NeuroRegulation

Exploring Effect of Chamber Restricted Environmental Stimulation Therapy on Salivary Cortisol and Information Overload in Young Adults

Igor Bartolen and Petra Sóláriková*

Comenius University, Department of Psychology, Bratislava, Slovakia

Abstract

Environmental challenges like noise, light exposure, and information overload impact young adults' overall health, reducing time for self-care. Restricted environmental stimulation therapy (REST), specifically chamber REST, offers a cost-effective intervention for stress management. In our study, 49 participants in chamber REST (N = 35) and a control group (N = 14) were compared. Measures, including cortisol, information overload, anxiety, stress, rumination, and obsessive-compulsive symptoms, were assessed before and after treatment, and selected at 1 week follow-up. Results showed no cortisol concentration differences, but at the 1 week follow-up, the chamber REST group reported significantly lower information overload, $t(45) = -3.04$, $p = .004$, $\eta^2 = .17$ and obsessive-compulsive symptoms, $t(46) = -2.1$, $p = .042$, than the control group. Correlational analysis revealed a calming effect in the chamber REST ($r = .421$, $p = 0.015$) but not in the control condition ($r = -.096$, $p = 0.744$). In conclusion, chamber REST seems to foster adaptive self-reflection, aiding coping, and resilience against information overload and obsessive-compulsive symptoms in young adults, suggesting its potential as an effective preventative intervention.

Keywords: restricted environmental stimulation therapy; cortisol; information overload; self-reflection; young adults

Citation: Bartolen, I., & Sóláriková, P. (2024). Exploring effect of chamber restricted environmental stimulation therapy on salivary cortisol and information overload in young adults. *NeuroRegulation, 11*(2), 160–171. https://doi.org/10.15540/nr.11.2.160

***Address correspondence to**: Igor Bartolen, Department of Psychology, Faculty of Arts, Comenius University, Gondova Street Nr. 2, SK-81102 Bratislava, Slovakia. Email: bartolen3@uniba.sk

Edited by:
Rex L. Cannon, PhD, Currents, Knoxville, Tennessee, USA

Reviewed by:
Rex L. Cannon, PhD, Currents, Knoxville, Tennessee, USA
Wesley D. Center, PhD, Liberty University, Lynchburg, Virginia, USA

Introduction

Environmental and Societal Challenges

A recent study analyzing the interplay of macroenvironmental physical and socioeconomic factors found a link between different urban environmental profiles and specific negative mental health symptoms (Xu et al., 2023). According to Ventriglio et al. (2021) environmental pollutants are exponentially increasing since industrialization processes and technology are being developed worldwide. Although, environmental factors seem to pose a greater risk for urban than rural communities (Sánchez-Rodríguez et al., 2006). In particular, noise represents the most frequent stressor and is caused by work environment and household appliances, planes, and city traffic. Young adults specifically have shown a positive attitude to noise, a passion for loud music, and lack of knowledge of the consequences of noise damage (Keppler et al., 2015). Prolonged noise exposure can lead to annoyance and sleep disruptions, triggering heightened activity in the hypothalamic-pituitary-adrenal (HPA) axis, elevating stress hormones like cortisol (Münzel et al., 2014). The HPA axis is a key endocrine system in psychological stress response (Ulrich-Lai & Herman, 2009), and cortisol, its primary output, profoundly influences stress-sensitive psychobiological processes, impacting immunity, learning, memory, and overall health (DeMorrow, 2018; Rohleder, 2012; Wolf, 2017).

Light pollution is another significant factor (Ventriglio et al., 2021). Life on Earth has evolved to align with the 24-hr solar day, synchronizing behavioral and biological processes (Bedrosian & Nelson, 2017). In their systematic review of 42 studies, Brautsch et al. (2023) found associations between bedtime or nighttime screen use of mobile phone to poor sleep outcomes and daytime tiredness in samples of young people aged 16–25 years. The human circadian system is highly sensitive to blue light, affecting melatonin and cortisol, key circadian mediators (Jung et al., 2010; Lewy et al., 1980). Contemporary lifestyles often clash with our natural rhythms, causing challenges for our circadian system (Schroeder & Colwell, 2013).

Last, but not least, need for work performance, attention and decision-making requirements, time pressure, and time restrictions often lead to information overload (Misuraca & Teuscher, 2013; Scheibehenne et al., 2010). This occurs when decision-makers face more information than they can process effectively, leading to decreased decision-making performance (Shields, 1980), reduced attention (Li & Sun, 2014), and lower judgment accuracy (Pennington & Kelton, 2016). Information overload also leads to decreased participation in social communities (Zha et al., 2018), demotivation (Baldacchino et al., 2002), and increased stress (Ledzińska & Postek, 2017). It can adversely affect mental, emotional, and physical well-being, often prompting irrational behavior like excessive engagement on social media instead of prioritizing self-care (Roetzel, 2019). Additionally, it reduces time for contemplative activities (Misra & Stokols, 2012). Individuals, mainly in the age group of 18–25, reported the highest levels of information overload, with less time to reflect or absorb them, compared to other age groups (Benselin & Ragsdell, 2016). Moreover, a large cross-sectional study (*N* = 4.731) comparing three generational cohorts of university students (pre-2004, pre-COVID, and post-COVID), found a gradual decline in coping skills (measured by self-regulation subsystem scale of Psychological Immune Competence Inventory), suggesting preventative programs and interventions aimed at improving their mental health and resilience (Takács et al., 2021).

Restricted Environmental Stimulation Approach

Excessive stimuli in modern-day age constitutes a major source of stress, and taking breaks from this bombardment can help to reduce and cope with it (Suedfeld & Kristeller, 1982). Restricted environmental stimulation therapy (REST) is an emerging intervention that shows promise in improving mental and physical well-being. It significantly reduces environmental information and stimulation influx. There are two main methods: chamber REST and flotation REST. In chamber REST, subjects spend up to 24 hours in a dark, sound-reduced room. Essentials like food, water, and toilets are accessible, and assistance is available via an intercom. In flotation REST, sessions last about 45 min in a quiet, dark environment with a pool or covered tank. The flotation medium, a warm mixture of water and Epsom salts, allows for safe and comfortable floating (Suedfeld & Bow, 1999).

Experience of REST and Its Effects on Physiology

Turner and Fine (1983) investigated the impact of repeated flotation REST on hormone levels in healthy subjects. Six participants received eight 35–min sessions. The results indicated a slight decrease in adrenocorticotropic hormone (ACTH) and a significant 20% decrease in noon plasma cortisol across sessions in the REST group compared to the control group. This supports the verbal reports of REST subjects who found the experience to be "very relaxing." In a follow-up study, same authors (Turner & Fine, 1991) explored the impact of repeated brief flotation REST on plasma cortisol levels with a larger sample size. The REST group (*N* = 15) underwent eight sessions over 3 weeks. The REST group exhibited a significant decrease in both the concentration and variability of cortisol in plasma (mean plasma cortisol decreased by 21.6%), while no changes were observed in the control group. This suggests a beneficial effect of flotation REST on cortisol regulation.

