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Posture affects emotional responses: A Head Down Bed Rest and ERP study

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ABSTRACT

Body posture, mainly represented by horizontal bed rest, has been found to be associated with cortical inhibition, altered perceptual and cognitive processing. In the present research, the influence of Head Down Bed Rest (HDBR) – a condition also termed simulated microgravity – on emotional responses has been studied. Twenty-two male subjects were randomly assigned to either Sitting Control or HDBR group. After 3-h, subjects attended to a passive viewing emotional task in which 75 IAPS slides, divided into 25 pleasant, 25 neutral and 25 unpleasant, were presented in random order for 6 s each, while EEG was recorded from F7, F8 and Pz locations. Results showed in Sitting Controls the expected greater P300 and Late Positive Potential (LPP) to pleasant and unpleasant compared with neutral slides, an effect which indicates greater processing of emotional arousing stimuli. The HDBR group showed smaller non-significant differences among all emotional conditions in both ERP components. Arousal and valence subjective evaluations, typically less sensitive to experimental manipulation, did not differentiate groups. The observed ability of HDBR to inhibit cortical emotional responses raises an important issue on the risk that astronauts underestimate a dangerous/threatening situation or that long-term bedridden inpatients develop depressive symptoms.

1. Introduction

In the last decade a substantial number of studies were carried out on the effects of body posture – namely long-term bed rest – on physiological functions such as bone and muscle mass, immune system, hormones, metabolism, or cardiovascular control (Ertl et al., 2002; Guell, Tallarida, & Wegmann, 1993; Hirayanagi et al., 2004; Kamiya et al., 2000; Zayzafoon, Meyers, & McDonald, 2005). This research issue is central for increasing our knowledge on physiological side effects arising in long-term bedridden inpatients, a problem leading to inflated socio-economic costs due to the growth of elderly population in west countries. A second more specific application of studies on posture is the possibility to simulate space microgravity by means of the well known condition termed Head Down Bed Rest (HDBR), in which the subject lies on a bed with the head tilted down by 6°. In almost all physiological domains, simulated microgravity induced changes very similar to those observed in real weightlessness (Guell et al., 1993). This allows to study astronauts' physiology in a valid ground model, and at the same time provides information also for the medical risks of bedridden patients. Little research has been undertaken so far on the influence of posture on cognitive processes and cortical activity. A first pioneer investigation of Vaitl, Gruppe, Stark, and Pössel (1996) demonstrated that HDBR induces greater delta and theta EEG activity together with slower reaction times: the observed increase of slow rhythms paralleled by poor performance is a clear marker of cortical inhibition. Consistent with this result, more recent research has demonstrated lack of startle reflex habituation in subjects submitted to 3-h HDBR compared with sitting controls, a result pointing to reduced learning (reflex habituation is a form of learning) and brain plasticity (Messerotti Benvenuti, Bianchin, & Angrilli, 2011). Furthermore, after 2-h of HDBR pain responses have been found to be inhibited both in the subjective perceptual domain and in the amplitude of the P1, N1 and P2 pain-elicited waves (Spironelli & Angrilli, 2011). Therefore, HDBR represents a body position particularly effective for its capacity to inhibit cortical activity and perceptual/cognitive processes. Currently, there are no data available on the influence of HDBR, or horizontal bed rest, on emotional responses. There is little empirical evidence that two body positions, intermediate between horizontal and vertical, are able to affect some emotional responses. In a first study, anger-induced EEG frontal asymmetry recorded from subjects was inhibited when the chair was reclined back as compared with an upright chair position (Harmon-Jones & Peterson, 2009). A second investigation of the same authors compared two body positions, backward reclining vs. leaning forward, during the recording of startle reflex and event-related potentials (ERPs) elicited by neutral and erotic pictures (Price, Dieckman, & Harmon-

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Jones, 2012). Results showed inhibited cortical response (both P1 and Late Positive Potential [LPP]) in reclining backward condition to erotic stimuli with respect to leaning forward position. Results have been interpreted in terms of embodying approach motivation, that is, in terms of emotion implicitly induced/suggested by body position (leaning forward being related to approach/pleasant action tendency, and reclining backward related to avoidance/unpleasant action tendency). Beside the observation that the two adopted body positions do correspond approximately to an incomplete horizontal bed rest (backward reclining on an armchair) and a sitting upright (leaning forward), our interpretation is that the backward reclining position does not affect emotions through an approach-avoidance motivation mechanism, but rather through a more general cortical inhibitory mechanism: this would explain why in two separate experiments, reclining backward induced relative inhibition of both the negative emotion anger and the ERP response to erotic pictures. The lack of both pleasant and unpleasant picture in the same experiment did not allow to test hypotheses alternative to those suggested by the authors.

Most of past results can be consistently interpreted by the simplest explanation that HDBR is able to inhibit cortical arousal, especially its modulation and motivational increase, by means of a still not clarified bottom-up physiological mechanism driven by horizontal/head down body posture.

