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Anxiety, emotional regulation and concentration during a 35-day bed rest

PETRA DOLENC, MATEJ TUŠAK, TJAŠA DIMEC and RADO PIŠOT

The psychological condition of astronauts is an important factor contributing to mission success in limited space. Bed rest is a well-accepted method by which an acute stage of human adaptation to weightlessness in space flights is simulated, as well as an important model to study consequences of physical inactivity and sedentary inactivity on human body. The objective of the study was to investigate anxiety level, concentration, as well as emotional regulation and control in ten young male subjects during a 35-day horizontal bed rest. Participants were asked to complete psychometric inventories before, during and after bed rest. The results have shown that a prolonged period of bed rest did not result in greater anxiety levels nor poorer emotional regulation and control. Likewise, concentration expressed as the quantity of performance was not impeded, whereas concentration expressed as the quality of performance improved after the bed rest experiment. The objective of this research was to provide evidence that the provision of favourable habitability countermeasures can prevent deterioration in the psychological state under conditions of physical immobilisation. Our findings have applied value in the field of health prevention and rehabilitation.

Key words: physical inactivity, psychological condition, healthy young subjects, bed rest, simulated weightlessness

With the construction of the international space station Freedom and ongoing preparations for the mission to Mars, man's presence in space is rapidly increasing. The role of astronauts will become even more important owing to longer and more complex space missions. Since man still remains a central element in the conquest of space despite the outstanding technological achievements, protection of human life and provision of support to astronauts constitute tasks of utmost importance, the very tasks that determine the success and efficiency of space expeditions.

The state of weightlessness as experienced by astronauts during stays in space cannot be recreated on Earth. Examples of experimental situations where said state can be simulated, however, are the bed rest (BR) studies involving prolonged periods of rest in the lying-down position. Such experiments represent an important model for the simulation of weightlessness on Earth and allow for the monitoring of the effects of complete physical inactivity on human body. Numerous research studies have proven that the physiological changes that occur following a prolonged period of BR are very similar to the changes observed in astronauts upon their return from space travel (Adams, Caiozzo, & Baldwin, 2003; Mekjavić, Golja, Tipton, & Eiken, 2005; Pavy-Le Traon et al., 1998).

Psychological factors (personal and psychosocial) also play an important role in the processes of adaptation under conditions of extreme confinement and isolation such as, for instance, during exposure to weightlessness or simulation thereof. Adaptation to new conditions undoubtedly represents an important source of stress which can induce psychological and behavioural disturbances, such as anxiety and other mood changes (Weiss, Nicolas, & Charras, 2005).

During space flights, astronauts experience atypical environment, weightlessness, isolation and absence of contacts with family and friends, immobility, monotony and

Petra Dolenc, University of Primorska, Science and Research Centre of Koper, Institute for Kinesiology Research, Garibaldijeva 1, 6000 Koper, Slovenia. E-mail: petra.dolenc@zrs.upr.si (the address for correspondence);

Rado Pišot, University of Primorska, Science and Research Centre of Koper, Institute for Kinesiology Research;

Matej Tušak and Tjaša Dimec, University of Ljubljana, Faculty of Sport, Gortanova 22, 1000 Ljubljana, Slovenia.

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discomfort (Ishizaki et al., 2002; Weiss & Moser, 1998). Such stressful conditions can be accompanied by numerous emotional symptoms, changes in immune functions, behavioural problems and cognitive dysfunctions.

Although the BR experiment cannot be equated with the conditions that astronauts are exposed to during space flights, the investigation of the psychological aspects of adaptation in bed rest studies is nevertheless considered to contribute to a more appropriate selection and training of astronauts and to the optimization of psychological preparations and monitoring of volunteers who form part of the control group on Earth. The obtained findings are of great applicable value also for other target groups exposed to similar conditions of physical immobility and social confinement (Gunji, 1997).

Professional literature that addresses the psychological aspects of adaptation to a prolonged period of rest in the lying-down position discusses horizontal bed rest (HBR) experiments and 6-degree head-down tilt bed rest (HDT) experiments. HDT appears to be a preferable method to apply, rather than HBR, given that simulation of this type speeds up all processes in human organism and comes closest to matching the conditions of weightlessness occurring during space missions (Hyeteok, Iwasaki, Miyake, Shiozawa, & Nozaki, 2003; Iwase et al., 2004).

