BRIEF REPORT

Effects of Caffeine on Postural Stability

Ashlee Enriquez,[1] Jessica Sklaar,[1] Erik Viirre,[2] and Bradley Chase[1]

[1] *University of San Diego and* [2] *University of California–San Diego, La Jolla, California, USA*

Abstract: The purpose of this study was to investigate the effects of a caffeine-containing "energy drink" on postural stability. Twenty-three young adult participants stood on a balance-measuring platform for two intervals of 30 seconds each, once with eyes open and once with eyes closed. Subjects performed the tasks before and 1 hour after consumption. Results showed no significant effect, either with eyes open or eyes closed, on movement of the body's center of pressure.

Key Words: caffeine; posture stability; vestibular function

Balance is a neurological function that depends on many sensorimotor systems. A key sensory system for balance is the vestibular apparatus. Further, the central nervous system, particularly the brainstem and cerebellum, are necessary for balance. Head injury can disrupt balance through injury to the balance sensors or through damage to the central circuitry used to maintain it.

Assessment of fitness after head injury has been a difficult problem. Fitness evaluation is important in such circumstances as football or soccer, in which mild head injury is common, or in hazardous occupations, including military duty. Monitoring the brain is a potential solution but is difficult technologically. Proxy tests of intact neurological status that can be readily implemented would be highly desirable. Assessing balance function through postural stability is such a potential proxy test [1–3].

Normative data on balance are established by testing populations with no known history of head injury. Then population norms can be compared to subjects after head injury. An important factor for assessment of neurological function of balance after head injury will be to detect confounding factors, such as the ingestion of stimulants. The most common stimulant in the young adult population is "energy drinks" or caffeinated carbonated beverages. These drinks have moderate levels of caffeine and glucose.

Reprint requests: Erik Viirre, MD, PhD, Department of Surgery, School of Medicine, Gilman Drive No. 0970, University of California–San Diego, La Jolla, CA 92093. Phone: 858-657-8590; E-mail: eviirre@otosound.com

This study looked at performance on a stable balance-measuring platform before and after stimulant ingestion. It was a within-subjects study comparison with and without stimulant. We wanted to determine whether a signature of balance performance with stimulant could be found in this test population. In the absence of significant difference, any confounding effect of stimulants on postural stability would be unlikely. Previous studies showed no effect of caffeine on the caloric tests of vestibular function [4] or on dynamic posturography as reported by Liguori and Robinson [5]. These authors used 200 and 400 mg of caffeine and also examined the effects of alcohol. Alcohol significantly decreased postural stability, and this decrease was not corrected by caffeine. The effects of caffeine were analyzed via a counterbalanced within-subjects design.

METHOD

Subjects

Thirteen male and ten female volunteers 18–32 years old participated in the study (mean age, 21 ± 2.9 years). Red Bull (Red Bull USA, Santa Monica, California), a common energy drink, was used as the source of caffeine. Exclusion criteria for subjects included the use of sedating medications, concomitant neurological or other vestibular disorders, and sensitivity to caffeine, the energy drink Red Bull, or any of the ingredients of Red Bull. Subjects were not allowed to have any caffeine 12 hours prior to participating in the study. Subjects were volunteers recruited through posted advertisements in the Engineering Department at the University of San Diego.

The study protocol was approved in advance by the institutional review board at the University of San Diego. Each subject was given a full explanation of the experimental procedures, and they submitted a written informed consent before participating, with the option to withdraw from the study at any time.

Procedure

We first briefed the subjects on the experiment and on each task they would perform. They were instructed to stand on the balance platform, as still as possible, with their feet just outside the designated lines and their hands at their sides. Subjects stood on the balance platform for 30 seconds with their eyes open, staring at a dot on the wall approximately at eye level. They then continued to stand on the balance platform for another 30 seconds with their eyes closed. Subjects then ingested two cans of Red Bull and repeated the experimental procedure 1 hour later. Caffeine is readily absorbed orally and reaches peak plasma levels 1 hour after ingestion [6].

Red Bull has 80 mg of caffeine per can, so the subjects were given 160 mg of caffeine, equivalent to one cup of coffee. Red Bull also contains glucose, taurine, and incidental levels of vitamins.

Instruments

Balance Platform

The main piece of equipment for the study was a balance-measuring platform provided by Neuro-Muscular Engineering and Technology, Inc. of Tweed Heads, New South Wales, Australia**.** By using pressure sensors under the platform, the machine measures the amplitude and timing of the subjects' swaying as they stand. It is a version of the clinical instrument known as *computerized dynamic posturography* that is intended to be deployed in non-hospital or non-laboratory conditions. The test instrument for this protocol was simply a metal plate (approximately 30 inches wide by 20 inches long by 1 inch high) that remained stationary while resting on pressure sensors.

Data Analysis

The relationship of postural stability and caffeinated beverage intake was assessed through means and two-way paired *t* tests, and the Pearson correlation coefficient was calculated using Minitab software (Minitab Inc., State College, PA).