The aim of the present experiment was to measure emotional cortical responses elicited by pleasant, neutral and unpleasant slides in two groups of subjects submitted to either Head Down Bed Rest or sitting control position. In line with the observed general mechanism of cortical inhibition described in past studies (Spironelli & Angrilli, 2011; Vaitl et al., 1996), we expected to find, in bed rest compared to sitting position, a reduced ability to modulate (i.e., increase) arousal levels typically triggered by high arousal emotional stimuli, both pleasant and unpleasant, with respect to the neutral ones. Since neutral stimuli were not expected to elicit arousal modulation, cortical response evoked by these stimuli were not hypothesized to differ between the groups. To this end, a standardized and well-consolidated psychophysiological paradigm of emotions was used (Bianchin & Angrilli, 2012; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Mini, Palomba, Angrilli, & Brevi, 1996; Palomba, Angrilli, & Mini, 1997). In this paradigm, the P300 wave, representing an index of stimulus elaboration and attention (e.g., Gray, Ambady, Lowenthal, & Deldin, 2004; Johnson, 1988; Johnston, Miller, & Burleson, 1986; Polich, 2007; Wickens, Kramer, Vanasse, & Donchin, 1983), has been reliably shown to be more positive for high arousal emotional stimuli compared to neutral ones (Mini et al., 1996; Palomba et al., 1997): this evidence highlights a greater attentional processing of biological and evolutionistic relevant stimuli (e.g., erotic scenes and mutilations) (Lang & Bradley, 2010; Lang, Bradley, & Cuthbert, 1997; Olofsson, Nordin, Sequeira, & Polich, 2008). Furthermore, similar patterns have also been found for the LPP (from about 400–600 ms to 1000 ms and over) peaking over the centroparietal cortex (Cacioppo & Berntson, 1994; Cuthbert et al., 2000; Mini et al., 1996; Palomba et al., 1997), a result suggesting a sustained and stable emotional response occurring for long intervals (Mini et al., 1996). In the present experiment we hypothesized a blunted cortical response to emotional high arousing stimuli starting with the P300 and following with the Late Positive Potential.

2. Materials and methods

2.1. Participants

Twenty-two healthy males (mean age = 27.1, SD = 2.6) were recruited from engineering and astronomy graduated student. All subjects gave informed consent to participate in the current study and received an economic credit of 54 €. They were randomly assigned to one of the two groups: Bed Rest (BR) and Sitting Controls ([SC], 11 participants per group). BR participants (mean age = 26.9, SD = 2.0) were requested to lie down for 4-h in −6° HDBR position (Vaitl et al., 1996), whereas SC (mean age = 27.2, SD = 3.1) control group sat down comfortably. The experiment was carried out in accordance with the Declaration of Helsinki, all procedures were carried out with the adequate understanding and written consent of the subjects. The experiment was approved by the Ethics Committee of Faculty of Psychology, University of Padova (Italy).

2.2. Procedure

Participants were requested not to drink coffee or tea and not to smoke cigarettes after 8:00 a.m., one hour before the experimental session. Participants started laboratory procedures at 9:00 a.m. and finished at 2:00 p.m. Upon arrival, participants were given general information about the experiment and their written informed consent was obtained. Next, electrodes were applied for electroencephalogram (EEG) recording. Then, the participants were randomly assigned to BR or SC condition and took position on a chair (SC) or on a −6° bed (BR) without pillow. After 3-h bed-rest (or sitting condition) at 12:00 a.m. tasks and physiological recordings started while subjects remained in their posture (overall the posture condition lasted 4-h). For the first two hours subject of both groups stayed relaxed and were continuously checked for not sleeping, after 2 h they started some cognitive testing, after 3 h they started emotional task. Seventy-five emotional pictures, selected from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 2008), were presented to participants. Slides were divided into three emotional valence categories: 25 pleasant (e.g., sports, nudes, erotic scenes), 25 neutral (e.g., faces, household objects) and 25 unpleasant (e.g., spiders, snakes, mutilations). Pleasant pictures had mean (SD) normative valence ratings of 7.6 (1.5), and mean (SD) arousal ratings of 7.1 (1.9). Neutral images had mean (SD) valence ratings of 4.9 (1.1) and mean (SD) arousal ratings of 2.6 (1.8). Unpleasant images had mean (SD) valence ratings of 3.0 (1.7) and a mean (SD) arousal ratings of 6.5 (2.2).[1] Pictures were projected for 6 seconds each in a semi-random sequence of the three categories. Inter-stimulus interval was randomly varied by 5–8 s. At the end of the session, slides were presented again and self-evaluation of emotional Valence and Arousal was assessed using a 9-point analog Self-Assessment Manikin scale (SAM) (Bradley & Lang, 1994).

2.3. Data acquisition and statistical analysis

Data acquisition and analyses were performed with ad hoc LabVIEW software (National Instruments) according to Angrilli (1995). EEG was measured through 10 mm Ag/AgCl electrodes placed at F7, F8, and Pz locations, according to the International 10/20 System (Jasper, 1958) and using linked mastoids as reference. Electrical impedance was kept below 3 kohm at each site, and Ten20 conductive paste was used. To avoid impedance asymmetry problems which arise when mastoids are physically linked, mastoids were electrically joined by using two 5 kohm resistors (one from each mastoid). The EEG was amplified with a gain of 10,000 and filtered by a 80 Hz low-pass filter and a time constant of 10 s (i.e.,

[1] The IAPS images were 1050, 1114, 1300, 1301, 1321, 1525, 1932, 2030, 2235, 2514, 3000, 3051, 3053, 3060, 3400, 3530, 4002, 4141, 4142, 4180, 4210, 4232, 4250, 4290, 4310, 4607, 4608, 4647, 4652, 4659, 4670, 4681, 4683, 4800, 4810, 5130, 5390, 5731, 5740, 6230, 6250.1, 6260, 6300, 6313, 6315, 6350, 6370, 6510, 6550, 6560, 6570.1, 7006, 7009, 7020, 7025, 7035, 7050, 7052, 7053, 7055, 7060, 7080, 7090, 7110, 7150, 7175, 7224, 7233, 7235, 7491, 8030, 8185, 8190, 8260, 8470.