There were no decreases in cortisol concentration after a single flotation REST session (Broderick et al., 2019; Schulz & Kaspar, 1994). The psychological effects, such as increased subjective levels of sedation and euphoria, were more prominent than the neuroendocrine changes associated with relaxation. The authors suggest that the relaxation induced by flotation REST may be linked to sedation, reduced central nervous system arousal, or mediated through muscle relaxation (Schulz & Kaspar, 1994). Another positive effect of REST was seen in reduction of subjective pain in 40 subjects diagnosed with chronic tension headache (Wallbaum et al., 1991). This effect was confirmed also in 37 chronic pain patients after receiving nine flotation REST sessions, with significantly lower levels of noradrenaline metabolite (3-methoxy-4-hydroxyphenylethyleneglycol; Kjellgren et al., 2001). Chamber REST sessions also positively influenced physiology of four patients suffering from essential hypertension. Completion of a 24-hr chamber REST combined with relaxation training led to a partial immediate but gradually more pronounced decrease in blood pressure at 1-month follow-up, measured during ongoing examinations by a cardiologist. Authors further attribute long-term effects of chamber REST to improved stress-management and health-related behaviors (Suedfeld et al., 1982). Unfortunately, to date, there have been no studies aimed at evaluating neurohormonal changes in relation to chamber REST.

In Flux et al.'s (2022) study, 37 anxious participants underwent a single 90-min session of flotation REST. This significantly reduced systolic and diastolic blood pressure, as well as breathing rate, compared to a nature documentary-watching control. Lower blood pressure correlated with reduced anxiety and increased serenity. These effects were unique to flotation REST. Additionally, it induced a relaxation response in heart rate variability, with lower sympathetic output (LF) and higher parasympathetic modulation (HF). The findings suggest consistent physiological benefits irrespective of anxiety level. Similar tendencies of cardiovascular reactivity was also found in chamber REST (Vytykáčová et al., 2022).

In their meta-analysis, van Dierendonck and Nijenhuis (2005) examined 25 articles from 1983 to 2002 involving 449 participants. They found positive effects of REST on physiology, well-being, and performance, with an overall pre–post mean effect size of d = 1.02. In randomized control groups, the effect size was d = 0.73. REST outperformed other stress reduction techniques like relaxation exercises and biofeedback. Long-term studies suggested that repeated exposure to REST amplified its effects, indicating improved integration and benefits over time.

The Current Study

Given the limited number of studies on physiological measures in this field, particularly cortisol measurement, which has yielded somewhat inconsistent results, our focus extended to this variable. Our review predominantly centers around flotation REST, with chamber REST research in physiology notably sparse (except for a few studies). Interestingly, post-1990s, researchers predominantly directed their attention towards flotation REST, largely overlooking chamber REST. Objectively, chamber REST, in contrast to flotation REST, is easier to implement, less demanding, and doesn't necessitate special preparations or hygienic procedures, making it more convenient for participants. In this study, using flotation REST as a reference due to its similar intervention essence, we honed in on the impact of a single brief chamber REST session on pre–post salivary cortisol changes—a marker of stress-sensitive psychobiological processes. Our aim was also to explore potential interactions of chamber REST with pre–post information overload and stress symptomatology in young adults. Our hypothesis is that a single session of brief chamber REST will induce a higher pre–post reduction in salivary cortisol concentrations compared to the control group. We also raise questions about the relationships between chamber REST, information overload, and interactions with other relevant psychological variables.

Materials and Methods

Participants

Our research sample consisted of 49 participants (40 women, 9 men; Age: mean = 23.69, SD = 4.68), healthy Caucasian young adults. Eligibility criteria of participants was based on no previously diagnosed psychiatric disorder, substance abuse, neuroendocrinological functional defects, or ongoing medication treatment. At first, participants were recruited for experimental group (chamber REST, N = 35), then for control group, but due to time constraints which coincided with the COVID-19 pandemic, included fewer subjects (N = 14).

Instruments

Cortisol Assessment. Cortisol assessment involved the use of synthetic-fiber absorbent rolls (e.g., Salivette Cortisol; Sarstedt, Nümbrecht, Germany). Participants placed the rolls in their mouths for approximately 2 min, gradually infusing them with saliva. Two samples (15 min apart) were collected before and after treatment, immediately stored at −20 ºC until laboratory testing. Notably, the samples were unlikely to be influenced by the cortisol awakening response (CAR) as the study occurred at least 1 hr after participants woke up for morning measurements.

Information Overload. Visual Analog Scale (VAS) was used for measuring information overload (1 = *not at all*, 10 = *completely*), before treatment, and at 1-week follow-up, “To what extent do you perceive that you are overloaded with stimuli and information during the last week?”

Obsessive-Compulsive Symptoms (OCS). We used a 10-question scale from The Symptom Checklist-90 (Derogatis et al., 1973). Participants rated on Likert scale (0 = *not at all*, 4 = *extremely*), how often they experience these symptoms. Cronbach's α of scale for our sample α = .79.

The Perceived Stress Scale (PSS). We used 10 question scale version (Cohen et al., 1983), to measure perceived stress in the last week (Likert scale: 0 = *never*, 4 = *very often*). Cronbach's α of scale in our sample was α = 0.84.

Rumination-Reflection Questionnaire (RRQ). RRQ is a 12-item scale for measuring compulsively focused attention on the symptoms of one's own distress, its possible causes and consequences, as opposed to solutions (Trapnell & Campbell, 1999). Participants rated (1 = *strongly disagree*, 5 = *strongly agree*), how much they agree with the occurrence of item in the last week. Cronbach's α = .90.

State-Trait Anxiety Inventory (STAI). STAI is a 20-item questionnaire for measuring state anxiety (Spielberger, 1989). Participants evaluated how they feel in the present moment on 4-point Likert scale (1 = *not at all*, 4 = *very*). Cronbach's α = .90.

The Stress Adjective Checklist (SACL). SACL measures individual's phenomenological awareness of bodily processes and assesses the behavioral and cognitive components of reaction (Mackay et al., 1978). The scale is divided into two dimensions each comprising of two counterparts and five items: (a) Stress (active-negative: α = .85) / Calm (passive-positive: α = .86) and (b) Fatigue (passive-negative: α = .77) / Arousal (active-positive: α = .85). Participants were asked to rate how they feel in the moment on 4-point Likert scale (1 = *not at all*, 4 = *extremely*).

