Salivary stress marker in Simulated microgravity and Zero gravity: Aeronautic dentistry

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Abstract

The objective of this study was to valid a ground-based model for microgravity and zero gravity and to study the effects of simulated condition salivary cortisol. Because 6° head-down tilt (HDT) and bed rest position (HB) an established method to mimic low gravity and zero gravity on earth, the aim of the present study was to determine the effects of 20-day HDT &HB on salivary cortisol levels in 10 healthy male volunteers. The cortisol was measured in saliva. During HDT and HB, all volunteers the diurnal rhythm of cortisol secretion was significantly increased in simulated conditions. Thus 6° HDT & HB appears to be a valid model to induce psychic stress due to increased levels of cortisol, changes that might also be encountered by astronauts and marsonaunts during long-duration spaceflights.

Key words: Head-down tilt, Bed rest position, cortisol, saliva

Introduction

Traditionally, the development of technology has taken the forefront in our efforts to sustain life underwater, in the air, in outer space, and in complex technological environments. The achievement of these technological and engineering feats provided an awareness of the physiological and biomedical stressors associated with operating in these environments. Myriad physiological conditions arising from spaceflight include Space Adaptation Sickness (SAS), bone demineralization, fluid shifts, and cardiovascular deconditioning. Accordingly, the development of biomedical and physiological countermeasures was undertaken in an effort to begin overcoming these stressors. These countermeasures allow us to sustain human presence in flight for increasing periods, as well as to participate in increasingly complex and lengthy missions. Russian experience in long duration spaceflight has revealed that among the most critical problems facing humans in long duration spaceflight, after the biomedical, are the psychological and psychosocial 1-4.Physiological stressors inherent in the long-duration space environment pose the greatest challenge to human spaceflight. The human body must physically adapt to the foreign microgravity environment and, in doing so, undergo cardiovascular, muscular, and skeletal deconditioning as well as changes in the immune and nervous systems, and radiation exposure. Regarding the physical effects of adaptation to spaceflight, about 40-50% of flight crews during their first few days of microgravity experience a condition called Space Adaptation Sickness (SAS), which causes symptoms such as nausea, disorientation, headache, and a sea-sick or flu-like feeling. Some of the above named factors can be alleviated by exercise and pharmacological interventions, but others remain a significant obstacle to maintaining the health of astronauts during long duration missions. Similarly, crews must undergo the stress associated with re-adapting to the 1-g environment upon return to Earth. These physiological factors are a significant concern for a human mission to Mars. These and other adaptive physiological and physical processes represent change from a normal state of functioning for the astronauts and can thus contribute to increased psychological stress levels. Many microgravity-induced responses in humans, including total body height increase and back pain, have been studied in simulation using 6 degrees of head-down tilt (HDT) 4-8. Bed rest exposes humans to restricted mobility.

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It has been shown that HDT with balanced traction is a better method than horizontal bed rest (HBR) to induce back pain in healthy subjects 8-22. There is very few studies on salivary cortisol in simulating microgravity environments. Hence, this study was designed to examine salivary cortisol in normal healthy subject in simulated microgravity condition of -6° head-down-tilt (HDT) bed rest and zero gravity of Bed rest position.