RESULTS

Three metrics were used for the study: total travel, total travel in *X*, and total travel in *Y*. Travel was calculated on the basis of movement of the body's center of pressure on the posture platform. Total travel is the aggregated sum of the vector movement of the center of pressure.

Travel in *X* is the movement in the medial-lateral dimension only, whereas travel in *Y* is movement in the anterior-posterior direction. With eyes open before caffeine, total travel was 5.10 inches ± 2.63 and, 1 hour after caffeine ingestion, it was 5.40 inches ± 1.71 (paired *t*-test; $p = .75$). With eyes closed before caf-

Table 1. Stability Measures with Eyes Open and Eyes Closed

	Total Travel			Travel in *X*			Travel in *Y*		
	Mean	**SD**	**SEM**	**Mean**	**SD**	**SEM**	**Mean**	**SD**	**SEM**
Men eyes open									
Before caffeine	5.131	1.993	0.553	1.608	1.004	0.278	3.523	1.303	0.361
After caffeine	5.185	1.429	0.396	1.377	0.796	0.221	3.808	1.04	0.289
p Value	.949			.605			.569		
Women eyes open									
Before caffeine	5.05	3.46	1.09	1.39	1.835	0.58	3.66	1.769	0.559
After caffeine	5.68	2.07	0.66	1.77	1.187	0.375	3.91	1.253	0.396
p Value	.557			.543			.653		
Men eyes closed									
Before caffeine	9	3.66	1.01	2.554	1.543	0.428	6.446	2.502	0.694
After caffeine	9.75	3.1	0.86	2.523	1.344	0.373	7.223	2.008	0.557
p Value	.468			.953			.216		
Women eyes closed									
Before caffeine	7.38	2.87	0.91	1.7	1.344	0.425	5.68	1.935	0.612
After caffeine	9.02	3.3	1.04	2.12	1.321	0.418	6.9	2.269	0.718
p Value	.201			.429			.164		

SD = standard deviation; SEM = standard error of the mean.

feine, the total travel increased to 8.30 inches ± 3.32; after caffeine, it was 9.43 ± 3.19 (paired *t*-test; $p = .34$). Thus, there was no significant effect of caffeine on total travel.

Ekdahl et al. [7] showed that women may have a higher level of postural stability than men. Table 1 shows the mean, standard deviation, and standard error of the mean of total travel, travel in *X*, and travel in *Y* for men and women individually for the pre- and post-caffeine ingestion. As can be seen, no value approached significance in these disaggregated values. Further, in these statistics there is no trend for men or women to be more stable overall.

DISCUSSION AND CONCLUSION

As described previously in the literature, we found no evidence that caffeine ingestion influences postural stability. It is interesting to speculate on how a stimulant could have an effect. If the stimulant were to have a heightening effect on attention, a reduction in motion while standing might be expected, as fatigue tends to increase postural instability [8]. However, if resting posture is stable with an energetic low, a stimulant that increases such muscle activity as involuntary twitching or an increase in the threshold of motion detection by the vestibular apparatus could result in increased postural instability.

The influence of attention on postural stability is an important possibility. As described earlier, alcohol can decrease postural stability [5]. Alcohol's reduction of stability may be the result of a reduction of attention. Further investigation of the role of attention on stability is required. In head injury conditions, attentional resources may be at a premium, and thus the effects of stimulants, depressants, or other items affecting attention may alter postural stability.

ACKNOWLEDGMENT

This research was supported in part by a grant from Neuromuscular Engineering and Technology Inc. to E. Viirre. The authors thank Colleen Benson for her technical assistance with the study and the volunteers for their participation.

REFERENCES

1. Lahat E, Barr J, Klin B, et al. Postural stability by computerized posturography in minor head trauma. *Pediatr Neurol* 15:299–301, 1996.
2. Guskiewicz KM, Ross SE, Marshall SW. Postural stability and neuropsychological deficits after concussion in collegiate athletes. *J Athl Train* 36(3):263–273, 2001.
3. Peterson CL, et al. Evaluation of neuropsychological domain scores and postural stability following cerebral concussion in sports. *Clin J Sports Med* 13:250–257, 2003.
4. Felipe L, Simões LC, Gonçalves DU, Mancini PC. Evaluation of the caffeine effect in the vestibular test. *Rev Bras Otorrinolaringol (Engl)* 71:758–762, 2005.
5. Liguori A, Robinson JH. Caffeine antagonism of alcohol-induced driving impairment. *Drug Alcohol Depend* 63: 123–129, 2001.
6. Goodman A, Goodman LS, Gilman A. *The Pharmacological Basis of Therapeutics*, 6th ed. New York: Macmillan, 1980:600–601.
7. Ekdahl C, Jarnlo GB, Andersson SI. Standing balance in healthy subjects. Evaluation of a quantitative test battery on a force platform. *Scand J Rehabil Med* 21:187–195, 1989.
8. Morad Y, Azaria B, Avni I, et al. Posturography as an indicator of fatigue due to sleep deprivation. *Aviat Space Environ Med* 78:859–863, 2007.