Chamber REST. The room provides conditions of limited environmental stimulation (darkness—complete absence of light stimuli, partial acoustic isolation, social isolation). There was comfortable chair, bed, pad for exercise, fully equipped bathroom. Food and drinks were provided according to the needs of the participant. There was an SOS device accessible to participants in case of any emergencies.

Control Group. The control group participants were placed into a fully lit room, without sound attenuation in laboratory premises, containing table and chairs, they were instructed to engage in an ordinary activity (which simulated exposure to "normal" levels of sensory and information stimulation); for example, reading, writing homework, working on computer, mobile phone, etc.

Procedure

In our study we used factorial design, where time assessments before and after the treatment session constituted the within-subject factor. Control and experimental (chamber REST) group constituted the between-subject factor. Participants in both groups were given option to assign for measurements in the morning (8:15–13:00) or in the afternoon (13:45–18:30), while respecting the need for equal distribution – [experimental: morning (n = 16), afternoon (n = 18); control: morning (n = 8), afternoon (n = 6)]. All procedures performed were in accordance with the ethical standards of the Faculty of Arts, Comenius University institutional research committee [Project code: EK/02/2020] and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All participants in the study signed an informed consent and received detailed instructions in advance, which allowed for coordinated measurements with little intrusion from experimenter. Testing was divided into several phases:

1) Data collection took place 2 days before the treatment in form of online questionnaires (completed between 16:00–22:00) and included demographics and additional information, Perceived Stress Scale (PSS), Rumination-Reflection Questionnaire (RRQ), obsessive-compulsive symptoms (OCS).
2) Data collection took place immediately before treatment on the premises of the laboratory, where pretreatment included two measures of salivary cortisol at Time 1 (0 min) and Time 2 (15 min), State-Trait Anxiety Inventory (STAI), The Stress Adjective Checklist (SACL), information overload.
3) Data collection took place immediately after a 3-hr (180 min) stay in chamber REST (or control condition) on the premises of the laboratory, where posttreatment included two measures of salivary cortisol at Time 3 (195 min) and after 15 min at Time 4 (210 min), State-Trait Anxiety Inventory (STAI), The Stress Adjective Checklist (SACL).
4) Data collection was followed up 1 week after the treatment in the form of online questionnaires (completed between 16:00–22:00), including Perceived Stress Scale (PSS), Rumination-Reflection Questionnaire (RRQ), obsessive-compulsive symptoms (OCS), information overload.

Results

Statistical analysis was conducted in IBM SPSS statistics (version 24) and JASP (version 0.18.1). All data were checked for normality distribution, and transformation has been recommended in psychoneuroendocrine research (Miller & Plessow, 2013). For the current analyses, we used a log transformation of the salivary cortisol concentration values.

Cortisol Analysis

In our analysis we utilized several cortisol indices as summarized by Khoury et. al. (2015). Overall cortisol reactivity (RT) is defined as change in cortisol between the baseline and last measured values (computed as last value minus baseline value). AUC_G (area under the curve with respect to ground) and AUC_I (area under the curve with respect to increase/decrease) represent the two most often used indices that capture cortisol levels across repeated measures. AUC_G measures total cortisol output, capturing both intensity (overall distance of cortisol samples from the ground) and sensitivity (difference between individual cortisol samples), whereas AUC_I measures change in cortisol over repeated samples, regardless of prechallenge cortisol concentrations (Fekedulegn et al., 2007; Pruessner et al., 2003).

Based on Pruessner et al. (2003) we computed AUC_G, according to following equation (with variable times between cortisol measurements):

$$AUC_G = \sum_{i=1}^{n-1} \frac{(m_{(i+1)} + m_i) \cdot t_i}{2}$$

And AUC_I was computed as follows:

$$AUC_I = \left(\sum_{i=1}^{n-1} \frac{(m_{(i+1)} + m_i) \cdot t_i}{2} \right) - \left(m_r \sum_{i=1}^{n-1} t_i \right)$$

For cortisol data analysis there was totally $N = 46$ (out of $N = 49$) participants (experimental = 33, control = 13), because of incomplete data from three subjects. Table 1 contains raw cortisol data for both groups, and according to Mann-Whitney U test, there were no significant differences between groups in raw cortisol indices at any measurement phase.

Table 1
Descriptive Statistics for Raw Cortisol Values

		Pre		Post	
Cortisol index	Group	Time 1	Time 2	Time 3	Time 4
Mean cortisol (nmol/l)	Experimental	6.43 (4.66)	4.94 (3.6)	2.80 (2.86)	2.79 (2.64)
	Control	6.55 (6.99)	5.05 (3.7)	2.07 (1.53)	1.63 (0.87)
AUC_G	Experimental	824.65 (520.46)			
	Control	755.97 (462.81)			
AUC_I	Experimental	−525.77 (688.02)			
	Control	−620.97 (1046.19)			
RT	Experimental	−3.63 (4.95)			
	Control	−4.92 (6.76)			

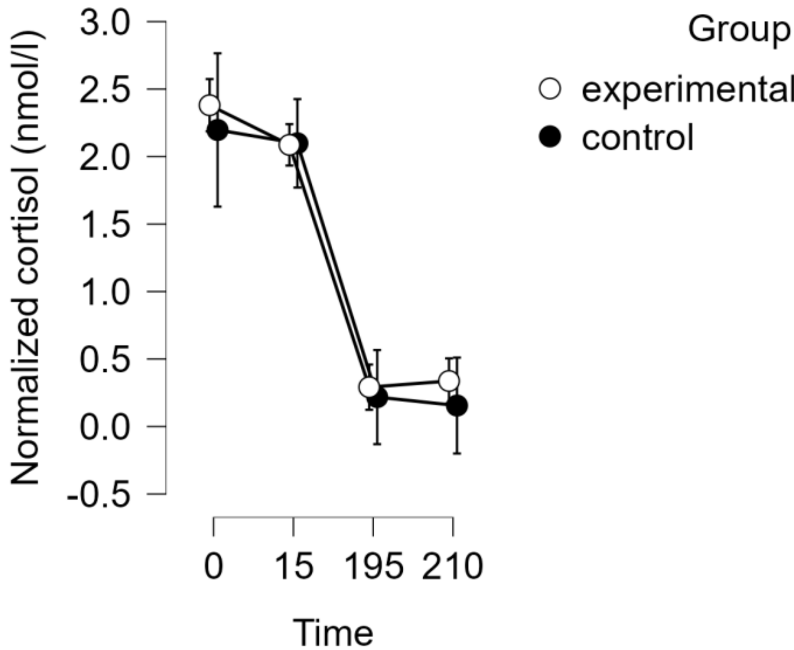
Note. Mean (standard deviation); Preintervention - Time 1 at 0 min, Time 2 at 15 min; Postintervention - Time 3 at 195 min, Time 4 at 210 min; AUC_G = area under the curve with respect to ground; AUC_I = area under the curve with respect to increase/decrease; RT = reactivity.