Materials and methods

After approval by the local ethics committee and receipt of informed consent, ten healthy male volunteers [age 25.8 , 7.5 (SE) yr, weight 64.2, 6.2 kg, height 167.7 , 76.2 cm] were subjected to permanent bed rest for 20 days at 6° HDT and ten healthy male volunteers [age 26.5 , 6.9 (SE) yr, weight 67.1, 5.6 kg, height 168.6 , 7.8 cm] were subjected to permanent bed rest for 20 days at 6° H R. To obtain constant experimental conditions and to avoid imbalances in the sleep-awake rhythm, lights were switched off between 2300-2400 and 0800-0900, whereas normal daylight illumination was present for the rest of the day. During the HDT period and HR , the subjects were not allowed to sit or to leave their bed; physical activities were limited to a very low state. The daily routine procedures were standardized and were kept constant during the entire study period. According to this study protocol, measurements were taken before the start of the HDT and HR period (Pre), at the first day and 20 days after the end of the bed rest (Post). Because glucocorticoids are known to be periodically secreted in response to a variety of environmental and hormonal stimuli (e.g., psychic stress and physical exercise), which alone and/or together with cortisol might affect the immune system, free cortisol was determined in saliva samples collected in the morning (8 AM) and in the evening (7 PM). Saliva was collected by having the subject chew on a cotton swab for 40-45 s; the swab was then stored in a SALIVETTE device tube. Samples were frozen, and free-cortisol concentrations were quantified by a commercially available ELISA according to the instruction of the manufacturer (Orion Diagnostica, Espoo, Finland). To evaluate possible changes in the circadian rhythm of cortisol secretion, the ratio between the morning and evening (m/e) cortisol values was calculated. Significant differences between mean values were tested with analyses of variance and paired t tests. The Wilcoxon signed-rank test was used for nonparametric tests.

Table 1. Saliva cortisol levels in before, during and After simulated microgravity and simulated zero gravity

Variables	Microgravity			Zero gravity		
	Before (Mean(SD)	During(Mean(SD)	After (Mean(SD	Before(Mean(SD	During(Mean(SD	After (Mean(SD)
Cortisol (morning 8 AM), nmol/l	13.63 (5.68)	24.65(6.89)	16.69(8.67)	13.25(5.64)	26.38(9.58)	12.68(6.87)
Cortisol (evening 8 PM), nmol/l	4.23(2.34)	12.69(5.21)	5.63(4.55)	3.99(1.21)	13.87(6.84)	4.68(2.35)

Results

Normal physiological variations in salivary cortisol secretion with higher levels in the morning followed by a decline down in the evening. Salivary cortisol concentration showed statistically significant increase during simulated microgravity and zero gravity as compared to before and after (Table -1, P<0.001).

Discussion

As reported previously activates cerebral regions, leading to subsequent alterations in the secretion of stress hormones such as cortisol and catecholamines, as observed changes in the diurnal rhythm of cortisol secretion. In this study, cortisol was determined in the saliva specimen for several reasons. First, it represents

a noninvasive method. Second, determination of cortisol in saliva allows the detection of the protein-unbound free cortisol, because only this form can enter saliva and is not affected by the saliva flow rate 19 lastly is the unbound, free cortisol that can reach target cells and their receptors 20 and hence reflects the biologically active cortisol that is responsible for the induction of physiological or pathophysiological effects. Under physiological conditions, cortisol levels show a diurnal rhythm because of four to fivefold higher levels in the morning than in the evening 21. In consequence, these finding may indicate that chronic stress leads to alterations in the regulation of the hypothalamic-pituitary-adrenocortical axis, ending up in the suppression of its circadian regulation. In contrast to the loss of the circadian rhythm of cortisol secretion during simulated microgravity and zero gravity . These results demonstrate that the short duration of HDT at 6° and HB are a reliable approach to inducing psychic stress and hence appears to be useful for the study of stress related changes. In view of long-duration flights on space stations or to other planets, such as Mars, there is a need for additional experiments by which the biological significance of spaceflight-induced changes of stress markers related in real microgravity such as in parabolic flight can be investigated further. In this respect, HDT and HB appears to be a helpful ground-based surrogate model.

