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CHANGES IN MENTAL HEALTH AND SATISFACTION WITH LIFE DURING PHYSICAL INACTIVITY INDUCED BY BED REST EXPERIMENT

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ABSTRACT

Simulated weightlessness in the case of bed rest model represents an important method to study the consequences of physical inactivity and sedentarism on the human body. The purpose of the study was to examine the effects of prolonged physical inactivity on psychological distress, depressive symptoms and satisfaction with life of healthy male adults. The volunteers who took part in the study were aged between 21 and 28 and were subjected to a 35-day head-down bed rest. The psychological state of the participants was measured with the General Health Questionnaire (GHQ-12), the Center for Epidemiological Studies Depression Scale (CES-D), and the Satisfaction with Life Scale (SWLS). The participants completed psychological inventories before, during and after the experiment. The results revealed no significant differences in mental health and satisfaction with life of the participants following the head-down bed rest, however, there was a tendency towards an increase in neurotic and depressive symptoms at the end of the experiment. The obtained results are interpreted in the light of stimulative living conditions in which the experiment was carried out, as well as the amount and the quality of social interactions during the period of extended physical inactivity.

Keywords: *prolonged physical inactivity, bed rest studies, mental health.*

SPREMEMBE V PSIHIČNEM ZDRAVJU IN ZADOVOLJSTVU Z ŽIVLJENJEM V OBDOBJU GIBALNE NEAKTIVNOSTI V OKVIRU *BED REST* RAZISKAVE

IZVLEČEK

Bed rest model, ki predpostavlja daljše obdobje ležanja v vodoravnem položaju, predstavlja pomembno metodo za spremljanje učinkov popolne gibalne neaktivnosti na človekov organizem. Cilj raziskave je bil proučiti spremembe v mentalnem zdravju, depresivni simptomatiki in zadovoljstvu z življenjem po obdobju daljše gibalne neaktivnosti pri zdravih odraslih moških. V raziskavi je sodelovalo deset odraslih oseb moškega spola, starih od 21 do 28 let, ki so bili izpostavljeni 35-dnevnemu neprekinjenemu ležanju s 6-odstotnim naklonom glave. Psihološki status udeležencev smo ugotavljali s Splošnim vprašalnikom o zdravju (GHQ-12), z Lestvico depresivnosti (CES-D) in Lestvico zadovoljstva z življenjem (SWLS). Preiskovanci so bili z izbranimi merskimi pripomočki testirani pred in med eksperimentom ter ob koncu eksperimenta. Rezultati so pokazali, da ni prišlo do pomembnih sprememb v mentalnem zdravju in zadovoljstvu z življenjem udeležencev po obdobju daljše neaktivnosti v ležečem položaju. Primerjava začetnega in končnega stanja pa je nakazala tendenco povečanja nevrotičnih znakov in depresivne simptomatike pri udeležencih. Razloge za dobljene rezultate smo poskušali pojasniti zlasti v luči ugodnih bivanjskih pogojev ter v količini in kvaliteti socialnih interakcij v obdobju daljše gibalne neaktivnosti.

Ključne besede: *popolna gibalna neaktivnost, bed rest raziskave, duševno zdravje*

INTRODUCTION

The benefits of physical activity on health and psychological well-being are well documented (Warburton, Nicol, & Bredin, 2006). Positive effects of physical activity have been found in both healthy individuals and individuals with various emotional disorders, regardless of their age, gender or abilities (Guszkowska, 2004). There has been a rather vast body of research examining the effects of physical / sports activities in the past. Studies have shown that physical activity (i.e. aerobic exercise) helps lower anxiety levels and leads to positive changes in emotional states (Berger & Motl, 2000; Biddle, 1995; Ekkekakis, Hall, & Petruzzello, 1999; O'Connor, Raglin, & Martinsen, 2000). Moderate intensity and regular physical activity helps alleviate psychological problems, such as depression and anxiety (Blinc & Bresjanac, 2005; Peluso & de Andrade, 2005), leads to an improvement in subjective well-being (Fox, 1999) and positive psychological effects, including higher general satisfaction with life (Fontaine, 2000; Penedo & Dahn, 2005).

