

Longevity Score — NHANES Validation Summary (Draft for Internal Review)

1. Overview

This document summarizes the first-pass validation of the **Longevity Score** using NHANES 2015–2016. My primary goal was to determine how well the score tracks with physiologic vulnerability, measured by a standard **Frailty Index (FI)**.

The following sections include:

- Interpretation of correlation results
- Distributions of both scores
- Quartile analysis
- Cohen's d effect size
- Figures embedded below for easy reading

As a caveat, several Longevity Score v1.1 components were not available in NHANES 2015–2016 public data. Therefore, the present validation uses a reduced Longevity Score, including only variables available in NHANES. The following components are missing from the dataset and were excluded from modeling:

- Coronary Artery Calcium (CAC) score
- Bone mineral density (DEXA hip or spine)
- Maximal VO_{max}
- Heart-rate variability (HRV)
- Grip strength
- Epigenetic age acceleration (e.g., TruAge)
- Small HDL particle count
- 2-hour OGTT glucose
- ALT (missing in this cycle)
- Detailed smoking exposure (pack-years)

Because these variables represent key cardiometabolic, functional, and biological aging domains, the NHANES-based LS is expected to have lower discrimination than the full Quotient Health Longevity Score.

2. Distribution of Frailty Index

The frailty index (FI) ranges from 0 to 1. In NHANES, older adults cluster toward the lower end.

Frailty Index Distribution

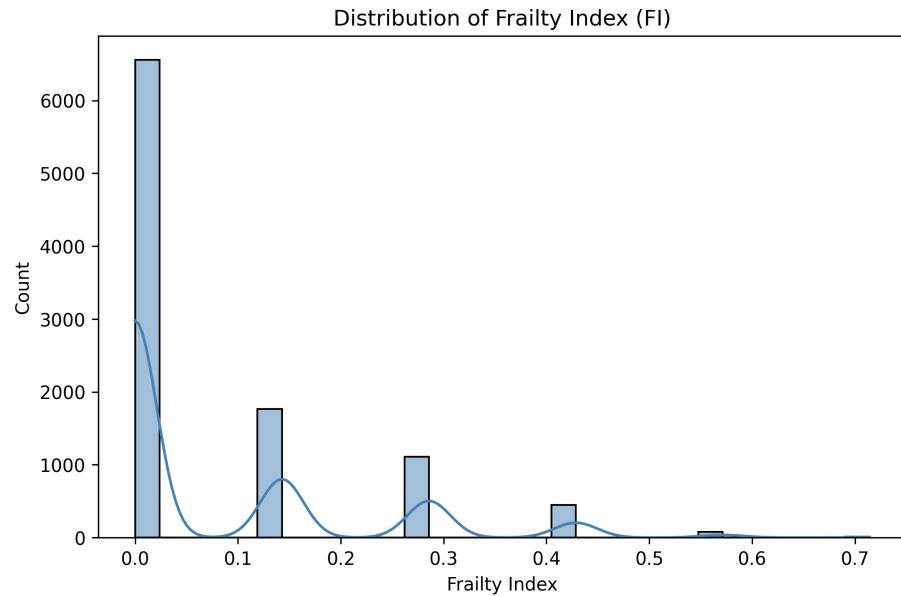


Figure 1: FI Histogram

Interpretation: Frailty is heavily right-skewed, as expected in a general population sample. Most individuals have FI < 0.1.

3. Distribution of Longevity Score

After normalization and credit-score mapping (300–850):

Longevity Score Distribution

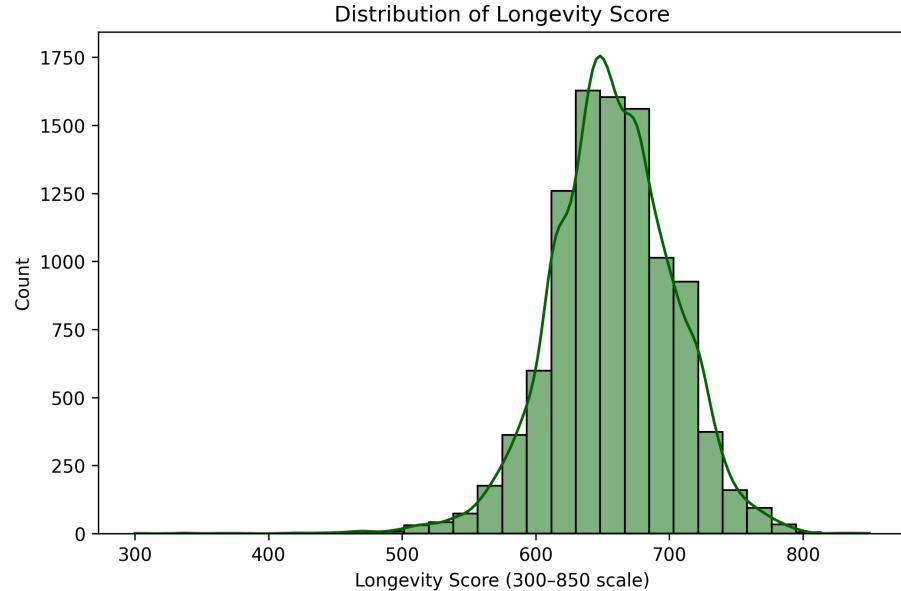


Figure 2: Longevity Histogram

Interpretation: The Longevity Score distributes smoothly with no major artifacts, indicating stable scaling.