References

1. Manzey D, Schiewe A, Fassbender C. Psychological countermeasures for extended manned spaceflights. Journal of Human Performance in Extreme Environments, 1995; 35: 39-60.
2. Herring L. Astronaut draws attention to psychology [communication]. Journal of Human Performance in Extreme Environments, 1997; 2:42-47.
3. Manzey D, Lorenz B. Human performance during prolonged space flight. Journal of Human Performance in Extreme Environments, 1997; 2: 68.
4. Morphew ME, MacLaren S, Herring L, et al. Voyage of discovery: American astronauts aboard Russia's Mir Space Station. Journal of Human Performance in Extreme Environments, 1997; 2: 39-61.
5. Hargens AR, Tipton CM, Gollnick PD, Mubarak SJ, Tucker BJ, Akeson WH. Fluid shifts and muscle function in humans during acute simulated weightlessness. J Appl Physiol, 1983; 54: 1003-9.
6. Parazynski SE, Hargens AR, Tucker B, Aratow M, Styf J, Crenshaw A. Transcapillary fluid shifts in tissues of the head and neck during and after simulated microgravity. J Appl Physiol, 1991; 71: 2469-75.
7. Hutchinson K, Watenpaugh D, Murthy G, Convertino V, Hargens A. Back pain during 6 degrees head-down tilt approximates that during actual microgravity. Aviat Space Environ Med, 1995; 66: 256-9.
8. Styf JR, Ballard RE, Fechner K, Watenpaugh DE, Kahan NJ,Hargens AR. Height increase, neuromuscular function, and back pain during 6 degrees head-down tilt with traction. Aviat Space Environ Med, 1997; 68: 24-9.
9. Ransford A, Cairns D, Mooney V. The pain drawing as an aid to the psychological ealuation of patients with low-back pain.Spine, 1976; 1: 127-34.
10. Melzack R. Pain measurement and assessment. New York: Raven Press; 1976.
11. Turk DC, Rudy TE, Salovey P. The McGill Pain Questionnaire reconsidered: confirming the factor structure and examining appropriate uses. Pain, 1985; 21: 385-97.
12. Bond A, Lader M. The use of analogue scales in rating subjective feelings. Br J Med Psychol, 1974; 47:211-8.
13. Wing PC, Tsang IK, Susak L, Gagnon F, Gagnon R, Potts JE. Back pain and spinal changes in microgravity. Orthop Clin North Am, 1991; 22: 255-62.
14. Styf JR, Ballard RE, Fechner K, Watenpaugh DE, Kahan NJ, Hargens AR. Height increase, neuromuscular function, and back pain during 6 degrees head-down tilt with traction. Aviat Space Environ Med, 1997; 68: 24-9.
15 Ohhashi T, Morimoto-Murase K, Kitoh T. Physiology and functional anatomy of the venous system. In: Hirakawa S, Rothe CF, Shoukas AA, Tyberg JV, eds. Veins: their functional role in the circulation. Tokyo: Springer-Verlag, 1993; 33-47.
16 Parazynski SE, Hargens AR, Tucker B, Aratow M, Styf J, Crenshaw A. Transcapillary fluid shifts in tissues of the head and neck during and after simulated microgravity. J Appl Physiol, 1991; 7: 2469-2475.

17. Satake H, Konishi T, Kawashima T, Matsunami K, Uno T, Imai S, et al. Intracranial blood flow measured with single photon emission computer tomography (SPECT) during transient -6 degrees headdown tilt. during transient -6 degrees headdown tilt. Aviat Space Environ Med, 1994; 65: 117-122.

18 Wen TS, Randall DC, and Zolman JF. Protein accumulation in cerebrospinal fluid during -90° head-down tilt in rabbit. J Appl Physiol, 1994; 7: 1081-1086.

19. Kirschbaum C and Hellhammer DH. Salivary cortisol in psychoneuroendocrine research: recent developments and applications. Psychoneuroendocrinology, 1994; 19: 313-333.

20. Laudat MH, Cerdas S, Fournier C, Guiban D, Guilhaume B, and Luton JP. Salivary cortisol measurement: a practical approach to assess pituitary-adrenal function. J Clin Endocrinol Metab, 1988; 66: 343-348.

21. Cooper TR, Trunkfield HR, Zanella AJ, and Booth WD. An enzyme-linked immunosorbent assay for cortisol in the saliva of man and domestic farm animals. J Endocrinol, 1989; 123: R13-R16.

22. Udelsman R and Holbrook NJ. Endocrine and molecular responses to surgical stress. Curr Probl Surg, 1994; 31: 653-720.