Complete physical inactivity is rather hard to enact in everyday life and the effects are fairly difficult to monitor. Therefore, the effects of complete physical inactivity are frequently examined by experimental situations of simulated weightlessness, known as *bed rest* (BR) studies. Prolonged exposure to strict lying position is the most frequently used ground-based method for monitoring the effects of adaptation to microgravity in space flights on the human body. Also, BR studies are important for assessing the effects of long-term physical inactivity on individuals (Rittweger, Felsenberg, Maganaris, & Ferretti, 2007). Literature that examine psychological aspects of adjustment to longer periods of bed rest also feature horizontal bed rest (HBR) experiments and head-down bed rest experiments (HDBR). Studies examining long-duration BR tackle both HBR and HBDR, involve limitations of body movements and generate various changes in physical and mental states (Hirayanagi et al., 2009). Compared to HBR, the HDBR method, mainly a 6 degrees head-down bed rest is considered to be more suitable as it speeds up physiological processes in the human body (e.g. redistribution of bodily fluids to the upper part of the body) and represents conditions being similar to zero gravity in space (Hyeteok et al., 2003; Styf, Hutchinson, Carlsson, & Hargens, 2001).

Psychological factors (i.e. personality variables and psychosocial variables) have a significant role in the processes of adaptation to conditions of extreme limitation and isolation, such as experienced in the state of (simulated) weightlessness. The adjustment to new circumstances undoubtedly represents a significant source of stress. Japanese scientists conducted BR experiments motivated by the fact that a growing body of population can no longer stand in an upright position either due to a disease or an accident. Thus, Japanese researchers conducted five long-term studies in the period from 1990 to 1994. The aim of the latter was to explore the main effects of physical inactivity on individuals' health. The obtained results were to be used to encourage people to awaken from inactivity and regain an active lifestyle. The results pertaining to the participants' mental status have shown a significant decrease in their mental health and a significant increase in depression symptoms after a prolonged period of physical inactivity induced by horizontal bed rest (Gunji, 1997).

Ishizaki and colleagues conducted a number of BR studies (Ishizaki et al., 1994; Ishizaki et al., 1997; Ishizaki et al., 2000) and reported a tendency for subjects to develop depressive and neurotic symptoms during a prolonged period of complete physical inactivity. In another study, changes in mood as well as the rate of depressive and neurotic signs during a 20-day bed rest on a sample young healthy males were examined (Ishizaki et al., 2002). Authors reported increased rates of depressive and neurotic symptoms after the completion of the study.

Slovenian researchers examined different psychological variables in two 35-day horizontal bed rest studies. According to the first study, performed in 2006, no significant decrease in anxiety level, emotion regulation and control and concentration ability was established after the period of strict physical immobility in young male participants (Dolenc, Tušak, Dimec Časar, & Pišot, 2008). In the study carried out in 2007, the level of psychological distress was enhanced during the BR period, whereas self-perceptions were relatively stable during the experiment. However, even after the period of physical

inactivity, the expression of these symptoms remained relatively low and did not represent a risk to the mental health of participants. Also, the results indicated a tendency toward an increase of emotion-focused coping and a decrease of problem-focused coping strategies (Dolenc, Tušak, Dimec Časar, & Pišot, 2009).

Nicolas and Weiss (2009) examined the psychological effects of a 60-day -6° head-down bed rest as well as the influence of exercise on the psychological state. The experiment consisted of three stages: a 20-day pre-experimental period, a 60-day head-down bed rest and a 20-day period of rehabilitation. The participants' psychological state was measured with The Recovery-Stress Questionnaire for Athletes consisting of items related to stress and recovery after stress. As the results revealed, the experimental group reported a higher level of stress when compared to the control group. After the period of rehabilitation, the experimental group continued to score higher on the scale Lack of Energy, while reaching lower values on scales General Well-being and Personal Accomplishments.

Furthermore, the most recent studies in China focused primarily on examining emotions during short- and long-duration -6° HDBR involving complete physical inactivity. Qin et al. (2010) conducted a 60-day study with measurements performed on a sample of 21 subjects on nine different occasions (on the 3rd, 10th, 17th, 24th, 31st, 38th, 45th, 52nd and 59th day) and found a 4-phase fluctuating trend of negative emotions (high – low – high – low). The measurements also revealed significant differences in the rate of fatigue or exhaustion (a dimension of the POMS questionnaire) and the cortisol levels, while the rate of depression significantly increased between the 38th and the 52nd day of bed rest. Conversely, Chen, Zhao, Zhou, Wang and Tan (2011) found no significant changes in anxiety, depression and positive / negative emotions in their 15-day study of HDBR. Further, two Chinese studies conducted over a longer time period (45 days of HDBR) also found no significant increase in symptoms of anxiety and depression (Liu, Zhou, Chen, & Tan, 2012; Zhao, Wang, Zhou, Wang & Tan, 2011).

