in Caucasian women during N2 and N2 + PE in REM sleep (Fig. 1; see Fig. 4). We similarly excluded any data associated with an abrupt BP rise during or just after the stimulation, whether or not EEG arousal was present. Stage 2 and slow-wave sleep were pooled as NREM sleep to increase power of the data; separate analysis was done for stage 2 and stage 3/4 sleep, and no significant differences were seen between these stages. For each subject, mean data for each variable were employed for analysis (thus using one observation per subject for each cell). The main effects of state (wakefulness, NREM, REM), race (African-American, Caucasian), stimulus type (N2, PE, N2 + PE), and gender on all response variables, as well as interactions among these effects, were tested by multway ANOVA (Stat View 4, Abacus Concepts, Berkeley, CA). State and stimulus type were considered repeated measures; gender and race were factorial variables in all parametric ANOVA. Significance for multiple contrasts was controlled by Fisher’s protected least significant difference. Statistical significance was considered at P < 0.05 (21). Gender did not represent a significant main effect, nor did it demonstrate a significant interaction with race, stage, or stimulus type on response variables tested in all instances, except attenuation of hypoxic ventilatory response with hypertension. Therefore, gender was pooled in the analysis. To ensure that no outlier effects contributed to these findings, all main effects were individually retested by nonparametric analysis (Mann-Whitney U-test for race effects, Kruskal-Wallis test for stimulus type and state effects). In every case, the significant effects found with parametric ANOVA were confirmed.
RESULTS

Anthropometric data for the subjects are displayed in Table 1. A total of 625 stimulations were analyzed among the 26 subjects (307 in African-Americans, 318 in Caucasians). The overall degree of chemostimulation (as measured by degree of $\text{SaO}_2$ decrease) and barostimulation (as measured by systolic BP increase) was similar in the African-American and Caucasian subjects, the only statistically significant difference in barostimulation being a greater increase in BP during $N_2 + \text{PE}$ in wakefulness and REM sleep in the African-Americans (Table 2). The only statistically significant difference in degree of induced hypoxemia was a greater decrease in $\text{SaO}_2$ in African-Americans than in Caucasians ($N_2 + \text{PE}$, $P < 0.002$). Baroresponse is significantly greater in Caucasians than in African-Americans ($P = 0.02$). Baroresponse attenuation during $N_2 + \text{PE}$ is significantly greater in African-Americans than in Caucasians in NREM sleep ($P = 0.03$). No statistically significant gender differences are present. There were insufficient data for Caucasian women during $N_2$ and $N_2 + \text{PE}$ to be included in ANOVA.

Heart rate and BP responses. Baroresponses for all states and stimulus types are shown in Fig. 1 for all subjects. **Table 2. Systolic BP increases in African-Americans and Caucasians: all subjects**

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Race Gender</th>
<th>Age, yr</th>
<th>BMI, kg/m²</th>
<th>Awake BP, mmHg</th>
<th>Awake $\text{SaO}_2$, %</th>
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<tbody>
<tr>
<td>1</td>
<td>AA F</td>
<td>23</td>
<td>68±2</td>
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<td></td>
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<tr>
<td>2</td>
<td>AA C</td>
<td>23</td>
<td>70±1</td>
<td>99±0</td>
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</tr>
<tr>
<td>3</td>
<td>AA F</td>
<td>24</td>
<td>83±2</td>
<td>99±1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AA F</td>
<td>22</td>
<td>90±3</td>
<td>99±1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>AA F</td>
<td>20</td>
<td>83±3</td>
<td>100±0</td>
<td></td>
</tr>
<tr>
<td>6</td>
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<tr>
<td>7</td>
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<td>97±2</td>
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<tr>
<td>8</td>
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<td>97±1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>C F</td>
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<td></td>
</tr>
<tr>
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<tr>
<td>11</td>
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</tr>
<tr>
<td>12</td>
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<td>20</td>
<td>94±1</td>
<td>98±1</td>
<td></td>
</tr>
<tr>
<td>13</td>
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<tr>
<td>14</td>
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<tr>
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<tr>
<td>16</td>
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<td>22</td>
<td>99±1</td>
<td>99±0</td>
<td></td>
</tr>
<tr>
<td>17</td>
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<td>21</td>
<td>95±1</td>
<td>98±0</td>
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</tr>
<tr>
<td>18</td>
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<td>83±3</td>
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<tr>
<td>19</td>
<td>AA M</td>
<td>23</td>
<td>89±1</td>
<td>96±2</td>
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</tr>
<tr>
<td>21</td>
<td>C M</td>
<td>25</td>
<td>77±2</td>
<td>96±0</td>
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<tr>
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<td>25</td>
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<td>98±0</td>
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</tr>
<tr>
<td>23</td>
<td>C M</td>
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<td>93±2</td>
<td>97±0</td>
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<tr>
<td>24</td>
<td>C M</td>
<td>20</td>
<td>88±1</td>
<td>98±0</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>C M</td>
<td>22</td>
<td>65±2</td>
<td>96±0</td>
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</tr>
<tr>
<td>26</td>
<td>C M</td>
<td>24</td>
<td>95±1</td>
<td>100±0</td>
<td></td>
</tr>
</tbody>
</table>