Cortisol – Repeated Measures Analysis

A two-way repeated measures ANOVA was conducted to compare normalized mean values of salivary cortisol at four different time points: preintervention - Time 1 at 0 min, Time 2 at 15 min; postintervention - Time 3 at 195 min, Time 4 at 210 min, for experimental and control groups (Figures 1–3). There was a significant within-subject effect for time Wilks' Lambda = .171, $F(3, 42) = 67.76$, $p < .001$, effect size was large (multivariate partial

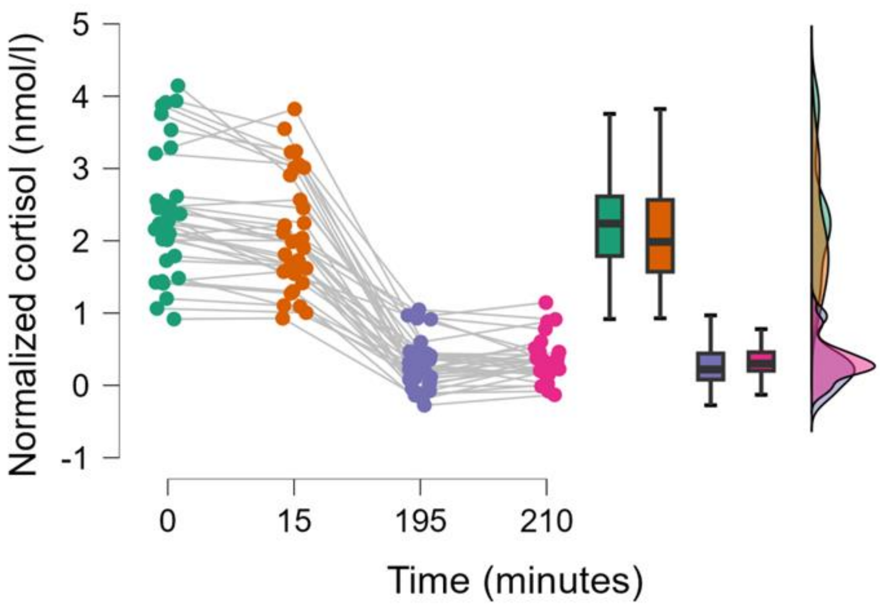
η^2 = .829) for participants in both groups. Post hoc test revealed significant differences between Time 2 and Time 3 (pre-post) values $F(3, 42) = 1.84$, $p < .001$, partial η^2 = .823. Between-subject analysis showed nonsignificant difference between groups $F(1, 44) = 0.421$, $p = .520$, partial $\eta^2 = .009$).

Figure 1. *Graphic Representation of Normalized Cortisol Changes Across Repeated Measures*.



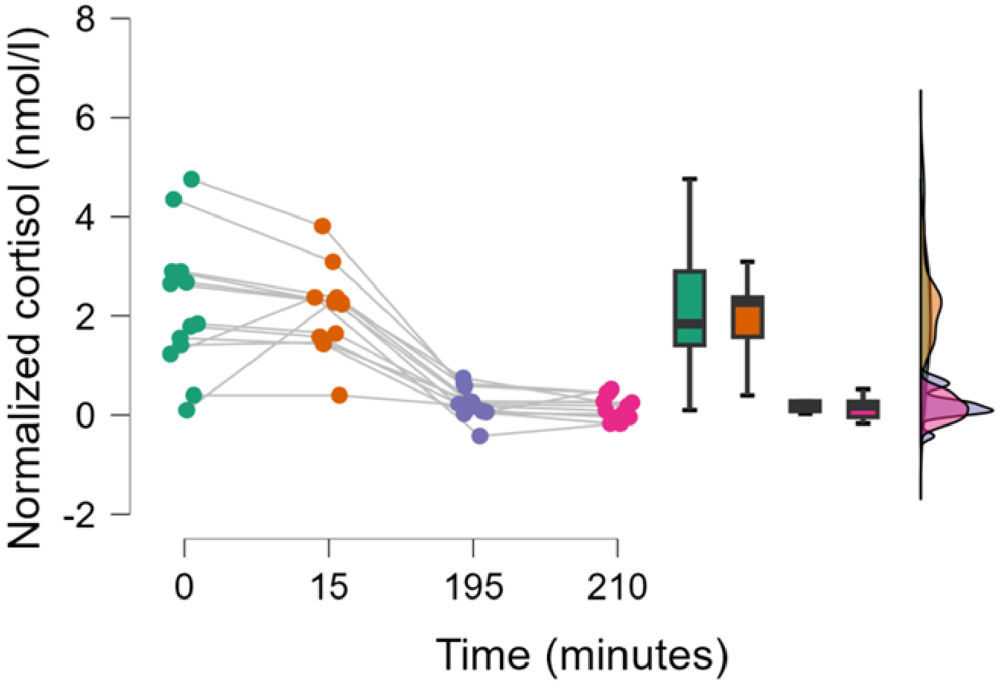
Note. Pre and posttreatment at time: 0 min, 15 min, 195 min, 210 min, for experimental and control group; [CI = 95%].

Figure 2. *Raincloud Plot of Normalized Cortisol Changes Across Repeated Measures*.



Note. Pre and posttreatment at time: 0 min, 15 min, 195 min, 210 min, for experimental group (N = 33).

Figure 3. *Raincloud Plot of Normalized Cortisol Changes Across Repeated Measures*.



Note. Pre and posttreatment at time: 0 min, 15 min, 195 min, 210 min, for control group (N = 13).

Cortisol – Individual Differences

On the individual level, we looked at raw AUC_I values for each participant and identified different overall cortisol reactivity patterns, based on direction of AUC_I change (increase/decrease) throughout repeated measures. In experimental group (N = 33, chamber REST), 26 (78.79%) participants exhibited a positive response (a decrease in salivary cortisol), 5 (15.15%) participants negative reaction (an increase in salivary cortisol), 2 (6.06%) neutral response (fairly unchanged cortisol levels). In control group (N = 13), 9 (69.23%) exhibited positive response, 3 (23.08%) negative response, 1 (7.69%) neutral (Table 2). However, based on one-way ANOVA, different responses in both groups did not significantly differ in levels of perceived stress (SACL), or anxiety (STAI) after treatment. A chi square test revealed that difference in distribution of responses between experimental and control groups was not statistically significant (X^2 = 0.487, p = 0.784).