Based on the above-mentioned research, it can be concluded that complete physical inactivity induced by bed rest model may lead to negative changes in the mental status of individuals. Our study aimed to examine the psychological effects of a 6 degrees head-down tilt bed rest in healthy male volunteers. In the year 2008, this type of bed rest was carried out for the first time in Slovenia. We assumed that 35 days' absence of physical activity will lead to poorer mental health, an increase in the level of depressive symptoms and a decline of the general satisfaction with life.

METHOD

Participants

The study was conducted on 10 healthy males with a mean age of 23.36 years (*SD* = 2.17) who volunteered to participate in the project "Valdoltra Bed Rest Study".

Previously, the participants were explained about the objectives and the procedure of the study. The participants' selection was based on an in-depth structured interview and a thorough medical examination to exclude neuromuscular, cardiovascular diseases and psychiatric disorders. The selected participants signed a written consent for participating in the research. A personality questionnaire (BFQ – Big Five Questionnaire; Caprara et al., 2002) was assessed to check the subjects' emotional stability and there were indeed no significant deviations in their personality profiles, hence rendering them suitable participants. The experiment was approved by the National Medical Ethics Committee of the Republic of Slovenia and was conducted in accordance with the principles of the Helsinki-Tokyo Declaration.

Experimental protocol

The study was conducted at the Valdoltra Orthopaedic Hospital, Slovenia. The 35-day bed rest was carried out in a strictly 6-degree head-down tilt position. The participants performed all daily activities lying down. Physical activity was strictly forbidden. During the entire bed rest, the participants received medical care and were monitored by video-cameras. They were allowed to watch television, listen to music, use computers with the Internet connection, read and have visits. Participants completed the psychological questionnaires in the forenoon, at three different test time points – a day before bed rest, on the 17th day of bed rest (during BR) and on the 35th day of bed rest (after BR).

Instruments

General Health Questionnaire – GHQ-12 (Goldberg, 1972) is a questionnaire used to assess general mental health at the time of measurement. It is a screening instrument used to discover neurotic disorders in the framework of general medical practice and primary care. The questionnaire consists of 12 items referring to general well-being and individuals' phenomenological experience. For the purpose of the present study, participants were asked to report the intensity of their feelings over the past week on a 4-point scale (0 – much more than usual, 1 – more than usual, 2 – same as usual, 3 – much less than usual). The final score obtained is the sum of all figures. Six answers are reverse scored. Scores range from 0 to 36 – a high result indicates poor health (individuals have trouble sleeping, find it hard to concentrate on their work, feel under pressure, feel unable to conquer problems, are unhappy, irritable and depressed, have been losing confidence in themselves and their abilities etc.). A low score, conversely, indicates absence of health problems. The questionnaire has high coefficients of internal consistency ($0.82 < \alpha < 0.90$) and reliability in time ($r_{test\text{-}retest} = 0.73$) (Goldberg & Williams, 1988).

Center for Epidemiologic Studies Depression Scale – CES-D (Radloff, 1977) is a 20-item self-report scale designed to measure depression symptoms with an emphasis on the affective component, i.e. depressed mood. The scale measures symptoms that constitute the criteria for clinical depression: depressed mood, feelings of guilt and worthlessness, feelings of helplessness and despair, psychomotor inhibition, loss of appetite and sleeping problems. It consists of 20 statements focusing on individuals' feelings. Respondents use a 4-point scale (0 – rarely or none of the time, 1 – some or a little of the time, 2 – occasionally or a moderate amount of the time, 3 – most or all of the time) in answering how often they have experienced the described emotional content recently. Total score is the sum of all items. Four items are reverse scored. Scores range from 0 to 60, a high result indicating a higher level of depression symptoms. A total score above 16 indicates the presence of clinically significant level of depression symptoms. Values between 16 and 21 indicate slight to moderate level of depression symptoms, while scores above 21 indicate a probable major depressive episode. The scale has high coefficients of internal consistency ($0.84 < \alpha < 0.90$) and reliability in time ($r_{test\text{-}retest}$ = from 0.45 to 0.70).

Satisfaction with Life Scale – SWLS (Diener, Emmons, Larsen, & Griffin 1985) measures general satisfaction with life. Among various components of the subjective well-being, this scale focuses on the cognitive aspect of satisfaction with life. The score obtained by the scale can be seen as an individuals' global assessment of the quality of their life based on their own criteria (the feeling that life was and is good, that life at the moment or life in general is full, meaningful and pleasant). The scale consists of five items and the participants answer on a 7-item scale (1 – strongly disagree, 2 – disagree, 3 – slightly disagree, 4 – neither agree nor disagree, 5 – slightly agree, 6 – agree, 7 – strongly agree). The final score is a sum of answers on all five items. Results range from 5 points (low satisfaction with life) to 35 points (high satisfaction with life). Authors report a high coefficient of internal consistency ($\alpha = 0.87$) and reliability in time ($r_{test\text{-}retest} = 0.82$).

