Biofeedback Protocols for Stress Management in High-Performance Work Environments

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Abstract

High demanding work environments are sources of potentially harmful stress reactions. Chronic stress experienced in working life generates an autonomic dysregulation, which in turn results in high resting heart rate and blood pressure, as well as reduced vagal tone. Here, we proposed a novel approach that exploits competitive biofeedback to reduce negative psychological and physiological outcomes of stress in high-performance work environments. We compared standard to competitive biofeedback, showing that competition enhances training efficacy in promoting health and restoring cardiac autonomic balance.

Keywords: stress management, biofeedback, cardiovascular risk, psychophysiology, respiratory sinus arrhythmia, competition

Introduction

Work environments with high demands are sources of potentially harmful stress reactions. Stress and job strain drive people to adopt unhealthy lifestyles (smoking, low physical activity, high-calorie diet, excessive alcohol consumption) and influence the activity of immune, endocrine, and cardiovascular systems, increasing disease susceptibility and progression across a broad spectrum of disorders [10]. In particular, stress and job strain represent a risk factor for development and exacerbation of cardiovascular diseases [17]. In response to stressors, the autonomic nervous system triggers short-lasting adaptive physiological changes, priming the organism for fighting or fleeing. However, prolonged stress alters autonomic regulation with predominant sympathetic activity and reduced vagal tone. This results in high resting heart rate (HR) and blood pressure (BP), impairing cardiovascular health [9]. Traditional stress management programs use various behavioral techniques, including cognitive procedures, relaxation, meditation, deep-breathing, and exercise protocols [14]. Whereas these techniques aim to relieve psychophysiological symptoms of stress, biofeedback training addresses the source of autonomic balance. Here, we propose a novel approach that exploits biofeedback technology to reduce negative physiological outcomes of stress in high-performance work environments. The approach takes advantage of competition as a motivating factor in challenging individuals to enhance their physiological self-regulation. Competition, indeed, contributes positively to achievement [5], enhancing competitor's intrinsic motivation, improving performance, and fostering the mastery of a skill [4, 13]. Our goal in this study was to assess the effect of competitive biofeedback training on stress managment in comparison to standard (non-competitive) biofeedback training. The ability to cope with stress was indexed by respiratory sinus arrhythmia (RSA), which is a measure of parasympathetic nervous system activity [2] and an index of cardiovascular health [13]. The ability to enhance RSA is associated with physiological flexibility to environmental demands [1] and emotional self-regulation [11].

Method

Participants

Thirty-six managers, recruited from private (banking group, manufacturing industries and media) and public (health service, education system, local government and military) companies with high-competitive work environments took part in the study. Participants were randomly assigned to the Competitive (n = 18) or Standard (n = 18) training group. All partcipants were males, aged 35-67 years, in active employment status, with no history of heart problems or other chronic mental or neurological disease. We did not include women in the study because of the few female managers in the recruiting area. None of the participants were taking medications influencing heart rate (i.e. beta-blockers), tranquilizers or antidepressants. All participants were instructed about the study's procedure and provided their written informed consent. The research was carried out in accordance with the Declaration of Helsinski and the study protocol was approved by the ethic committees of the involved institutions. For data analyses, we included only participants who completed all the training sessions and who had no major training or post-training scheduling irregularities. Five participants did not complete the training schedule, thus the final sample used for the analyses consisted of 31 participants (Age: M = 47.75; SD = 7.87), 17 in the Standard and 14 in the Competitive training group.