DeRoshia and Greenleaf (1993) have studied cognitive functions and mood state during a 30-day HDT in eighteen healthy male subjects. The participants completed psychological tests and questionnaires (ten cognitive tests and eight scales,six of which were relating to mood and two to sleep) before, during and after the BR period. Although a trend of mild decrease in the values of the measured parameters was established during the experiment, the authors conclude that mood and performance did not deteriorate in response to prolonged BR. Shehab, Schlegel, Schiflett and Eddy (1998) studied the effects of a 17-day HDT on cognitive performance in eight male volunteers with the application of the NASA Performance Assessment Workstation test battery which was initially developed for the purpose of studying mental functions during space flights. The test battery uses six performance tasks to assess directed and divided attention, spatial, mathematical and memory skills, as well as tracking ability. No statistically significant differences in performance were observed when comparing BR with control period.

Ishizaki et al. (1994) evaluated the effect of immobilization during BR on the mental health of nine young subjects (six male and three female) before, during and after 20 days HBR. The psychological state was repeatedly assessed by measuring their depression status (Self-Rating Depression Scale) and neurotic symptoms (Cornell Medical Index and General Health Questionnaire). Although no influence of BR on Cornell Medical Index was seen, Self-Rating Depression Scale and General Health Questionnaire displayed a tendency to development of depression and neurotic symptoms, respectively. This tendency disappeared two months after the BR study.

In a more recent study, Ishizaki et al. (2002) evaluated changes of mood status and depressive and neurotic levels in nine healthy male subjects aged 18–28 during a 20-day HDT. Depressive and neurotic levels were enhanced, mood state “vigor” was impaired and “confusion” was increased during BR compared to pre-BR and ambulatory control periods, whereas the mood “tension-anxiety”, “depression-dejection”, “anger-hostility” and “fatigue” were relatively stable during the experiment.

Styf, Hutchinson, Carlsson and Hargens (2001) investigated back pain, mood state, and depression in six subjects, all of whom were exposed to microgravity, simulated by two forms of BR for 3 days. One form consisted of bed rest with 6 degrees of head-down tilt (HDT) and balanced traction, and the other consisted of horizontal bed rest (HBR). Subjects had a 2-week period of recovery between the experiments. They experienced significantly more intense lower back pain, lower abdominal pain, headache and leg pain during HDT. They had also more depressive symptoms and poorer mood status during HDT.

A recent study examined the effect of acute simulated microgravity on nocturnal sleep, daytime vigilance and psychomotor performance. Seven subjects were maintained for 3 days of head-down and horizontal bed rest in a counter-balanced design. Results suggest that nocturnal sleep, daytime vigilance and psycho-physiological functions were not disturbed in head-down conditions, although there was a mild deterioration of high-attention functions in the mornings (Komada et al., 2006).

On the basis of the evaluation of available contributions it may be concluded that extreme physical inactivity resulting from simulated weightlessness may contribute to the deterioration of mental health. However, the results of the studies of cognitive functions during bed rest experiments appear to be less conclusive. The inconsistency of the presented research findings might be conditioned, in particular, by the form and duration of BR experiments and also by methodological characteristics of studies (e.g. sample of subjects, applied psychological instruments).

Even though it would be difficult to determine the exact cause of psychological change in subjects, some possible explanations may be offered. Extreme and prolonged confinement to bed and immobility resulting from simulated weightlessness might contribute to psychological changes reflected in tension, greater stress and alteration of mood status and behaviour. Another factor that plays an important role is isolation from familiar environment and adaptation to experimental conditions. The discussed BR studies involved significantly limited social contacts between subjects and the exterior environment, meaning that the subjects spent the majority of the BR days without seeing visitors. Lack of social contacts and isolation from familiar environment are expected to contribute greatly to the psychological changes occurring during the period of prolonged BR. In such unnatural living conditions, interpersonal relationships and positive atmosphere among subjects constitute an important factor which affects the mental state and well-being of subjects.

Furthermore, cardiovascular and skeletal-muscle changes occurring due to the microgravity simulated by BR might induce headache, back pain, sleep disturbances and other problems (Kume, 1997) which could in turn affect the psychological well-being of an individual (e.g. greater depression levels and poorer mood status).

The objective of the study was to evaluate the effects that a 35-day horizontal bed has on participants as regards the anxiety level, emotional regulation and control and the ability to concentrate.