Statistical analysis

IBM SPSS Statistics 20 was used to calculate the relevant parameters. Differences in psychological variables before, during and after BR were tested using Wilcoxon signed rank test. In addition to statistical significance, practical relevance of the obtained results was reported using Pearson's *r* as effect size measure (Field, 2005). Cohen's guidelines for interpreting effect size were followed, with r = 0.10 indicating small, r = 0.30 medium, and r = 0.50 large effect size (Field, 2005).

RESULTS

Results in Table 1 show no significant decrease in the mental health (GHQ-12) of participants following the BR period however, there was a medium to high effect size in the direction of health deterioration. The analysis of depressive symptoms assessed by

the CES-D revealed no significant changes after the BR period although the effect size measure indicates a medium to high effect, indicating a tendency toward an increase of depressive symptoms. Furthermore, no significant differences were found in satisfaction with life assessed by SWLS during the 35-day bed rest. The effect size coefficient revealed a medium effect.

Table 1: Differences in mental health, depressive symptoms and satisfaction with life before and after 35-day bed rest (BR).

	Before BR			After BR						
Variables	*Me*	*Min*	*Max*	*Me*	*Min*	*Max*	*t*	*Z*	*p*	*r*
Mental Health (GHQ-12)	16.50	7	18	18.00	15	32	5.00	–1.83	0.07	–0.41
Depressive Symptoms (CES-D)	3.50	1	18	5.00	0	44	6.50	–1.83	0.07	–0.41
Satisfaction with Life (SWLS)	25.00	12	31	24.50	9	34	9.00	–1.27	0.21	–0.28

Legend: BR – bed rest, *Me* – median, *Min* – minimum value, *Max* – maximum value, *t* – test statistics, *Z* – standardized value of *T*, *p* – significance of differences: * - $p < .05$, *r* –effect size coefficient.

Data collected during the experiment (on the 17th day of BR) revealed that the participants' health deteriorated in the first half of the experiment, the participants' scores were significantly lower before BR than during BR ($Me_{during} = 18.00$; $t = 4.00$; $Z = –1.97$; $p < 0.05$; $r = –0.44$). The biggest rise in depressive symptoms, however, was in the first part of the experiment and results also reveal a tendency towards a statistically significant difference ($Me_{during} = 7.00$; $t = 10.00$; $Z = –1.80$; $p = 0.07$; $r = –0.40$). Depressive symptoms continued to increase slightly in the second half of the experiment, however, the increase was no longer as pronounced as in the first part. In the first half of BR, satisfaction with life gradually decreased. During BR, participants reported the lowest rate of satisfaction with life, although their scores were still relatively high, while a slight enhancement in satisfaction with life occurred in the second half of BR. However, there were no significant differences in the measured variable before and during BR.

DISCUSSION

At the time of the first measurement, participants' scores on the mental health questionnaire (GHQ-12) and depression scale (CES-D) were low and indicated an absence

of health problems, neurotic signs and depressive symptoms. Comparison of results collected at the beginning and at the end of the experiment revealed that after 35 days of BR, there were no significant differences in mental health and depression, however, there was a tendency towards a decrease in both parameters. Similar results were obtained in several studies (Ishizaki et al., 1994; Ishizaki et al., 1997; Ishizaki et al., 2000), but are in contrast with some studies reporting a significant increase in psychological distress of participants after horizontal BR (Dolenc et al., 2009).

A 35-day head-down bed rest had a medium to high effect (Field, 2005) leading to a decrease in the participants' psychological health, however, due to generally low scores, it can be concluded that the mental health of the participants was good immediately before, during, as well as at the end of the experiment. Despite the slight trends towards an increase in depressive symptoms and a deterioration of mental health, the latter was not in serious danger at any point during the experiment. The obtained results are similar to the findings of most recent head-down bed rest studies that similarly found no increase in depressive symptoms due to physical inactivity (Chen et al., 2011; Liu et al., 2012; Zhao et al., 2011) and contradict the findings of some older studies (Ishizaki et al., 2002).

