Attenuated Sympathetic Baroreflex Sensitivity Evoked by Acute Mental Stress but not Prolonged Sleep Restriction in Healthy Adults

Spencer R Majerus[1], Ashley R Goodrie[1], Ted Wilson[1], and Sarah E Baker[2]

[1]Department of Biology, Winona State University [2]Department of Anesthesia and Perioperative Medicine, Mayo Clinic, Rochester MN

Introduction

In the United States, approximately one-third of adults, aged 18-60 years, currently sleep less than 7 hours per night (Lui et al. 2014). An association between sleep restriction, blood pressure, and acute mental stress where mean arterial blood pressure (MAP) was shown to increase when an individual was undergoing mental stress and was amplified after one night of sleep restriction (Franzen et al. 2011).

Arterial blood pressure is regulated from beat-to-beat as a result of sympathetic baroreflex sensitivity (sBRS) and reflex changes in muscle sympathetic nerve activity (MSNA) (Durocher et al. 2015). Changes in MSNA cause the blood vessels of the leg to vasoconstrict in order to increase blood pressure or vasodilate to reduce blood pressure. Blood pressure reactivity at the onset of mental stress determines whether there is an increase or decrease in MSNA (El Sayed et al. 2018).

Continuous MSNA was measured along with continuous real-time blood pressure and heart rate to evaluate sBRS. Changes in MSNA may represent altered sympathetic recruitment patterns that can be associated with the early development of hypertension (Incognito et al. 2020).

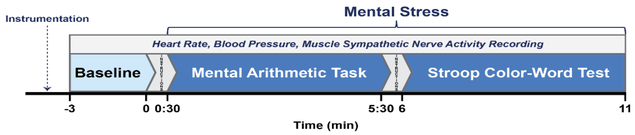
To understand how these factors affect blood pressure, the sBRS was measured throughout **1)** 10 minutes of mental stress and **2)** after a period of consecutive sleep restriction.

Methods

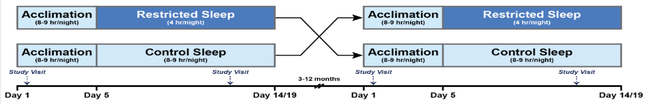
Participants: Fourteen healthy adults (10M/4F, 25±1 yrs.) were recruited for this study. Subjects were non-obese (BMI 25±1 kg/m^2) and normotensive (BP 115±11/66±8 mmHg).

Measurements: Heart rate (electrocardiography), blood pressure (finger photoplethysmography), and muscle sympathetic nerve activity (microneurography of the common peroneal nerve) were continuously measured to determine sBRS at baseline and during mental stress.

Mental Stress Protocol: After 2 minutes of baseline measurements, subjects underwent 10 minutes of mental stress, consisting of a 5-minute mental arithmetic task (timed subtraction-based math questions), followed immediately by a 5-minute Stroop color-word conflict test.



Sleep Restriction Protocol: A subset of subjects (n=9) completed the sleep restriction protocol under both control and restricted sleep conditions. These were completed while inpatient at the Mayo Clinic Clinical Research and Trials Unit. Subjects underwent a 3-night period of acclimation, followed by 9- or 14-nights of sleep restriction (00:30-04:30) or control sleep (22:00-07:00). Subjects were studied on Days 1 and 15 or Days 2 and 13.



Results

Table 1: Hemodynamics and MSNA during baseline and mental stress after a 4-day/3-night acclimation period prior to experimental sleep restriction (n=14).

	Baseline	0.5-5.5 min Arithmetic	6-11 min Stroop
Heart Rate (beats/min)	68 ± 3	79 ± 4*	75 ± 3*
Systolic BP (mmHg)	131 ± 5	139 ± 6*	138 ± 6*
Diastolic BP (mmHg)	76 ± 3	82 ± 3*	82 ± 3*
MAP (mmHg)	95 ± 7	104 ± 5*	104 ± 4*
MSNA (bursts/100hb)	23 ± 2	18 ± 2*	21 ± 2

- Denotes significant difference from baseline (p<0.05)
- sBRS = - MSNA/Diastolic BP

Flow of Participants

23 patients admitted and completed the larger protocol

↓

14 patients with at least one trial of baseline MSNA **before sleep restriction**

↓

9 patients with MSNA data at **all 4 visits**

↓

5 patients MSNA unable to obtain after repeated attempts **after sleep restriction**

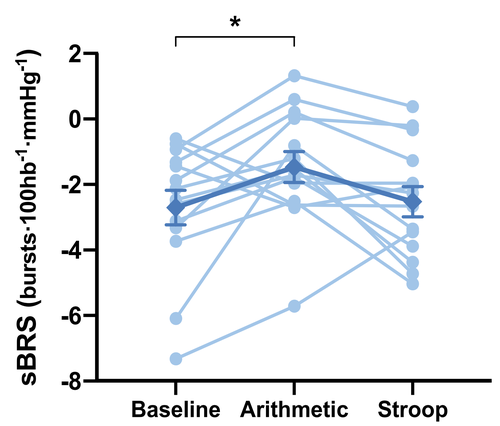


Figure 1. Individual changes in sBRS due to Arithmetic and Stroop stress demonstrate that not all subjects responded to stress in an identical manner. (m± SEM, significance (P<0.05) indicated by asterisk)

