

From Experience to Biology: An Analysis of Multi-Domain Perceived Stress and Allostatic Load

An AIM-AHEAD Bridge2AI AI-READI Project

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INTRODUCTION

- Perceived stress due to asymmetric exposure to systemic factors (AES) is associated with adverse physical and mental health outcomes.
 - It serves as a psychosocial stressor that contributes to physiological dysregulation (allostatic load)
 - Allostatic Load (AL) – prolonged wear and tear of the body's regulatory system (metabolic, cardiovascular, immune, and neuroendocrine)
- Gap:** While earlier studies have demonstrated an association between AES and AL, less is known about this association in individuals with T2DM
- Purpose:** Determine whether perceived stress measured via AES is associated with chronic physiological stress (AL) among individuals with T2DM.
 - H1. Individuals with T2DM will exhibit distinct physiological stress phenotypes derived from the clustering of AL biomarkers.*
 - H2. Higher self-reported AES will be associated with a greater likelihood of belonging to higher-risk allostatic load clusters.*

METHODS/ANALYSIS PLAN

- Data source:** AI-READI dataset

Measure	Description	Example items/criteria
Asymmetric exposure to systemic factors	Assessed using REDQ; three domains (Institutional, Interpersonal, Workplace). Items scored by sum and mean.	Institutional: 6 items (pxrd1, pxrd2, pxrd16, etc.) Interpersonal: 10 items (pxrd13, pxrd14, etc.) Workplace: 4 items (pxrd4, pxrd5, etc.)
Perceived Stress	Subjective stress responses have three domains (Coping/Internalization –staying silent, feeling angry, and taking action), Violence/Threat , and Subjective Impact). Items are scored by sum and mean.	Coping/internalization: pxrd34 to pxrd42 – emotional and behavioral coping responses Violence/Threat: pxrd49 to pxrd51 – experiences of being harassed, threatened or physically harmed Impact: pxrd52 to pxrd54 – how different life would be without these experiences
Overall AES Composite	Global score based on 36 items across all domains, representing cumulative lifetime and past-year AES exposure.	pxrd1 to pxrd53: interpersonal, institutional, workplace, and reflective items
Allostatic Load Index (ALI)	Physiological stress from 5 biomarkers (WHR, HR, CRP, HDL, HbA1c). One point per high-risk biomarker. Range: 0 to 5.	WHR > 0.90, HR > 90 bpm, CRP > 3.0 mg/L, HDL < 40 mg/dL, HbA1c > 6.5%

- Data Analysis:**
 - Descriptive statistics (mean, media, quartiles, min/max, response distributions and percentages)
 - Visualizations (histograms, boxplots, violin plots, heat maps, radar plots)
 - Allostatic Load Index (ALI) will be calculated using five biomarkers: **Waist-to-hip ratio (WHR)**, **Heart Rate**, **C-reactive Protein (CRP)**, **HDL Cholesterol**, and **Hemoglobin A1c**. For each biomarker, a risk score of 1 will be assigned if the value exceeds the established clinical cutoff and 0 if it does not. The clinical cutoffs are:
 - WHR > 0.90 (high risk)
 - Heart Rate > 90 bpm (high risk)
 - CRP > 3.0 mg/L (high risk)
 - HDL Cholesterol < 40 mg/dL (high risk)
 - HbA1c > 6.5% (high risk)