Measurements performed during bed rest, on the other hand, revealed a significant difference in health in the first half of the experiment. Ishizaki et al. (1994) in their study examining the influence of complete physical inactivity on mental health similarly found a significant increase in raw values for all participants on the 19th day of BR, however, these values decreased until the end of bed rest. Possible reasons for the deterioration of health in the first part of the experiment can perhaps be found in the processes of basic physical and psychological adaptation caused by physical inactivity and spending days in a restricted environment. In this initial stage, problems may arise due to fatigue and disturbances in the vestibular and sensorimotor system caused by weightlessness. Participants also experienced some secondary effects of the simulated weightlessness state (e.g. headaches, sleep disturbances, etc.) (Gushin, Kholin, & Ivanovsky, 1993). Based on a closer overview of the obtained results, we can thus come to the conclusion that the first half of the experiment had a somewhat negative influence on participants' health, while their health only slightly deteriorated in the second half of the experiment. The obtained findings could be a result of the healthy and fit participants' bodies adapting to inactivity after the initial "shock". Additionally, they opted to participate in the experiment including inactivity voluntarily and were highly motivated for participation.

The largest increase in depressive symptoms occurred in the first part of the experiment. The difference was not significant, however, there was a tendency towards statistical significance and a medium to high effect size. Kanas and Manzey (2003) similarly report an increase in the depressive mood following a decrease in physical / sports activity − in our study, the biggest effect of physical inactivity was found in the first part of the experiment. Manzey, Lorenz and Poljakov (1998) further report a stabilization of mood after a successful adaptation to the new environment, which is similar to our findings as the depressive mood continued to increase only slightly until

the end of our experiment. Styf et al. (2001) examined differences in depression in BR and HDBR and reported similar findings.

After a 35-day period of complete physical inactivity, satisfaction with life did not significantly decrease. Examining the effect size, however, it can be seen that the long-duration complete physical inactivity had a medium effect leading to deterioration in an individuals' satisfaction with life. Measurements conducted during the experiment revealed that participants reported the lowest satisfaction with life at that time compared to their initial results and results at the end of the experiment, however, their satisfaction with life scores were still in the range of average satisfaction with life.

The participants thus reported an average level of satisfaction with life throughout the experiment. When discussing the main sources of satisfaction with life, Diener (2000) mentions individuals' satisfaction with oneself, faith or spiritual life, process of learning and development as well as free time as main sources of satisfaction and perhaps this is also the reason for the participants' relatively stable level of satisfaction with life. The experimental situation did not touch any of those areas, quite the contrary, participants were able to learn something new about themselves and dedicate time to themselves and their own personal growth.

Our study revealed no prominent decrease in the mental state and well-being of the participants after a long-lasting physical inactivity induced by head-down bed rest. The results can perhaps be explained in the light of various factors: stimulating living conditions during the experiment (participants had access to computers and the Internet connection as well as television, music, books, newspapers etc.); good initial mental state of the participants; the fact that participants could have contacts with family and friends every day and were consequently satisfied with the amount of social contacts; absence of conflicts between the participants; the possibility of communication with various staff members at all times and the satisfaction of the participants with the quality of interaction with staff members; participants feeling safe and trusting the research and healthcare staff; the awareness that intervention is possible at any moment and they will get immediate help if any problems should arise: predictability of events at the time of bed rest (participants knew what to expect from the next step, saw the experiment as something positive or as a challenge, they decided to participate in the experiment voluntarily, the absence of or lack of any real danger (e.g. to their own physical or mental health) as well as the awareness of the participants that their state is only temporary and that they will be able to continue with their active lifestyle after the experiment. The above-mentioned findings could also be used for suggestions for psychological interventions aimed at lowering stress and improving individuals' quality of life in conditions of long-lasting physical inactivity.

To conclude, better psychological outcomes and fewer problems in psychological adjustment can be expected if mentally stable young individuals exposed to a longer period of physical inactivity (e.g. in the initial stage of rehabilitation or following a surgery) are provided with positive and stimulating living conditions, the possibility for frequent social interactions and a feeling of safety as well as being cared for by trust-worthy health staff. We can further predict that in cases of slightly poorer initial

mental health, favourable living conditions and social interactions could bear an even more significant role in maintaining a favourable mental status.

CONCLUSIONS

The study of psychological aspects of acute physical inactivity, induced by bed rest model deserves special attention and consideration in the future. Bed rest studies could further be enriched by examining the effects of various psychological interventions, such as relaxation and visualisation techniques on participants' mental status.

The results of the present study could be applied with the aim of providing adequate psychological support and assistance in the cases of prolonged planned physical inactivity in otherwise healthy individuals, in particular in the field of sport and exercise, e.g. after orthopaedic surgeries that require long-term recovery and other medical indication which presume prolonged physical inactivity.

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