Comparison and Correlation Analysis of Self-Report Measures of Whole Sample and Individual Groups

For information overload analysis there was N = 47 (out of N = 49) participants (experimental = 33, control = 14)—missing data from two subjects. Also at 1-week follow-up, for measures of PSS, RRQ, OCS there was N = 48 participants (experimental = 34, control = 14)—missing data from one subject.

Table 2
Number of Participants who Exhibited Positive/Negative/Neutral Responses According to AUC_I Changes Throughout Repeated Measures for Experimental and Control Conditions

	Experimental group (N = 33)	Control group (N = 13)
Positive response	26 (78.79 %)	9 (69.23 %)
Negative response	5 (15.15 %)	3 (23.08 %)
Neutral response	2 (6.06 %)	1 (7.69 %)

Measurement of information overload with VAS in our sample, was as shown appropriately chosen, because of significant Pearson correlation with PSS (at 1-week follow-up; r = .410, n = 47, p = .004) the higher subjective information overload, the higher perceived stress.

An independent-samples *t*-test was conducted to compare pre–post treatment information overload VAS scores for experimental and control groups. Pretreatment, there were no significant differences in information overload for experimental (M = 7, SD = 2.3) and control group (M = 6.57, SD = 1.78), $t(45)$ = 0.62, p = .538. At 1-week follow-up posttreatment, we found significantly lower information overload in experimental (M = 5.69, SD = 2) than in control group (M = 7.64, SD = 1.82) week after treatment, $t(45)$ = −3.04, p = .004. The magnitude of the differences in the means was large (η^2 = .17; Table 3).

An independent-samples *t*-test was conducted to compare pre–post treatment obsessive-compulsive symptoms (SCL 90) for experimental and control group. Pretreatment, there was no significant difference in obsessive-compulsive symptoms between experimental (M = 23.22, SD = 9.48) and control group (M = 26.71, SD = 6.5), $t(47)$ = −1.26, p = .215. At 1-week follow-up, we found significantly lower level of obsessive-compulsive symptoms in experimental (M = 22.44, SD = 8.16), compared to control group (M = 27.78, SD = 7.67), $t(46)$ = −2.1, p = .042 (Table 3).

Using correlation analysis, we found significant positive relationship between information overload and obsessive-compulsive symptoms at 1-week follow-up (r = .354, n = 47, p = .015).

Pearson correlation analysis also showed significant relationship between information overload pretreatment and scores on SACL dimension—feeling calm, measured after exposure to experimental condition (r = .421, n = 33, p = .015), but not for control condition (r = −.096, n = 14, p = .744).

Table 3
Descriptive and Independent Samples T-test Statistics for Experimental and Control Group Pre–Post (1-Week Follow-up) Intervention.

	Group	Pre (week prior)				Post (1-week follow-up)			
		Mean (*SD*)	*t*(df)	CI = 95% Lower	CI = 95% Upper	Mean (*SD*)	*t*(df)	CI = 95% Lower	CI = 95% Upper
PSS	Experimental	17.8 (7.38)	$t(47)$ = −.257 p = .798	−4.920	3.806	15.58 (7.08)	$t(46)$ = −947 p = .348	−6.581	2.265
	Control	18.35 (5.22)				17.64 (6.14)			
RRQ	Experimental	39.25 (13.63)	$t(47)$ = −.958 p = .343	−11.384	4.042	37.67 (10.6)	$t(46)$ = −1.3 p = .199	−10.807	2.526
	Control	42.92 (6.7)				41.92 (9.39)			
OCS	Experimental	23.22 (9.48)	$t(47)$ = −1.25 p = .215	−9.058	2.0874	22.44 (8.16)	$t(46)$ = −2.1 p = .042*	−10.718	−0.3681
	Control	26.71 (6.5)				27.78 (7.67)			
Information overload	Experimental	7.00 (2.3)	$t(45)$ = 0.62 p = .538	−0.963	1.821	5.69 (2.06)	$t(45)$ = −3.04 p = .004**	−3.231	−0.660
	Control	6.57 (1.78)				7.64 (1.82)			

Note. **p < .01; *p < .05; PSS = Perceived Stress Scale; RRQ = Rumination-Reflection Questionnaire; OCS = obsessive-compulsive symptoms (SCL 90).

Discussion

In our hypothesis we suggested that single chamber REST condition would elicit higher reduction in salivary cortisol concentration compared to control condition. Results showed that raw cortisol indices RT, AUC_G, and AUC_I did not significantly differ between groups, meaning that overall reactivity (increase/decrease) and concentration of cortisol were at similar levels. Both groups also achieved analogous normalized cortisol concentration values during observed period of time; therefore, our hypothesis was not confirmed. Chamber REST intervention did not provoke greater cortisol reduction, as seen compared to control group, both showed similar pattern. Based on mean gradual cortisol reduction in the control group, we can conclude that chamber REST condition also simply followed similar cortisol diurnal rhythm seen in healthy individuals (Oster et al., 2017). Onset of our morning measurements (at least 1 hr after awakening of participants) started after beginning of CAR decline, with slow continuation until the evening. There was significant reduction in cortisol concentration between Time 2 and Time 3 (pre–post treatment) for both groups, but measurements being so far apart (3 hr) only suggests leap over gradual cortisol diurnal decline.

On the individual level, as measured by AUC_I, we identified that not all participants manifested decreases in cortisol levels. In total of five participants (15.15%), chamber REST induced “negative response” as seen by an increase in cortisol concentrations over measurement phases. Individual reports suggest that for few individuals, adaptation to complete darkness and absence of stimuli was more challenging than for others. However, positive and negative response individuals did not significantly differ in the levels of perceived anxiety (STAI) and stress (SACL), with only minor indication. In control group, three participants (23.08%) exhibited negative response with elevated cortisol, which is comprehensible with regards to characteristics of condition (engagement in work duties, writing homework or staying at laboratory over time can be perceived as frustrating for someone). For others, not engaging in such burdensome activities during observed time, was perceived as more plausible (positive response). Similarly, there was not significant difference in perceived anxiety and stress in control group. Problematic association between cortisol and self-report anxiety was noted previously (Leininger & Skeel, 2012). Nevertheless, results showed that higher information overload week before treatment significantly correlated with feeling calm (SACL) after chamber REST session. In other words, the higher experienced information overload, the better calming effect chamber REST facilitated. An effect of rapid deafferentation from normal or excessive stimuli could be perceived as challenging for some individuals, yet beneficial in whole. This relationship was not observed in control condition. Our results regarding cortisol changes and psychological effects are more in line with explanation of Schulz and Kaspar (1994), such as, that perceived subjective levels of comfort after treatment (feeling calm), were more notable than the neuroendocrine changes associated with relaxation.