Values are means ± SE for arterial pressure averaged over baseline wakefulness period before stimulations (Awake BP) and $O_2$ saturation of hemoglobin averaged over baseline wakefulness period before stimulations (Awake $\text{SaO}_2$). AA, African-American; C, Caucasian; F, female; M, male.
subjects. During wakefulness and sleep, with the hypoxic stimulus (N₂) alone, the baroresponse slope was negative; that is, heart period decreased as BP increased. With the hypertensive stimulus (PE) alone, baroresponse slope was positive; that is, heart period increased as BP increased. Baroresponse was significantly increased in NREM sleep compared with wakefulness for all subjects (P = 0.007). A similar trend to increased baroresponse in REM sleep did not reach statistical significance (P = 0.19). With concomitant hypoxemia and hypertension (N₂ + PE), baroresponse remained positive but was attenuated compared with PE alone (P ≤ 0.002). Polysomnographic tracings showing baroresponse during PE and N₂ + PE in a representative Caucasian man are displayed in Figs. 2 and 3, respectively.

Baroresponse (PE alone) was significantly greater among Caucasians than among African-Americans during wakefulness and sleep (P = 0.02). When the hypoxic challenge was given along with the barostimulation (N₂ + PE), baroresponse was attenuated more in African-Americans than in Caucasians in NREM sleep (P = 0.03). There were similar but not statistically significant trends to a greater baroresponse attenuation during concomitant hypoxemia in the African-Americans during wakefulness (P = 0.09) and REM sleep (P = 0.13). These data are displayed in Fig. 1.

Ventilatory responses. For all subjects, mean ventilatory response slopes (ΔV̇/ΔSaO₂) to the hypoxic challenge (N₂) were not significantly different between wakefulness and sleep. African-Americans demonstrated a greater (more negative) slope than Caucasians during wakefulness and sleep. This difference was statistically significant only for NREM sleep (P = 0.01). These data are displayed in Fig. 4.

When transient hypertension was induced along with hypoxemia (N₂ + PE), there was a statistically significant attenuation of the hypoxic ventilatory response in African-American and Caucasian men (P = 0.04) in NREM and REM sleep. Such an attenuation of the ventilatory response with concomitant hypertension was not demonstrated in the women (Fig. 4).

**DISCUSSION**

These data in normal young African-Americans and Caucasians indicate that sleep is associated with a greater enhancement of baroresponse to transient BP elevation in normal young Caucasians than in African-Americans. Chemoresponsiveness in NREM sleep appeared to be greater in the African-Americans than in the Caucasians.

It must be emphasized that the number of subjects in this protocol is relatively small, and thus these physiological findings, specifically those indicating a difference between African-American and Caucasian responses, may not be representative of young African-American and Caucasian populations overall. We attempted to control for variability in subject selection by limiting these studies to young, healthy, nonobese, nonapneic, normotensive subjects. Furthermore, we collected and analyzed multiple runs of interventions from all subjects, as well as a large number of data

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**Table 3. SaO₂ decreases from baseline in African-Americans and Caucasians: all subjects**

<table>
<thead>
<tr>
<th></th>
<th>N₂</th>
<th>PE</th>
<th>N₂ + PE</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>AA</td>
<td>C</td>
<td>AA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wakefulness</td>
<td>-9±1</td>
<td>-9±0</td>
<td>0.1±0</td>
</tr>
<tr>
<td>Sleep</td>
<td>-7±1</td>
<td>-10±0</td>
<td>0.3±0</td>
</tr>
<tr>
<td>NREM</td>
<td>-8±1</td>
<td>-7±1</td>
<td>0.1±0</td>
</tr>
</tbody>
</table>

