Stress, Inflammation, and Resilience:

Biomarker and Psychological Changes Following Digital Well-Being Training

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Introduction

- Healthcare professionals experience high levels of stress, burnout, anxiety, and depression, which can negatively impact both personal well-being and patient care (Salyers et al., 2017).
- This study takes a psychoneuroimmunology approach to examine how psychological and biological processes interact in response to stress.
- Chronic stress activates inflammatory pathways, reflected in biomarkers such as IL-6, TNF-α, and CRP, while anti-inflammatory markers like IL-10 help regulate these responses.
- Inflammation is linked to: Emotional regulation, Cognitive control, Stress response systems
- Digital well-being interventions show psychological benefits, but their biological mechanisms (inflammation) are not well understood

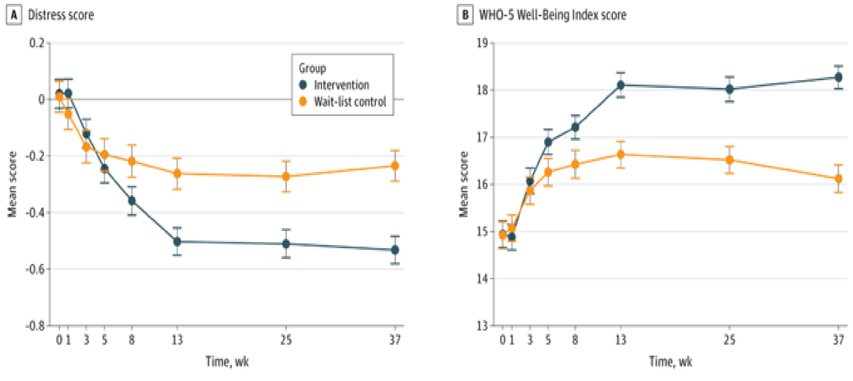

Figure 1. Changes in distress and well-being scores over time by study group (intervention vs. waitlist control). *Excerpted from Hirshberg et al. (2025).*

Objective

Purpose: Examine whether changes in inflammatory biomarkers are associated with changes in psychological well-being following a digital intervention

Questions: Does the digital well-being intervention affect inflammatory biomarkers? Do higher baseline inflammations moderate intervention effects?

Hypothesis:

1) Participants assigned to the intervention will show lower pro-inflammatory biomarkers (IL-6, TNF-α, CRP) and improved inflammatory regulation (IL-10) at post-intervention (T6) and follow-up (T7).

Methods

Study Design

- Secondary analysis of a randomized controlled trial
- 13-week digital well-being intervention
- Groups: Intervention and Waitlist control

Participants:

- N = 2,315 healthcare professionals (Mexico)
- Biomarker subset:1,477 DBS samples, 549 participants

Time Points: T1 - baseline; T6 - post (13 weeks); T7 - follow-up (37 weeks)

Measures:

- Biomarkers (DBS): IL-6, TNF-α, CRP (pro-inflammatory); IL-10 (regulatory)
- Psychological: Stress, anxiety, depression; Well-being (WHO-5); Awareness, insight, connection, purpose

Data Analysis

- Linear regression and Tobit models (censored data)
- Adjusted for infection status and time since last meal
- Tested group differences in biomarker change and moderation by baseline inflammation.

Results

Main Effects:

- No significant group differences in biomarker change between intervention and control groups
- Suggests no evidence that the intervention directly altered inflammatory biomarkers

Moderation Effects:

- No significant moderation by baseline inflammatory biomarker levels
- Example: IL-6 at follow-up (T7) was not significant (b ≈ 0.27, p ≈ 0.28)

Additionally:

- Baseline inflammation strongly predicted later inflammation

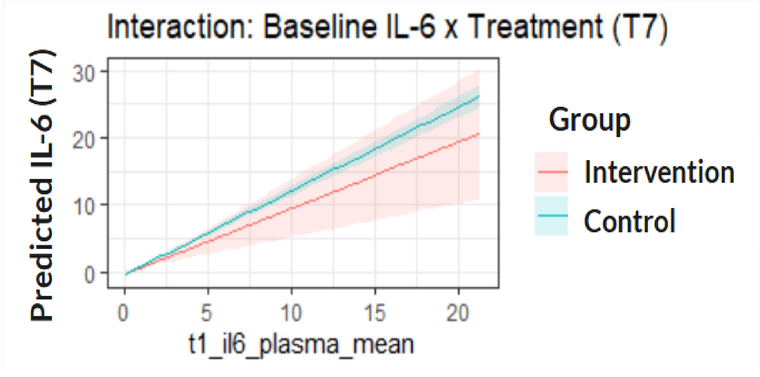

Figure 2. Predicted IL-6 levels at follow-up (T7; 37 weeks) as a function of baseline IL-6 by study group (intervention vs. control)

Conclusions

- The digital well-being intervention did not produce detectable changes in inflammatory biomarkers
- Baseline inflammation remained a strong predictor of future inflammation
- Limited evidence that baseline inflammation moderated intervention effects

Future Directions

- Increase sample size and extend follow-up to better detect biological change
- Address variability in inflammatory biomarkers
- Improve measurement and detection of biomarkers
- Further investigate whether psychological improvements translate to biological outcomes

Acknowledgments

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References

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Salyers, M. P., Bonfils, K. A., Luther, L., Firmin, R. L., White, D. A., Adams, E. L., & Rollins, A. L. (2017). The relationship between professional burnout and quality and safety in healthcare: A meta-analysis. *Journal of General Internal Medicine, 32*(4), 475–482. https://doi.org/10.1007/s11606-016-3886-9