Official title
Ambulatory electrodermal activity measurements
as part of identification and prevention of job burnout

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Statistical Analysis Plan and Partial Implementation Summary

1. Study Objectives

Primary objectives:

Investigate the association between electrodermal activity (EDA) and emotional valence (EV) with psychological job well-being.

Identify latent developmental trajectories of job burnout symptom levels and work engagement levels.

Secondary objectives:

Explore possible EDA biomarkers for the early identification of job burnout symptoms.

2. Study Design Overview

Study type:

Observational Cohort Study.

Population Inclusion Criteria:

- Voluntary knowledge workers from three Finnish companies
- Healthy volunteers, but they may have mental health issues
- Employed by one of the target organizations in the beginning of the study
- Informed consent in a written form by the study subject

Exclusion Criteria:

- Nickel sensitivity

Sample size:

A sample size of 150 participants was planned. An a priori power analysis was conducted based on estimated prevalence rates of mild (23.5%) and severe (2.5%) job burnout in the working population. Expected mean BAT-12 scores were derived from these assumptions. Power was estimated using simulated longitudinal data with four measurement points and a predefined effect size calculated as the difference between the expected population mean and BAT-12 category thresholds. A linear mixed-effects model was used to account for within-subject correlation over time. Statistical power was computed using the Pwr function from the lmeU R package based on fixed effects F-tests from lme models, following the approach described by Galecki & Burzykowski (2013). Similar power

estimation procedures were applied for other psychological wellbeing measures, including GAD-7, BDI-21, UWES-9, and a general single-item measure of work wellbeing.

In the article "Associations of continuous electrodermal activity with job burnout and work engagement", a generalized least squares (GLS, Aitken) model is used instead of a mixed-effects model, as individual-level random effects were not relevant to the research questions. The covariance matrix of the Aitken model used in the analysis corresponds to that of the mixed-effects model employed in the power analysis.

Outcomes:

1. Association analysis: Determine the relationship between electrodermal activity (EDA), emotional valence (EV), and job burnout symptom levels, as measured by BAT-12 scores.

2. Trajectory identification: Identify latent trajectories of job burnout symptom levels across four measurement periods based on BAT-12 scores.

3. Predictive assessment: Evaluate whether EDA and EV patterns can serve as early indicators of future job burnout trajectory group membership.

3. Statistical Hypotheses

1. There is a statistically significant association between electrodermal activity (EDA) and emotional valence (EV) and job burnout levels, as measured by BAT-12 scores.

2. EDA and EV are significantly associated with self-reported anxiety (GAD-7) and depression (BDI-21) symptom levels.

3. EDA and EV are significantly associated with work engagement, as measured by UWES-9.

4. Distinct and interpretable latent trajectories of job burnout symptom levels (BAT-12) can be identified across the four measurement periods.

5. Patterns in EDA and EV data can serve as early indicators of future burnout trajectory group membership, suggesting their potential as physiological biomarkers.

4. Statistical Methods

Analysis methods for primary outcomes:

To investigate the relationship between electrodermal activity (EDA), emotional valence (EV), and work-related well-being in the article "Associations of continuous electrodermal activity with job burnout and work engagement", the main statistical approach involved two generalized least squares (Aitken) models to evaluate associations between EDA/EV and burnout or engagement scores. Significance testing was based on t-statistics and likelihood ratio tests. Predictive performance and alignment with the circumplex model of work-related well-being were assessed using both asymptotic and simulated prediction intervals.

In the planned article "Early Signs of Job Burnout", burnout symptom trajectories will be examined using a Gaussian finite mixture modeling approach applied to scores from the four measurement periods. Bootstrap confidence intervals for model parameters will be estimated using the R's mclust package.

Analysis methods for secondary outcomes:

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Adjustment for covariates:

In the Aitken models, in the article "Associations of continuous electrodermal activity with job burnout and work engagement", covariates were included to control for potential confounding. These included age, sex, medication known to affect sympathetic nervous system activity (either increasing or decreasing it), participation in work wellbeing interventions, and levels of anxiety and depression symptoms.

Handling of missing data:

In the planned article "Early Signs of Job Burnout", missing values in BAT-12 scores will be imputed to complete participant-level burnout trajectories across the four measurement periods. Intraclass correlation coefficients (ICC) will be used to assess clustering at the participant level, which will be accounted for in the imputation. Predictive mean matching for two-level data (2l.pmm), implemented via the miceadds package in R, will be used. This method, based on fully conditional specification with mixed-effects models, will include background variables and symptom scores as predictors but exclude EDA and EV variables to avoid biasing associations. The imputation is planned to preserve the ICC structure, and distributional checks will be performed to support the plausibility of the imputed values. The same approach will be applied to UWES-9 engagement scores.

5. Multiplicity Adjustment

Where appropriate, p-values were adjusted using the Tukey or Benjamini-Hochberg methods to address multiple testing.

6. Reporting of Results

Reported results in the article "Associations of continuous electrodermal activity with job burnout and work engagement" included correlations between BAT-12 and UWES-9 scores, model estimates from Aitken regressions with t-statistics and p-values, and likelihood ratio tests for model comparison. Prediction intervals were calculated to assess alignment with the circumplex model. Group differences in 24-hour EDA patterns were analyzed using linear mixed-effects models with Tukey-adjusted comparisons.

Planned reporting in the article "Early Signs of Job Burnout" includes describing burnout symptom trajectories with bootstrap confidence intervals, summarizing EDA levels by

group (excluding high anxiety or depression), and assessing group differences using appropriate statistical tests.

7. Software and Tools

All statistical analyses and simulations were conducted using R (R Core Team, 2024).
R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Additional R packages were used for data handling and modeling, but are not individually cited here.