Values are means ± SE expressed as change in oxyhemoglobin saturation (SaO₂) from prestimulus baseline (in percent) during stimulation with N₂, PE, and N₂ + PE for African-Americans and Caucasians. Decrease in SaO₂ was greater in Caucasians than in African-Americans during N₂ in NREM sleep; no other differences between African-Americans and Caucasians were statistically significant. *C > AA (P = 0.01).
points for each intervention, spanning 20 cardiac cycles of baseline and 40 cardiac cycles of response. Each significant main effect of ANOVA, including those that indicated a difference in responses between the groups of African-American and Caucasian subjects, was also subjected to nonparametric analysis, objectively confirming that no individual subject deviated greatly from the group behavior within each race. The possibilities of type 1 error also pertain to the use of multiple tests and variables in a relatively small group of subjects. The positive findings we report were hypothesis driven rather than outcomes of testing for all possible interactions. Furthermore, the multiple individual contrasts were controlled by protected least significant difference at levels that would be unlikely to allow false positives. At the same time, type 2 error in this study cannot be ruled out, and statistical similarities reported between African-Americans and Caucasians and between men and women in this protocol might in fact have become significantly different with more subjects (7). Also there were many fewer REM than NREM data in this protocol, and REM data were not obtained in all subjects. Thus, for baroresponse, N₂ REM data included three African-American men, three Caucasian men, three African-American women, and no Caucasian women; N₂ + PE data included four African-American men, six Caucasian men, five African-American women, and one Caucasian woman. For ventilatory N₂ response, REM data included three African-American men, three Caucasian men, three African-American women, and no Caucasian women; N₂ + PE data included four African-American men, six

![Polysomnographic tracing during NREM sleep in subject in Fig. 2 after simultaneous 25-µg bolus of PE and inhalation of 100% N₂. SaO₂ nadir is 85%. Cardiac baroresponse is attenuated compared with response to PE alone. Segment begins 8 cardiac cycles after PE bolus. See Fig. 2 legend for definition of abbreviations.](https://jap.physiology.org/)

![Ventilatory response slopes (ΔV/ΔSaO₂, where Vᵢ is minute ventilation) for African-American and Caucasian subjects during wakefulness and NREM and REM sleep during transient hypoxemia (N₂) and concomitant hypoxemia and hypertension (N₂ + PE). Values are means ± SE for 40 successive cardiac cycles after stimulus. ΔV/ΔSaO₂ during N₂ is not significantly different between wakefulness and sleep. African-Americans demonstrate a greater (more negative) slope overall than Caucasians during wakefulness and sleep; ANOVA was significantly different only in NREM sleep (P = 0.01). Transient hypertension induced along with hypoxemia (N₂ + PE) shows a statistically significant attenuation of hypoxic ventilatory response in African-American and Caucasian men (P = 0.04) in NREM and REM sleep but not in women. There were insufficient data for Caucasian women during N₂ to be included in ANOVA.](https://jap.physiology.org/)
African-Americans appear to have an increased prevalence of diurnal and nocturnal hypertension compared with Caucasians at virtually all ages (29a) and increased sleep-disordered breathing compared with Caucasians at a relatively early age (29). African-American women as a group appear to have the highest prevalence of systemic hypertension from middle to old age (29a). In this study the African-American subjects showed decreased baroresponses with and without concomitant hypoxemia compared with similar Caucasian subjects, and this was most specific to NREM sleep. Decreased baroresponses have similarly been found in patients with obstructive sleep apnea (4), older subjects (16), and young subjects with borderline hypertension or a strong family history of hypertension (36, 37). In the present study, African-American subjects also demonstrated relatively increased ventilatory responses to hypoxemia. Increased peripheral chemosensitivity (increased ventilatory drive) has been found in young men who demonstrate mild essential hypertension (35). The net effect of decreased baroreponse and increased chemoresponsiveness may result in increased exposure during sleep to sympathetic stimulation in the young African-American subjects, particularly if the baroreflex normally decreases the reflex vascular effects of chemostimulation (22).

The accuracy of finger pulse oximetry in dark-pigmented vs. lighter skinned subjects has been questioned by studies in which greater variability between measured finger pulse oximetry and direct measurement of $\text{SaO}_2$ was found in “black” than in “white” patients undergoing mechanical ventilation (20). Although there are no similar data for healthy young populations, we cannot exclude the possibility that there was a greater degree of hypoxemia among African-American subjects in this protocol. This would not be likely to influence comparison of the slopes of the hypoxic ventilatory response but could have resulted in occultly greater depression of baroresponse with combined stimuli in the African-Americans.

Although we did not observe consistent changes in airflow or end-tidal CO$_2$ in these subjects suggestive of increasing upper airway resistance during sleep, we did note that some subjects (African-Americans and Caucasians) snored intermittently during REM sleep. Our methodology cannot rule out the possibility of a systematic difference in upper airway resistance between groups, as might occur, for example, during PE challenges (14), which thus could have affected the measurement of ventilatory and baroresponses.