Measurements and apparatus

We recorded blood volume pulse (BVP) and abdominal respiration using a FlexComp Infiniti™ encoder and BioGraph Infiniti software (Thought Technology Ltd, Montreal, Quebec). Data were processed via a 14-bit analog-to-digital converter with a sampling rate of 256 Hz (bandwidth DC – 64Hz) and stored for analyses in a IBM-compatible Intel Core™ 2 computer. BVP was measured with a photoplethysmographic sensor (BVP-Flex/Pro) on the right ring finger. Heart rate (HR) was computed as a reciprocal of R-R intervals (RRI) derived from BVP signal. Respiration was measured using a strain gauge sensitive Respiration-Flex/Pro sensor stretched around the participant's abdomen. The software calculated respiration rate from differences in chest expansion in the raw signal waveform. Kubios-HRV 2.0 (Kuopio, Finland) software was used to correct artifacts with a piecewise cubic spline interpolation method. RSA was then computed with a fast Fourier transformation (FFT) on RRI. For each participant, RSA was estimated as the power spectrum of RRI within the range of the individual respiratory rate. HR, abdominal respiration, and RSA were fed back to participants via a 15-inch PC display, positioned in front of them at a distance of 50 cm.

Procedure

All participants received a semi-structured interview, aimed at collecting socio-demographic and health behavior data, and two questionnaires: the Occupational Stress Indicator (OSI) [5], which assesses job stress and its effects, and the Jenkins Activity Survey (JAS) [6], which evaluates Type A behavior. At pre-training and post-training, participants received a psychophysiological assessment. This started with a 4-minute period of rest during which BVP and respiration rate were recorded to derive RSA data. Biofeedback training consisted of 5 weekly sessions, each lasting about 40 minutes. Each session included a 4-minutes resting period, two 6-minutes biofeedback trials, and another 4-minutes resting period. Participants attended training sessions in pairs, matched for age, body mass index, and level of physical activity. In the Standard training group, each participant was trained to synchronize his breathing and HR tachogram (i.e., beats/min) until they covaried in perfect phase, with the goal of maximally increasing the amplitude of RSA. A horizontal bar provided feedback on the individual ability to increase RSA. The bar grew from left to right, by one incremental step, each time RSA exceeded a threshold value for 10 consecutive seconds. The threshold was computed at the beginning of each session, on the basis of the RSA mean value recorded during rest period. In the Competitive training group, each participant was asked to synchronize his breathing and HR tachogram better than the challenger (i.e., the paired participant). The system compared the gain in RSA of both participants each respiratory cycle. Accordingly, a horizontal bar grew, by one incremental step, only for the participant who was more efficient at enhancing RSA for 10 consecutive seconds.

Data Reduction and Analysis

Student's *t* tests for independent groups were performed on mean age, body mass index, sleep time, JAS and OSI subscale scores. χ^2s were calculated for educational qualifications, sleep disorders, smoking habits, physical activity levels, family history of hypertension and cardiovascular diseases. Mean values were computed for RSA and a log transformation was applied for data normalization. A mixed-model analysis of variance (ANOVA) with Group (Competitive or Standard) as the between-subjects factor, and Time (pre-training or post-training) as the within-subjects variable, was performed on mean RSA. Significant main effects and interactions ($p < 0.05$) followed Newman–Keuls' post-hoc comparisons to identify specific differences.

Results

Groups did not differ in any socio-demographic characteristics, health behaviors, JAS or OSI score. Thirty participants (97%) had a Type A percentile score above 55 and twenty-three (74%) presented a score above 75, indicating high impatience, ambition, competitiveness, time urgency, and hostility in the whole sample. A 2 (Group: Competitive, Standard) X 2 (Time: pre-training, post-training) mixed-model ANOVA on mean RSA at rest yielded a significant main effect of Time [$F(1, 29) = 14.67$; $p < .0005$], as well as a significant interaction [$F(1, 29) = 4.44$; $p < .05$]. There was no significant main effect of Group. Post-hoc comparisons revealed a significant increase in RSA from pre to post training (2.01 vs. 2.77 log ms^2) in the Competitive training group only (see Figure 1).

