SUPPLEMENTARY MATERIALS

1. Rad-Score

To simplify the logistic regression model for interpretability, we defined the Rad-score as a substitute for the 13 principal components. The Rad-score is computed based on a weighted sum of selected principal components derived from the logistic regression model. First, the features are standardized to ensure consistency across scales. Then, a logistic regression model is trained on the standardized features using grid search to identify the optimal regularization parameter. The model assigns each feature a coefficient, reflecting its contribution to the prediction. The Rad-score is calculated as the sum of each feature multiplied by its respective coefficient, representing an aggregated predictive score for the model. In our model, its calculation formula is:

Rad-score = 1.491*PC1+-0.300*PC2+-0.466*PC3+-0.329*PC4+0.203*PC5+-0.077*PC6+0.065*PC7+0.123*PC8+0.178*PC9+-0.044*PC10+-0.208*PC11+0.157*PC12+-0.198*PC13

2. Feature Selection

1) Least Absolute Shrinkage and Selection Operator

Least absolute shrinkage and selection operator (LASSO) was first applied to select the most relevant features from the dataset. Using cross-validation (cv = 5), the optimal hyperparameter (alpha) for LASSO was determined, minimizing the mean squared error. Supplementary Fig. 1 demonstrates that the model's mean squared error is minimized at alpha = 0.0473, with the selected features listed in Supplementary Table 3.

2) Principal Component Analysis

Principal component analysis (PCA) was used for further feature dimensionality reduction. PCA is a method that converts a set of possibly correlated features into a smaller set of linearly uncorrelated components, known as principal components. By setting `n_components = 0.95`, the number of principal components was chosen such that they capture 95% of the cumulative variance. A total of 13 principal components (PC1–PC13) were retained for calculating the Rad-score (Supplementary Fig. 2). Supplementary Fig. 3 visualizes how the first 3 principal components capture key variance in the data to differentiate between classes. Supplementary Fig. 4 is a heatmap of the correlation coefficient matrix for PC1–PC13, demonstrating the very low correlations between the principal components.