A notable result is that chamber REST group achieved significantly lower subjective information overload at 1-week follow-up, compared to control group. The core of the explanation could be in the process of directing one’s attention during the course of these conditions, which was in the control group focused outwards and in chamber REST attention directed inwards, which is a major difference. Based on closer analysis of individual reports from the REST session, we have identified several emerging themes of “activities”, such as contemplating/meditating/self-reflecting; reviewing own personality traits/relationships and reactions to close people; processing previous experiences; planning/time managing upcoming duties and free time; catching up on sleep deficit/regenerating/relaxing; and pausing from screen time (mobile phone). Mediated effect of processing of these themes was also emphasized at 1-week follow-up by majority of participants. Added value of chamber REST, based on Dishon et al. (2017), could be for both: individuals with higher levels of trait self-awareness who are more predisposed to engage in self-reflective reasoning, and also others, for whom suitable environmental conditions might act as the catalyst for self-reflection. As for the diminished subjective information overload in chamber REST group, possible explanation could be found in current models of self-reflection. They propose that engaging in self-reflection regarding the management of everyday stressors, and extracting coping strategies from these reflections (insights), could serve as means to fine-tune and fortify one’s resilience capabilities, which in turn heightens the probability of achieving psychologically resilient outcomes (Crane et al., 2019)—such as greater tolerance of information influx or improvement in processing capacity (sufficiently attended residual or avoided sensations and experiences can unburdened cognitive capacities for new processing). It is further important to stress that adaptive (healthy) self-reflection is associated with perceived resilience and well-being indirectly, via insight. This component is missing in general self-reflection (Bucknell et al., 2022). Based on our results, a possible sign that adaptive self-reflection is occurring in chamber REST session could be the outcome of declined rumination score, although nonsignificant, and significantly lower obsessive-compulsive symptoms at 1-week follow-up compared to control group. Chamber REST facilitating adaptive self-reflection could be emphasized in comparison to general self-reflection, which has been found to predict rumination (Takano & Tanno, 2009), and its associations with higher prevalence of obsessive-compulsive symptoms (Raines et al., 2017).

It is noteworthy that single chamber REST session seems to facilitate processes (contemplation, adaptive self-reflection) observed particularly in meditation (Dorjee, 2016) and achieve similar effects, but without prolonged practice or systematic training. Life needs periods of rest and introspection, especially in the period of identity development. Results of our study could be beneficial not only for personal life resolution and optimal functioning of young adults, but also in corporate environment, where the term *information overload* is used frequently. Arnold et al. (2023) in their latest review of 87 studies, including the fields of medicine, production and management, listed number of recommendations in dealing with information overload and technostress, including various types of skill training and coping strategies. Among five identified levels through which the information is mediated and processed, this intervention could be applicable on the personal level, for development of healthy coping measures, ensuring sufficient work-life balance and prevention of burnout. Actually, flotation REST has already been utilized as health care measure for corporate employees (Kjellgren & Westman, 2014). However, this is the first study to date, to explicitly associate actual reductions in subjective information overload following REST.

Limitations

The main limitation of our study is unequal distribution of participants in experimental and control group, in addition, majority of participants consisted of women. Also, participants themselves in both groups chose a preferable time for their measurements (morning to afternoon). Another widely emphasized issue is self-report character of psychological variable measures. The degree and accuracy of self-reflection are presumably variable among participants. Measurements of cortisol variations only before and after single chamber REST could not have fully capture individual characteristics of cortisol concentration changes. For the future research, an individual cortisol diurnal profile acquired through several days of measurements, before and after single chamber REST session would shed better light on possible changes in cortisol values.

Conclusion

Our study explored effect of single brief chamber REST on cortisol reactivity and information overload in sample of young adults. Preliminary results indicate that chamber REST in this condition does not have significant effect on secretion of cortisol. It seems that REST in greater extent affects psychological functioning of an individual. As shown, the higher information overload before treatment the better calming effect (measured by SACL) chamber REST exhibited. Moreover, REST seems to facilitate adaptive self-reflection, leading to healthier coping and resilience with significantly less subjectively perceived information overload and obsessive-compulsive symptoms at 1-week follow-up as compared to control condition.

Author Acknowledgements

We express our gratitude to Associate Professor Igor Brezina, PhD, Department of Psychology, Faculty of Arts, Comenius University, Bratislava, Slovakia for overseeing this project. We want to thank Prof. Dr. Clemens Kirschbaum, Dresden Labservice GmbH, Tatzberg 47-49, 01307 Dresden, Germany for providing hormonal analysis of collected samples. Our gratitude goes to all participants and technical staff involved in this research.

Author Disclosure

This paper was supported by the following grants: Slovak Research and Development Agency [17-0451], Ministry of Education Science Research and Sport of the Slovak Republic [1/0786/21]. The authors report there are no competing interests to declare.

References

Arnold, M., Goldschmitt, M., & Rigotti, T. (2023). Dealing with information overload: A comprehensive review. *Frontiers in Psychology, 14*, Article 1122200. https://doi.org/10.3389/fpsyg.2023.1122200

Baldacchino, C., Armistead, C., & Parker, D. (2002). Information overload: It's time to face the problem. *Management Services, 46*(1), 18–19.

Bedrosian, T. A, & Nelson, R. J. (2017). Timing of light exposure affects mood and brain circuits. *Translational Psychiatry, 7*(1), Article e1017. https://doi.org/10.1038/tp.2016.262

Benselin, J. C., & Ragsdell, G. (2016). Information overload: The differences that age makes. *Journal of Librarianship and Information Science, 48*(3), 284–297. https://doi.org/10.1177/0961000614566341

Brautsch, L. A. S., Lund, L., Andersen, M. M., Jennum, P. J., Folker, A. P., & Andersen, S. (2023). Digital media use and sleep in late adolescence and young adulthood: A systematic review. *Sleep Medicine Reviews, 68*, Article 101742. https://doi.org/10.1016/j.smrv.2022.101742

Broderick, V., Uiga, L., & Driller, M. (2019). Flotation-restricted environmental stimulation therapy improves sleep and performance recovery in athletes. *Performance Enhancement & Health, 7*(1–2), Article 100149. https://doi.org/10.1016/j.peh.2019.100149

Bucknell, K. J., Kangas, M., & Crane, M. F. (2022). Adaptive self-reflection and resilience: The moderating effects of rumination on insight as a mediator. *Personality and Individual Differences, 185*, Article 111234. https://doi.org/10.1016/j.paid.2021.111234

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*(4), 385–396. https://doi.org/10.2307/2136404

Crane, M. F., Searle, B. J., Kangas, M., & Nwiran, Y. (2019). How resilience is strengthened by exposure to stressors: The systematic self-reflection model of resilience strengthening. *Anxiety, Stress, and Coping, 32*(1), 1–17. https://doi.org/10.1080/10615806.2018.1506640

DeMorrow, S. (2018). Role of the hypothalamic–pituitary–adrenal axis in health and disease. *International Journal of Molecular Sciences, 19*(4), Article 986. https://doi.org/10.3390/ijms19040986

Derogatis, L. R., Lipman, R. S., & Covi, L. (1973). SCL-90: An outpatient psychiatric rating scale-preliminary report.

