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Heart rate variability biofeedback using different breathing rates: a randomized study

Submission date
31/12/2025

Recruitment status
No longer recruiting

Registration date
20/01/2026

Overall study status
Completed

Last Edited
20/05/2026

Condition category
Mental and Behavioural Disorders

[ ] Prospectively registered
[ ] Protocol
[ ] Statistical analysis plan
[X] Results
[ ] Individual participant data

Plain English summary of protocol
Not provided at time of registration

Contact information

Type(s)
Public, Scientific, Principal investigator

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Study information

Scientific Title
Effects of heart rate variability biofeedback using individualized resonance frequency versus fixed-rate breathing on psychological outcomes, resting heart rate variability, and physiological stress responses in adults with elevated stress: a randomized controlled trial

Study objectives
1. To evaluate whether heart rate variability biofeedback (HRV-B) training with individually determined resonance frequency (RF) leads to greater improvements in self-reported psychological outcomes (perceived stress, anxiety, and depressive symptoms) and resting heart rate variability compared with HRV-B performed at a fixed breathing rate of 0.1 Hz.
2. To examine the effects of HRV-B training on affective and autonomic responses to an experimentally induced mental stressor, including stress reactivity and post-stress recovery, in comparison with a waitlist control group.
3. To assess whether repeated HRV-B training and daily home practice influence the subjective affective experience of slow-paced breathing at 0.1 Hz, making the task more relaxing over time.

Ethics approval required
Ethics approval required

Ethics approval(s)
Approved 15/11/2021, Ethics Committee for Research with Human Participations of Warsaw University of Life Sciences in Poland (Instytut Nauk o Żywieniu Człowieka Szkoła Główna Gospodarstwa Wiejskiego w Warszawie Nowoursynowska 159c, Warsaw, 02-776, Poland; +48 (0) 22 59 37 010; inzc@sggw.edu.pl), ref: 48/2021

Primary study design
Interventional

Allocation
Randomized controlled trial

Masking
Open (masking not used)

Control
Uncontrolled

Assignment
Parallel

Purpose
Basic science

Study type(s)

Health condition(s) or problem(s) studied
Prevention of psychological difficulties in healthy individuals with elevated stress levels

Interventions
Participants were randomly assigned to one of three study groups:
1. HRV biofeedback with individually determined resonance frequency (RF Group),
2. HRV biofeedback at a fixed breathing rate of 0.1 Hz (0.1 Hz Group),
3. A waitlist control group (Control Group).

Randomization was performed using a computer-generated simple randomization sequence with a 1:1:1 allocation ratio. Group assignment was concealed from participants until completion of baseline assessments.

Participants in both intervention groups received heart rate variability biofeedback (HRV-B) training over a 4-week period. The intervention consisted of weekly individual laboratory sessions and daily home practice. Laboratory sessions were conducted once per week, lasted approximately 40 minutes, and were delivered individually.

During the sessions, participants were instructed in slow-paced breathing techniques, including diaphragmatic breathing, relaxation breathing, and prolonged exhalation, with explicit guidance to avoid hyperventilation. Participants practiced slow-paced breathing while receiving real-time visual feedback of heart rate (cardiotachogram) and respiration.
HRV-B training was delivered using Biograph Infiniti software and standard training protocols provided by the biofeedback equipment manufacturer (Thought Technology Ltd., Montreal, Canada).

Participants were instructed to practice slow-paced breathing at home for 20 minutes using a provided visual breathing pacer.
The two HRV-B groups differed only in the breathing frequency applied:
1. RF Group: The breathing rate was individually determined based on each participant's resonance frequency, assessed during a standardized RF evaluation procedure. This breathing rate was used during both laboratory sessions and home practice.
2. 0.1 Hz Group: The breathing rate was fixed at 0.1 Hz (6 breaths per minute) for both laboratory sessions and home practice, regardless of the individual RF assessment.

For both intervention groups, the inhalation-to-exhalation ratio was set at 4:6 during laboratory sessions and home practice.

Participants assigned to the Control Group received no intervention during the 4-week study period (waitlist control). They completed the same pre- and post-intervention assessments as the intervention groups. After completion of the final assessment, participants in the Control Group were offered the opportunity to take part in the HRV-B training.
No follow-up assessments were conducted after the post-intervention measurement.

Intervention Type
Behavioural

Primary outcome(s)
1. Stress, symptoms of anxiety and depression measured using Depression Anxiety and Stress Scale (DASS-21) at immediately after completion of the intervention

2. Resing heart rate variability measured using electrocardiography (ECG) at immediately after completion of the intervention

3. Affect measured using the Swedish Core Affect Scale (SCAS) at during intervention and immediately after completion of the intervention

4. Physiological reaction to laboratory-induced mental stress measured using electrocardiography (ECG), surface electromyography (sEMG), electrodermal activity (EDA), blood volume pulse (BVP), respiratory rate, and skin temperature of the hand at immediately after completion of the intervention

Key secondary outcome(s)

Completion date
30/11/2022

Eligibility

Key inclusion criteria
1. Age between 25 and 40 years
2. All sexes
3. High self-reported stress levels

Healthy volunteers allowed
Yes

Age group
Adult

Lower age limit
25 Years

Upper age limit
40 Years

Sex
All

Total final enrolment
88

Key exclusion criteria
1. Chronic diseases (e.g., diabetes)
2. Psychiatric disorders (e.g., depressive disorders, anxiety disorders)
3. Neurological disorders (e.g., epilepsy)
4. Cardiovascular diseases (e.g., hypertension, heart failure, myocardial infarction, arrhythmias)
5. Respiratory diseases (e.g., asthma)
6. Substance use disorders or addiction to psychoactive substances (e.g., alcohol, nicotine)
7. Use of medications affecting the central nervous system or cardiovascular system (e.g., hypnotics, antidepressants, anxiolytic medications, cardiovascular medications)
8. Current participation in psychotherapy
9. Regular practice of breathing-based techniques (e.g., yoga, meditation, breathing exercises)
10. Pregnancy

Date of first enrolment
01/02/2022

Date of final enrolment
31/10/2022

Locations

Countries of recruitment
Poland

Sponsor information

Organisation
Central Institute for Labour Protection

ROR
https://ror.org/03x0yya69

Organisation
Ministry of Science and Higher Education

ROR
https://ror.org/05dwvd537

Funder(s)

Funder type

Funder Name
Centralny Instytut Ochrony Pracy - Państwowy Instytut Badawczy

Alternative Name(s)
Central Institute for Labour Protection - National Research Institute, CIOP-PIB

Funding Body Type
Private sector organisation

Funding Body Subtype
Research institutes and centers

Location
Poland

Results and Publications

Individual participant data (IPD) sharing plan

The datasets generated during and/or analysed during the current study will be stored in a publicly available repository (the Zenodo repository, doi: 10.5281/zenodo.17733890). All shared data will be fully anonymized to protect participant confidentiality. Data will include de-identified questionnaire responses, resting HRV measurements, and physiological parameters recorded during laboratory procedures. The datasets will be accessible upon publication of the study results and will remain available indefinitely. Access to the data will be unrestricted for researchers, who may use it for secondary analyses or meta-analyses. There are no additional ethical or legal restrictions beyond the protection of participant privacy.

IPD sharing plan summary

Stored in publicly available repository

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Results article		19/05/2026	20/05/2026	Yes	No