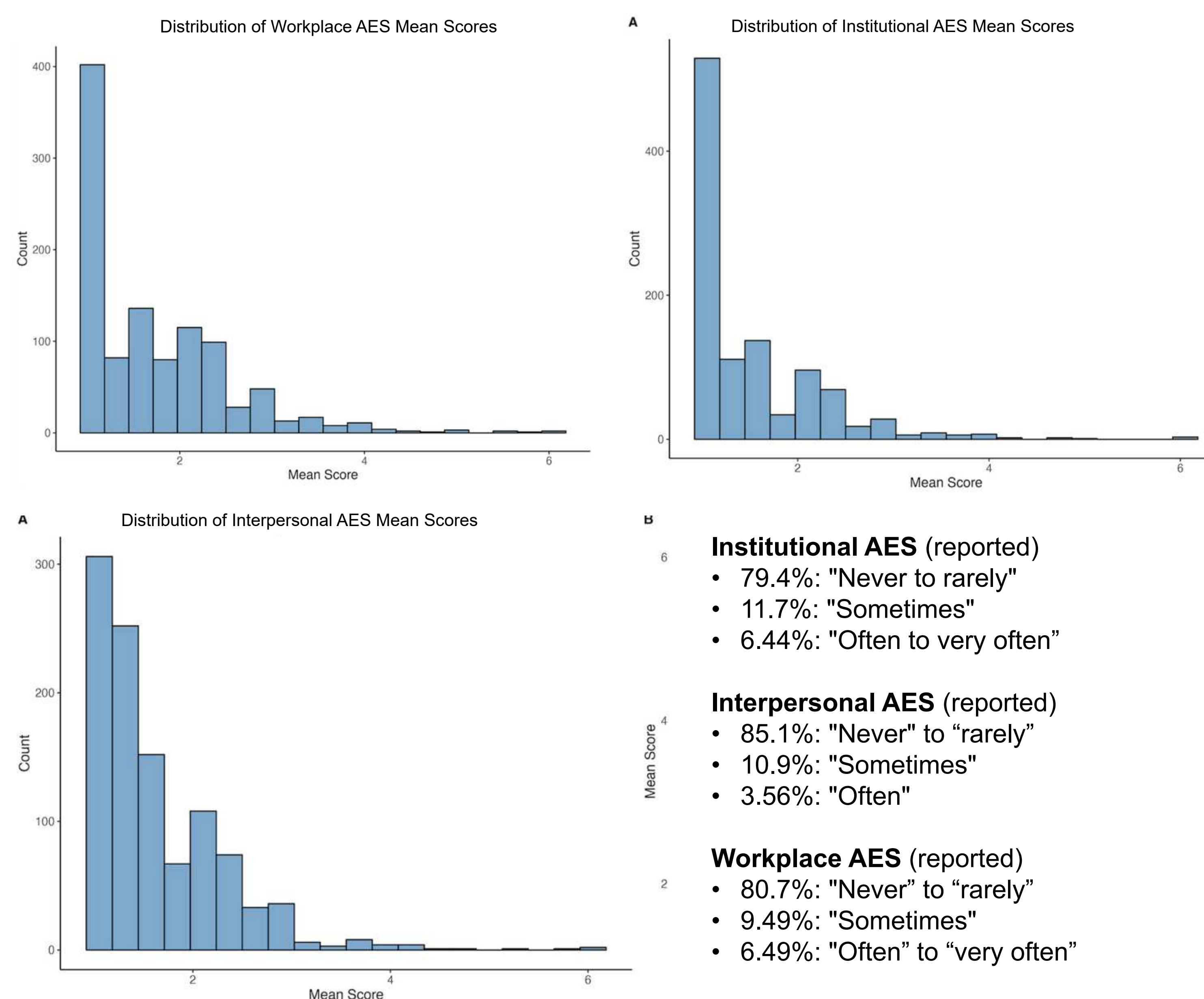


Figure 1. Frequency of workplace, institutional and interpersonal AES (perceived)