Dishon, N., Oldmeadow, J. A., Critchley, C., & Kaufman, J. (2017). The effect of trait self-awareness, self-reflection, and perceptions of choice meaningfulness on indicators of social identity within a decision-making context. *Frontiers in Psychology*, *8*, Article 2034. https://doi.org/10.3389/fpsyg.2017.02034

Dorjee, D. (2016). Defining contemplative science: The metacognitive self-regulatory capacity of the mind, context of meditation practice and modes of existential awareness. *Frontiers in Psychology, 7*, Article 1788. https://doi.org/10.3389/fpsyg.2016.01788

Fekedulegn, D. B., Andrew, M. E., Burchfiel, C. M., Violanti, J. M., Hartley, T. A., Charles, L. E., & Miller, D. B. (2007). Area under the curve and other summary indicators of repeated waking cortisol measurements. *Psychosomatic Medicine*, *69*(7), 651–659. https://doi.org/10.1097/PSY.0b013e31814c405c

Flux, M. C., Fine, T. H., Poplin, T., Al Zoubi, O., Schoenhals, W. A., Schettler. J., Refai, H. H., Naegele, J., Wohlrab, C., Yeh, H.-W., Lowry, C. A., Levine, J. C., Smith, R., Khalsa, S. S., & Feinstein, J. S. (2022). Exploring the acute cardiovascular effects of floatation-REST. *Frontiers in Neuroscience, 16*, Article 995594. https://doi.org/10.3389/fnins.2022.995594

Jung, C. M., Khalsa, S. B. S., Scheer, F. A. J. L., Cajochen, C., Lockley, S. W., Czeisler, C. A., & Wright, K. P., Jr. (2010). Acute effects of bright light exposure on cortisol levels. *Journal of Biological Rhythms, 25*(3), 208–216. https://doi.org/10.1177/0748730410368413

Keppler, H., Dhooge, I., & Vinck, B. (2015). Hearing in young adults. Part II: The effects of recreational noise exposure. *Noise & Health*, *17*(78), 245–252. https://doi.org/10.4103/1463-1741.165026

Khoury, J. E., Gonzalez, A., Levitan, R. D., Pruessner, J. C., Chopra, K., Basile, V. S., Masellis, M., Goodwill, A., & Atkinson, L. (2015). Summary cortisol reactivity indicators: Interrelations and meaning. *Neurobiology of Stress*, *2*, 34–43. https://doi.org/10.1016/j.ynstr.2015.04.002

Kjellgren, A., Sundequist, U., Norlander, T., & Archer, T. (2001). Effects of flotation-REST on muscle tension pain. *Pain Research & Management*, *6*(4), 181–189. https://doi.org/10.1155/2001/768501

Kjellgren, A., & Westman, J. (2014). Beneficial effects of treatment with sensory isolation in flotation-tank as a preventive health-care intervention - a randomized controlled pilot trial. *BMC Complementary and Alternative Medicine*, *14*, Article 417. https://doi.org/10.1186/1472-6882-14-417

Ledzińska, M., & Postek, S. (2017). From metaphorical information overflow and overload to real stress: Theoretical background, empirical findings, and applications. *European Management Journal, 35*(6), 785–793. https://doi.org/10.1016/j.emj.2017.07.002

Leininger, S., & Skeel, R. (2012). Cortisol and self-report measures of anxiety as predictors of neuropsychological performance. *Archives of Clinical Neuropsychology, 27*(3), 318–328. https://doi.org/10.1093/arclin/acs035

Lewy, A. J., Wehr, T. A., Goodwin, F. K., Newsome, D. A., & Markey, S. P. (1980). Light suppresses melatonin secretion in humans. *Science*, *210*(4475), 1267–1269. https://doi.org/10.1126/science.7434030

Li, P., & Sun, Y. (2014). Modeling and performance analysis of information diffusion under information overload in Facebook-like social networks. *International Journal of Communication Systems*, 27(9), 1268–1288. https://doi.org/10.1002/dac.2774

Mackay, C., Cox, T., Burrows, G., & Lazzerini, T. (1978). *Stress Adjective Checklist (SACL)* [Database record]. *APA PsycTests*. https://doi.org/10.1037/t11187-000

Miller, R., & Plessow, F. (2013). Transformation techniques for cross-sectional and longitudinal endocrine data: Application to salivary cortisol concentrations. *Psychoneuroendocrinology, 38*(6), 941–946. https://doi.org/10.1016/j.psyneuen.2012.09.013

Misra, S., & Stokols, D. (2012). Psychological and health outcomes of perceived information overload. *Environment and Behavior, 44*(6), 737–759. https://doi.org/10.1177/0013916511404408

Misuraca, R., & Teuscher, U. (2013). Time flies when you maximize—maximizers and satisficers perceive time differently when making decisions. *Acta Psychologica, 143*(2), 176–180. https://doi.org/10.1016/j.actpsy.2013.03.004

Münzel, T., Gori, T., Babisch, W., & Basner, M. (2014) Cardiovascular effects of environmental noise exposure. *European Heart Journal, 35*(13), 829–836. https://doi.org/10.1093/eurheartj/ehu030

Oster, H., Challet, E., Ott, V., Arvat, E., de Kloet, E. R., Dijk, D.-J., Lightman, S., Vgontzas, A., & Van Cauter, E. (2017). The functional and clinical significance of the 24-hour rhythm of circulating glucocorticoids. *Endocrine Reviews, 38*(1), 3–45. https://doi.org/10.1210/er.2015-1080

Pennington, R. R., & Kelton, S. A. (2016). How much is enough? An investigation of nonprofessional investors information search and stopping rule use. *International Journal of Accounting Information Systems, 21*, 47–62. https://doi.org/10.1016/j.accinf.2016.04.003

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, *28*(7), 916–931. https://doi.org/10.1016/s0306-4530(02)00108-7