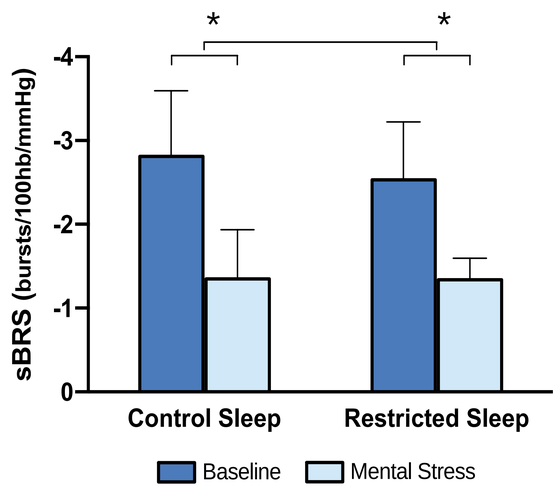


Figure 2. Comparing changes in mean baroreflex operating point in controlled sleep versus experimental sleep restriction while undergoing mental stress. *(significance P<0.01)

Major Points

- MSNA is an invasive protocol in nature that is difficult to maintain for long periods and associated with physical discomfort leading to high attrition rates.
- HR, systolic BP, diastolic BP, and MAP all increased during arithmetic and Stroop testing **(Table 1).**
- In arithmetic condition, MSNA decreased whereas in the Stroop condition, it returned to a baseline value.
- The two mental stress interventions revealed a significant decrease in sBRS during the initial 5 minutes of arithmetic stress, *but not* during the subsequent 5 minutes of Stroop testing (**Figure 1** Arithmetic: p=0.03; Stroop: p=0.75).
- Mental stress reduced baroreflex function following control and experimental sleep conditions (p<0.01) (**Figure 2**).
- However, the experimental sleep condition reduction in baroreflex function was not significantly different when compared to the control sleep condition (p=0.78).

Conclusions

10 min of mental stress resulted in a significant attenuation of sympathetic baroreflex sensitivity in healthy adults; however, the blunting of baroreflex sensitivity was isolated to the initial 5 min of stress.

Sympathetic baroreflex sensitivity is attenuated early in mental stress but quickly returns to baseline values.

Experimental sleep restriction did not have a significant effect on sympathetic baroreflex function during mental stress when compared to control sleep conditions.

Experimental sleep restriction does not alter sympathetic control of blood pressure.

Acknowledgements

Funding: NIH HL114024 (VKS), NIH HL114676 (VKS), NIH HL083947 (MJJ), FAER Medical Student Anesthesia Research Fellowship (NMP)

Many thanks to: Our research participants, the members of the Human Integrative Physiology Laboratory at the Mayo Clinic, and the staff of the Saint Mary's Clinical Research and Trials Unit

Works Cited

Liu Y, Wheaton AG, Chapman DP, Cunningham TJ, Lu H, Croft JB. Prevalence of Healthy Sleep Duration among Adults — United States, 2014. MMWR Morb Mortal Wkly Rep 65:137–141, 2016. DOI: http://dx.doi.org/10.15585/mmwr.mm6506a1external icon.

Franzen, Peter L., Peter J. Gianaros, Anna L. Marsland, Martica H. Hall, Greg J. Siegle, Ronald E. Dahl, and Daniel J. Buysse. Cardiovascular Reactivity to Acute Psychological Stress Following Sleep Deprivation. Psychosom. Med. 73 (8): 679–82, 2011. https://doi.org/10.1097/PSY.0b013e31822ff440.

Durocher, John J., Jenna C. Klein, and Jason R. Carter. Attenuation of Sympathetic Baroreflex Sensitivity during the Onset of Acute Mental Stress in Humans. Am J Physiol Heart Circ Physiol 300 (5): H1788–93, 2011. https://doi.org/10.1152/ajpheart.00942.2010.

El Sayed, K., Macefield, V. G., Hissen, S. L., Joyner, M. J., & Taylor, C. E. Blood pressure reactivity at onset of mental stress determines sympathetic vascular response in young adults. Physiol. Rep., 6(24), e13944, 2018. https://doi.org/10.14814/phy2.13944

Incognito, A. V., Samora, M., Shepherd, A. D., Cartafina, R. A., Guimarães, G., Daher, M., Millar, P. J., & Vianna, L. C. Arterial baroreflex regulation of muscle sympathetic single-unit activity in men: influence of resting blood pressure. Am J Physiol Heart Circ Physiol. 318(4), H937–H946, 2020. https://doi.org/10.1152/ajpheart.00700.2019