METHODS

Participants

Ten healthy adult males, aged between 20 and 25 (M ± SD; 22.3 ± 1.7) participated in the study. An invitation for the enrollment in the study was sent to several faculties in Slovenia. The selection process involved two steps: an interview about a past history and a present condition of the subject's physical and psychosocial status was the first step, and the second step included a physical examination, where routine medical and laboratory analyses were used to exclude chronic diseases. Ten selected participants were university students, non-smokers and took no medications or drugs. Written informed consent was obtained following a detailed explanation of the study (purpose and research hypotheses, experimental procedures and methods, research conditions, possible problems and complications). Participants got a financial award at the end of the study. The study design and protocol were approved by the National Committee for Medical Ethics at the Ministry of Health, Slovenia.

Procedure

The study investigating the effects of simulated microgravity on human organism was conducted at the Orthopaedic Hospital Valdoltra, Slovenia in July and August 2006. BR consisted in confinement to bed in a horizontal supine position for 35 days. The participants were housed in three hospital rooms (3-4 in each room) and were under constant video surveillance. They performed all daily activities lying down and were not pemitted to leave their beds. The bedrooms were air-conditioned and the room temperature was kept below 25° C. Nursing care was provided throughout the duration of the study. Physicians checked the physical condition of the participants regularly. Their vital signs were taken every morning upon awakening, urine and saliva samples were collected and body weight was measured. They received standard hospital meals three times a day at 7:30, 12:00 and 18:00, and had no strict restrictions against eating snacks, whereas consumption of alcohol was strongly forbidden. In order to take care of their personal hygiene the participants were transferred in their bed to the bathroom. During BR the participants were allowed to freely communicate with each other, to watch television and video, to listen to radio and tapes, to read books and magazines, to work on comuputer and use the Internet, and to receive visitors. They were also permitted to move with their beds from the room to the hospital balcony from time to time. Three times a week they received physiotherapy which included passive exercise of the joints and gentle neck and back massage.

The participants were asked to complete psychometric inventories during the pre-BR period (5 days before the experiment) and at the end of BR (on day 33 of the experiment). They filled out the questionnaires and preformed the test in the morning, after breakfast.

Instruments

State-Trait Anxiety Inventory (Spielberger, 1983) provides a reliable measure of both temporary and dispositional anxiety in adults. For the purpose of the study the Slovene version of the questionnaire was used (Lamovec, 1988). We have included only the part of the instrument that relates to state anxiety and allows for the identification of temporary emotional state of individuals. The scale contains 20 items. Subjects are asked to evaluate how they feel "right now, at this moment", on a four-point scale (1 – Not at all, 2 – Slightly, 3 – Moderately so, 4 – Very much so). Scores range from 20 to 80, with higher scores indicating greater level of anxiety. The instrument is frequently used for studying anxiety in research settings.

Emotional Regulation and Control Questionnaire (Takšić, 2003) consists of 20 items and measures self-reported ability to regulate and control of negative emotions. Subjects mark the answer that best describes them on five-point scale. Scores range from 20 to 100, with higher scores indicating better emotional regulation and control. The internal reliability of the original scale is high, and in different semples Cronbach Alphas are in range from 0.79 to 0.83. For the purposes of this study we translated the questionnaire into Slovenian, following the approval of the author.

Test of Concentration and Achievement (Düker & Lienert, 1965) is a speed test for measuring the ability to concentrate and identifying mental ability required for adequate performance. We used the Slovene version of the test (Bele-Potočnik, 1976), which was acquired from the Center for Psychodiagnostic Resources Ltd., Slovenia. The test contains 250 arithmetic problems, each arithmetic problem comprising two simple addition and subtraction equations,

Table 1
Differences in studied variables before and after BR period

	before BR *M (SD)*	after BR *M (SD)*	difference *M*	*t* (*df* = 9)	*p*
State anxiety	28.22 (2.69)	27.72 (5.90)	0.50	0.35	.73
Emotional regulation and control	45.22 (6.98)	46.61 (7.82)	-1.39	-0.99	.33
Concentration-quantity of achievement	93.22 (35.61)	95.88 (33.14)	-2.66	0.32	.75
Concentration-quality of achievement	10.39 (4.64)	7.18 (3.39)	3.21	3.76	.02

and the time designated for the completion of the test is limited to 30 minutes. The results of the test are evaluated according to the number of equations calculated (quantity) and according to the number of mistakes (quality), with both parameters assessing the ability to concentrate.

RESULTS

The mean and standard deviation (M ± SD) of scores relating to state anxiety, emotional regulation and control and concentration before and after BR period are shown in Table 1. Paired-samples t-test was used to calculate differences in studied psychological variables. Anxiety level, emotional regulation and control and concentration expressed as the quantity of achievement did not change significantly following BR period. Concentration expressed as the quality of achievement, however, was significantly improved (p<.05).