Raines, A. M., Vidaurri, D. N., Portero, A. K., & Schmidt, N. B. (2017). Associations between rumination and obsessive-compulsive symptom dimensions*, Personality and Individual Differences, 113*, 63–67. https://doi.org/10.1016/j.paid.2017.03.001

Roetzel, P. G. (2019). Information overload in the information age: A review of the literature from business administration, business psychology, and related disciplines with a bibliometric approach and framework development. *Business Research, 12*(2), 479–522. https://doi.org/10.1007/s40685-018-0069-z

Rohleder, N., (2012). Acute and chronic stress induced changes in sensitivity of peripheral inflammatory pathways to the signals of multiple stress systems – 2011 Curt Richter Award Winner. *Psychoneuroendocrinology, 37*(3), 307–316. https://doi.org/10.1016/j.psyneuen.2011.12.015

Sánchez-Rodríguez, M. A., Santiago, E., Arronte-Rosales, A., Vargas-Guadarrama, L. A., & Mendoza-Núñez, V. M. (2006). Relationship between oxidative stress and cognitive impairment in the elderly of rural vs. urban communities. *Life Sciences*, *78*(15), 1682–1687. https://doi.org/10.1016/j.lfs.2005.08.007

Shields, M. D. (1980). Some effects of information load on search patterns used to analyze performance reports. *Accounting, Organizations and Society, 5*(4), 429–442. https://doi.org/10.1016/0361-3682(80)90041-0.

Scheibehenne, B., Greifeneder, R., & Todd, M. P. (2010). Can there ever be too many options? A meta-analytic review of choice overload. *Journal of Consumer Research, 37*(3), 409–425. https://doi.org/10.1086/651235

Schroeder, A. M., & Colwell. C. S. (2013). How to fix a broken clock. *Trends in Pharmacological Sciences, 34*(11), 605–619. https://doi.org/10.1016/j.tips.2013.09.002

Schulz, P., & Kaspar, C.-H. (1994). Neuroendocrine and psychological effects of restricted environmental stimulation technique in a flotation tank. *Biological Psychology*, *37*(2), 161–175. https://doi.org/10.1016/0301-0511(94)90029-9

Spielberger, C. D. (1989). *State-Trait Anxiety Inventory: Bibliography* (2nd ed.). Consulting Psychologists Press.

Suedfeld, P., & Bow, R. A. (1999). Health and therapeutic applications of chamber and flotation restricted environmental stimulation thxrapy (REST). *Psychology & Health, 14*(3), 545–566. https://doi.org/10.1080/08870449908407346

Suedfeld, P., & Kristeller, J. L. (1982). Stimulus reduction as a technique in health psychology. *Health Psychology, 1*(4), 337–357. https://doi.org/10.1037/h0090238

Suedfeld, P., Roy, C., & Landon, P. B. (1982). Restricted environmental stimulation therapy in the treatment of essential hypertension. *Behaviour Research and Therapy, 20*(6), 553–559. https://doi.org/10.1016/0005-7967(82)90033-X

Takács, R., Takács, S., T Kárász, J., Horváth, Z., & Oláh, A. (2021). Exploring coping strategies of different generations of students starting university. *Frontiers in Psychology*, *12*, Article 740569. https://doi.org/10.3389/fpsyg.2021.740569

Takano, K., & Tanno, Y. (2009). Self-rumination, self-reflection, and depression: Self-rumination counteracts the adaptive effect of self-reflection. *Behaviour Research and Therapy, 47*(3), 260–264. https://doi.org/10.1016/j.brat.2008.12.008

Trapnell, P. D., & Campbell, J. D. (1999). Private self-consciousness and the five-factor model of personality: Distinguishing rumination from reflection. *Journal of Personality and Social Psychology, 76*(2), 284–304. https://doi.org/10.1037/0022-3514.76.2.284

Turner, J. W., Jr., & Fine, T. H. (1983). Effects of relaxation associated with brief restricted environmental stimulation therapy (REST) on plasma cortisol, ACTH, and LH. *Biofeedback and Self-regulation, 8*(1), 115–126. https://doi.org/10.1007/BF01000542

Turner, J. W., Jr., & Fine, T. H. (1991). Restricting environmental stimulation influences levels and variability of plasma cortisol. *Journal of Applied Physiology, 70*(5), 2010–2013. https://doi.org/10.1152/jappl.1991.70.5.2010

Ulrich-Lai, Y. M., & Herman, J. P. (2009). Neural regulation of endocrine and autonomic stress responses. *Nature Reviews Neuroscience, 10*, 397–409. https://doi.org/10.1038/nrn2647

van Dierendonck, D., & Te Nijenhuis, J. (2005). Flotation restricted environmental stimulation therapy (REST) as a stress-management tool: A meta-analysis. *Psychology & Health, 20*(3), 405–412. https://doi.org/10.1080/08870440412331337093

Ventriglio, A., Bellomo, A., di Gioia, I., Di Sabatino, D., Favale, D., De Berardis, D., & Cianconi, P. (2021). Environmental pollution and mental health: A narrative review of literature. *CNS Spectrums, 26*(1), 51–61. https://doi.org/10.1017/S1092852920001303

Vytykáčová, S., Soláriková, P., Masarovičová, T., & Horňáková, M. (2022). Effect of short-term restricted environment stimulation on perceived stress. *Psychologie a její kontexty, 13*(1), 49–61. https://doi.org/10.15452/PsyX.2022.13.0004

Wallbaum, A. B., Rzewnicki, R., Steele, H., & Suedfeld, P. (1991). Progressive muscle relaxation and restricted environmental stimulation therapy for chronic tension headache: A pilot study. *International Journal of Psychosomatics*, *38*(1–4), 33–39.

Wolf, O. T. (2017). Stress and memory retrieval: Mechanisms and consequences. *Current Opinion in Behavioral Sciences, 14*, 40–46. https://doi.org/10.1016/j.cobeha.2016.12.001

Xu, J., Liu, N., Polemiti, E., Garcia-Mondragon, L., Tang, J., Liu, X., Lett, T., Yu, L., Nöthen, M. M., Feng, J., Yu, C., Marquand, A., Schumann, G., & the environMENTAL Consortium (2023). Effects of urban living environments on mental health in adults. *Nature Medicine, 29*, 1456–1467. https://doi.org/10.1038/s41591-023-02365-w

Zha, X., Yang, H., Yan, Y., Liu, K., & Huang, C. (2018). Exploring the effect of social media information quality, source credibility and reputation on informational fit-to-task: Moderating role of focused immersion. *Computers in Human Behavior, 79*, 227–237. https://doi.org/10.1016/j.chb.2017.10.038

Received: January 8, 2024
Accepted: April 9, 2024
Published: June 27, 2024