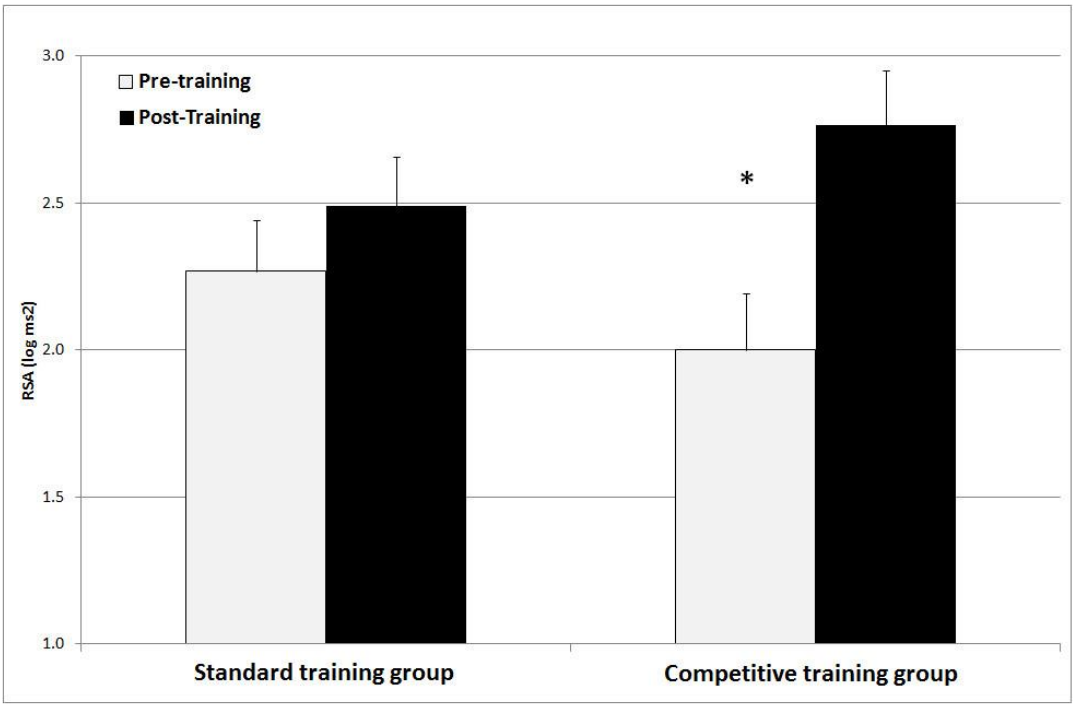

Figure 1. Mean RSA (log ms^2) pre and post-training in the Standard and Competitive training group.

Discussion

The study examined the efficacy of competitive biofeedback training in reducing negative physiological outcomes of stress in high-performance work environments. Our results suggest that competition may be a crucial factor in improving the ability to enhance RSA. Indeed, only the group trained with competitive biofeedback showed a significant RSA increase after training, regardless of the outcome of competition. RSA is an index of parasympathetic predominance over sympathetic activity. Increasing RSA fosters cardiac autonomic balance, that in turn is associated with physiological flexibility and adaptive regulation [1, 8]. Given our small sample size, however, further research is necessary to clarify the effects of competitive biofeedback in the acquisition of autonomic regulation. Moreover, follow-up studies are required to investigate whether the positive effects of competitive biofeedback on vagal cardiac regulation are long-lasting. Competition, indeed, may foster extrinsic motivation, giving negative outcomes in the long run. Our findings are consistent with studies suggesting that, when striving to excel, competitive persons could be motivated for better performance even when this requires reducing physiological activation [12, 16, 18]. Our sample, indeed, presented strong Type A behavior traits, such as impatience, ambition, and competitiveness. Future studies are needed to investigate whether competition in non-Type A individuals facilitates self-regulation in the same way or, on the contrary, prevents a generalized sympathetic withdrawal. In conclusion, the present study suggests that highly competitive individuals might profit from competitive biofeedback training for improving self-regulation strategies, restoring cardiac autonomic balance and reducing the risk for cardiovascular disease.

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