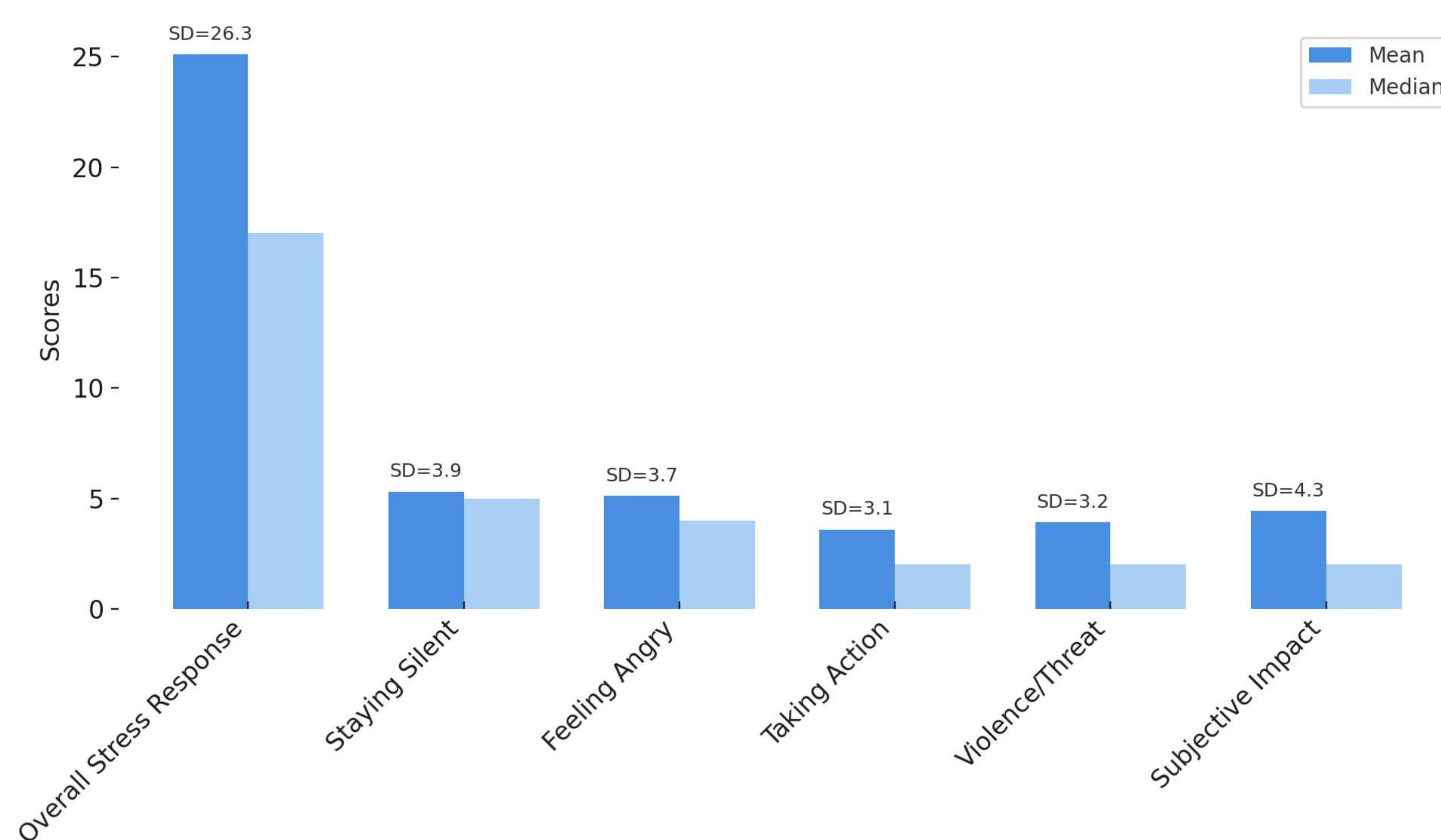


Figure 2. Mean, SD, and median scores of perceived stress

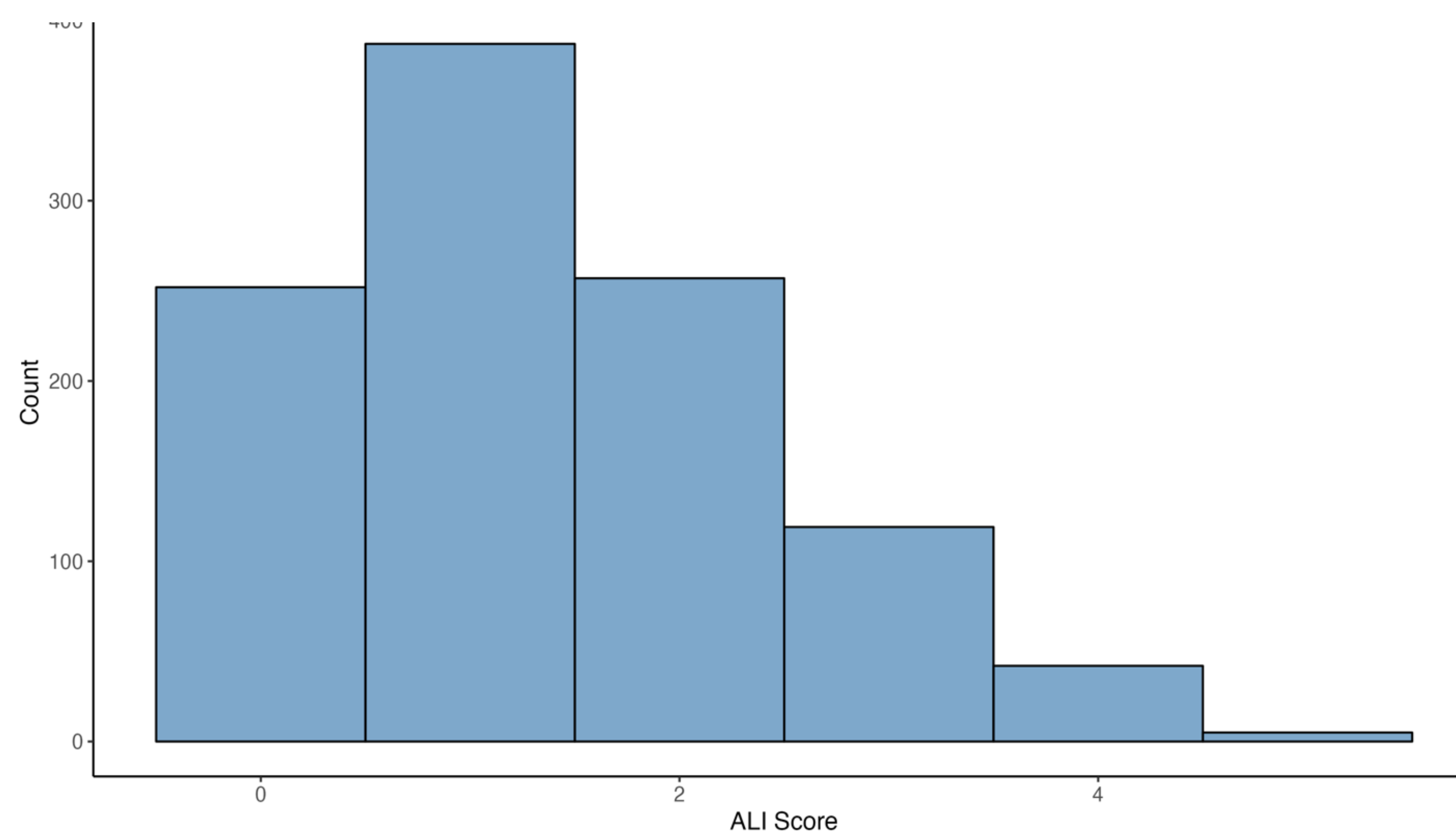


Figure 3. Allostatic Load Index distribution

NEXT STEPS

- Clustering analysis of AL**
 - Data standardization using Z-scores to ensure equal weighting of all biomarkers
 - K-means clustering with K=3 (determined by elbow method)
 - Validation through ANOVA testing of between-cluster differences
- Machine Learning**
 - We will test three models—Random Forest, XGBoost, and Regularized Logistic Regression—to predict allostatic load (AL) cluster membership from standardized AES scores and interaction terms.
 - The dataset will be split into training (80%) and testing (20%) sets using stratified sampling; models will be tuned via 10-fold cross-validation.
 - Model performance will be evaluated using accuracy, Kappa, confusion matrices, and calibration plots; paired t-tests will assess performance differences.
 - Feature importance will be assessed using Gini index (Random Forest), gain (XGBoost), and validated through permutation importance.

CONCLUSION

- Initial descriptive analysis showed that majority of participants reported infrequent experiences of AES across institutional, interpersonal, and workplace domains, with only 3.4%–6.5% endorsing frequent exposure.
- Despite this, perceived stress scores varied widely and internalized coping strategies (e.g., staying silent, feeling angry) were more prevalent than direct action or reports of intergroup harm.
- Most participants exhibited low physiological stress burden, with ALI scores concentrated in the 0–2 range, suggesting limited multisystem dysregulation across the sample.

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