A positive correlation between the level of anxiety and the number of mistakes made during the concentration test, namely both before BR period (r=.56, p<.05) and after BR period (r =.55, p<.05) has been identified.

DISCUSSION AND CONCLUSION

During the pre-BR measurement the participants manifested, on average, rather low anxiety level and below-average values on the Emotional Regulation and Control Scale, which fact points to the selection of appropriate candidates. Namely, the results have shown that the participants' negative emotional states do not hinder their mental processes nor interfere with their actions; moreover, the participants felt they had control over their emotional state. After prolonged BR, no statistically significant changes occurred in anxiety level and emotional regulation and control. Their ability to concentrate expressed as the quantity of performance (total number of equations calculated) did not change significantly following BR. However, concentration expressed as the quality of performance (number of mistakes) was statistically different following the BR period. Namely, the results show that participants made fewer mistakes after BR period compared to pre-BR period. The experimental situation had therefore a rather positive effect on participants in terms of quality of their attention.

The obtained results may well be due to the significantly smaller number of stimuli to which subjects were exposed during BR as opposed to the multitude of stimuli to which individuals are usually exposed in every-day life. The reduction of stimuli and the more relaxed living condition thus contributed to a less stressful experience and this might facilitate concentration on respective tasks.

Another possible explanation is that participants were free to pursue a variety of mental activities during BR (reading, writing, studying for exams, working on PC, playing games, information research with Internet), which may have contributed to a better cognitive performance in terms of improved concentration capacity.

Correlation coefficients helped us establish that participants with higher anxiety levels made more mistakes in the concentration test, which may point to the existence of a relationship between anxiety and anxiety-related manifestations at the physiological, experience and behavioural levels on the one hand, and the quality of achievement on the other. A relationship of a similar kind had previously already been established in Slovenia, in a selected population of top athletes (Tušak & Tušak, 2003).

Even though the obtained results overlap partly with the findings of previous studies which did not establish statistically significant differences in perfrormance in the periods before and after BR (DeRoshia & Greenleaf, 1993; Shehab et al., 1998), they are inconsistent with the majority of findings that report mood impairments and increased values of depressive and neurotic experience after BR period (Ishizaki et al., 2000, 2002).

Research findings reporting deterioration of mental state and psychological well-being after a prolonged period of BR were mostly carried out under strict experimental conditions where, in addition to the conditions of simulated weightlessness (i.e. restricted physical mobility), researchers tried to recreate the conditions of extreme social isolation and seclusion similar to those experienced by astronauts on space missions. The higher degree of subject adaptability to the conditions of our study was attributed to the selection of participants with optimal characteristics for adaptation to confinement and restricted mobility and to the highly favourable environmental habitability factors in our study relative to previous studies. These habitability factors included maintenance of a stimulating environment, the possibility to use various media and access to communications with friends and families. All participants answered that they experienced no interpersonal conflicts with other paricipants and that the social climate was agreeable. Participants were also in constant contact with the medical staff and research teams during BR period. It is possible that these "protective" circumstances have had some bearing on the fact that the mental state of subjects did not deteriorate in the course of the experiment.

Results suggest that favourable living conditions and the possibility of social interactions during a period of restricted physical activity represent a kind of safeguard against an impairment of mental state, or, in other words, that they alleviate the negative effects caused by prolonged physical immobilization.

Research on the psychological aspects within bed rest studies has a potentially great applied value in the field of health prevention and rehabilitation. Namely, we could apply the findings in the study of the effects of physical inactivity on human mental health (post-operative conditions requiring long-term recovery; in cases of health indications requiring physical inactivity or bed rest; in lifestyles dominated by extreme physical inactivity) and anticipate the use of appropriate psychological interventions to prevent psychological stress and increase the quality of life under conditions of prolonged physical immobility.

The study of psychological and cognitive aspects under conditions of simulated weightlessness undoubtedly deserves special attention and in-depth consideration in the future. Our research represents a small yet important and valuable contribution in this direction. For the future, it seems reasonable to apply the models of simulated weightlessness used abroad (6-degree head-down tilt bed rest) and to also include, in addition to psychological status, the evaluation of the social and environmental factors that play an important role in such isolated and confined conditions (interpersonal interaction, experience of isolation and limited mobility, boredom and monotony; concepts of psychological well-being, stress-coping strategies).

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