Although there was an expected decrease in baseline ventilation (before stimulations) from wakefulness to sleep in this study, we found, somewhat unexpectedly, that the hypoxic ventilatory response was not attenuated with sleep. Sleep has been shown to decrease ventilatory response to progressive isocapnic hypoxemia in humans (2, 10). However, hypocapnic hypoxemia, similar to the present study, has not been found to produce consistent ventilatory changes in NREM sleep compared with wakefulness, possibly because hypocapnia may cause a selectively decreased ventilatory response during wakefulness (15). It is also likely that a transient hypoxic stimulus is modulated differently from progressive hypoxemia during sleep.

Using a bolus of PE, Abdel-Rahman and colleagues (1) found decreased baroreceptor responses in wakefulness in young normal women compared with men (race not specified). We, however, found that responses during wakefulness were similar in men and women of both races. The women in the present study displayed baroresponses to 25 µg of PE quantitatively similar to those in the study of Abdel-Rahman et al.; the men in the present study showed less baroresponse than did the men in the earlier study (1). We cannot specifically explain this difference, but we would note that the state of wakefulness itself may involve different levels of apprehension and sympathetic stimulation during such experiments; neither study clearly differentiates such change in arousal within the state of wakefulness.

Although the duration of baseline and response interval varied slightly among subjects, stimuli, and states, we do not believe that such variation affected results, since all analyzed stimulations utilized a stable and reasonably lengthy and representative baseline, whereas each response interval captured the beginning and resolution of changes in ventilation, heart rate, and BP. Furthermore, there was no difference in the number of response beats among subjects in the final data analysis, since these data were averaged to produce one observation for each cell (sleep and stimulus type) for each subject in the ANOVA.

We did not employ “sham” stimuli; therefore, we cannot be certain whether the methods used (gas inhalation, bolus of 2 ml of liquid) themselves contributed to responses. In particular, Caucasian women tended to arouse more frequently than the other groups during N$_2$ inhalation, and this protocol cannot differentiate whether this tendency to arousal was due to the methodology of gas inhalation employed rather than the hypoxemia itself. We believe it is unlikely that the methodology of PE infusion was responsible for the results we found. Subjects did not show a particular tendency to arouse with PE alone, and, using a similar bolus of 2 ml of saline in normal subjects, Abdel-Rahman et al. (1) did not demonstrate an effect on heart rate or BP.

There was considerable variation in the degree of hypoxic challenge we employed, which could have affected between-group results. We aimed from the outset for an $\text{SaO}_2$ range of 75–89% for hypoxic challenges, comparable to the range of $\text{SaO}_2$ in previous studies of hypoxic challenge during sleep (10). The number of N$_2$ breaths was determined for each subject as the number that reliably brought the $\text{SaO}_2$ down to that range and was adjusted throughout each subject’s study as necessary. This number tended to vary with state as well as with subject. We found, for example, that wakefulness tended to be more resistant than REM sleep to $\text{SaO}_2$ decrease. However, there were no systematic trends in that regard, and the range of
breaths of N₂, as well as the range of SaO₂ decrease, was similar among subjects. Decreases in SaO₂ from baseline were similar in African-Americans and Caucasians for all stimuli and states (Table 3).

We used a noninvasive method of BP measurement rather than an intra-arterial catheter to maximize subject safety and minimize discomfort. Arterial BP measured in this manner has correlated well with pressure measured by arterial catheter in awake and sleep states during similarly changing conditions of BP (9, 26, 27). Furthermore, the baroreflex slopes we obtained with hypertension are similar to those obtained in normal subjects using intra-arterial catheters under similar conditions (33).

We excluded data that coincided with or followed EEG arousal, inasmuch as even minimal abrupt EEG changes, below the minimal threshold for scoring of arousal by standard guidelines, may be associated with evidence of autonomic arousal, including increased blood pressure (9). Furthermore, we excluded any data associated with an abrupt BP rise with or just after the stimulation, whether or not an EEG arousal was present. However, we cannot exclude arousal-related autonomic discharge not discernible on EEG, since arousal stimuli unassociated with clear EEG change may cause autonomic discharge (9, 24).

The race-related differences in chemo- and barore- responses in this group of normal young subjects during sleep may have implications concerning diathesis for development of systemic hypertension, particularly since African-Americans have also been found to have elevated BP during sleep compared with Caucasians as early as adolescence (17). Further studies of race-related chemo- and baroreponses in normal young humans might help lead to improved strategies of screening and therapy of individuals with a diathesis for diurnal hypertension and sleep-disordered breathing.

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