4. Correlation Between Longevity Score & Frailty Index

Scatter Plot with Trend Line

Key finding:

- Pearson correlation: **-0.33**
- Higher Longevity Scores tend to correspond to lower frailty levels.

This is consistent with expected relationships between physiological risk scores and frailty constructs.

5. Quartile Analysis

We divided the sample into Longevity Score quartiles (Q1–Q4).

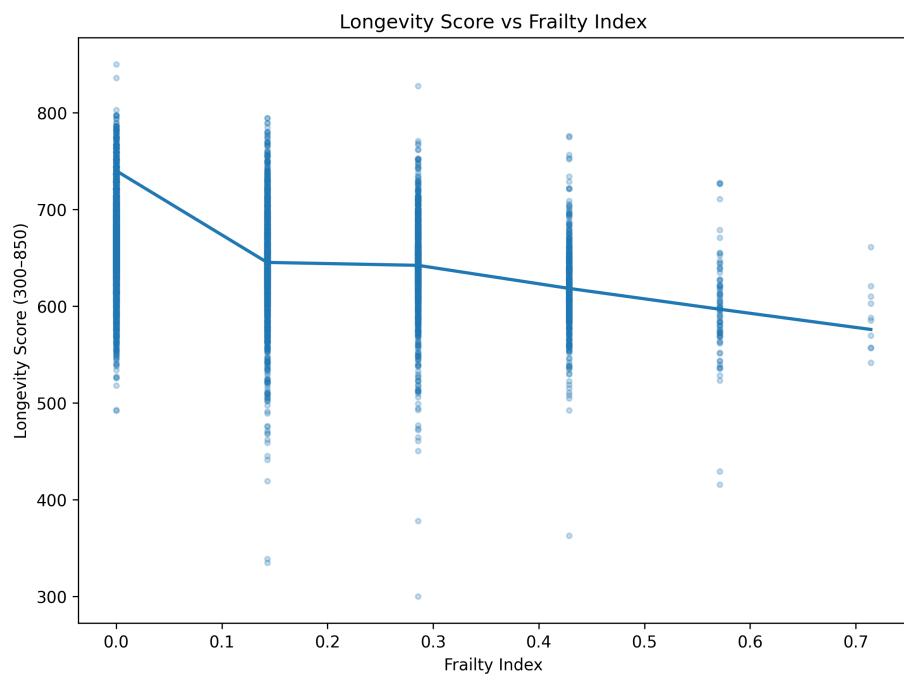


Figure 3: LS vs FI Scatter

Frailty Index Across Longevity Score Quartiles

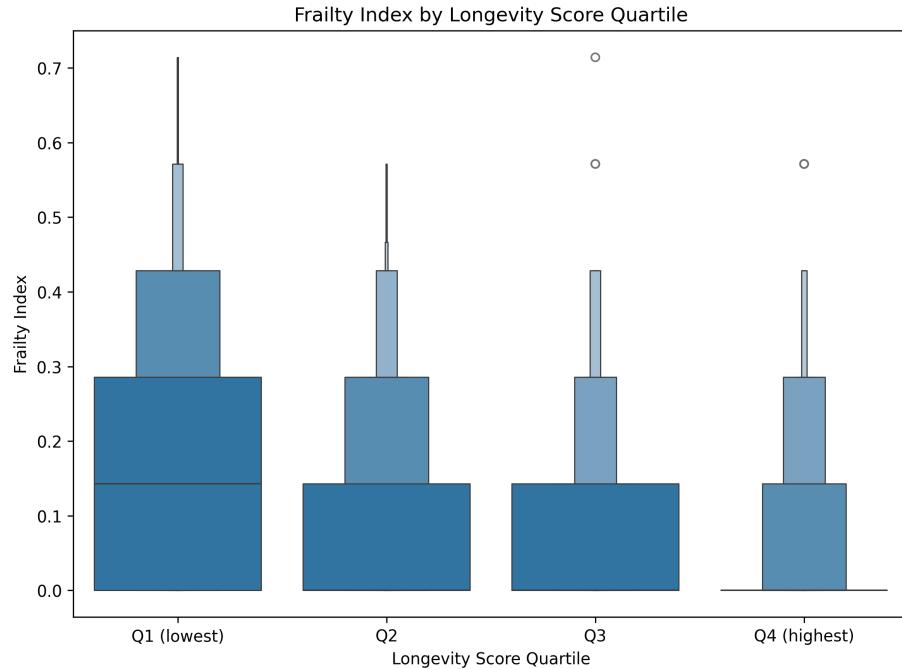


Figure 4: Quartile Boxplot

Mean FI by quartile:

Quartile	Mean FI
Q1 (Lowest LS)	0.149
Q2	0.084
Q3	0.055
Q4 (Highest LS)	0.039

Interpretation: Frailty burden decreases **monotonically** with improving Longevity Score. The healthiest quartile shows **3–4× lower frailty** than the least healthy group.

6. Effect Size (Cohen's d)

We dichotomized frailty using the standard cutoff (FI > 0.25 = “frail”).

Longevity Score Differences by Frailty Group

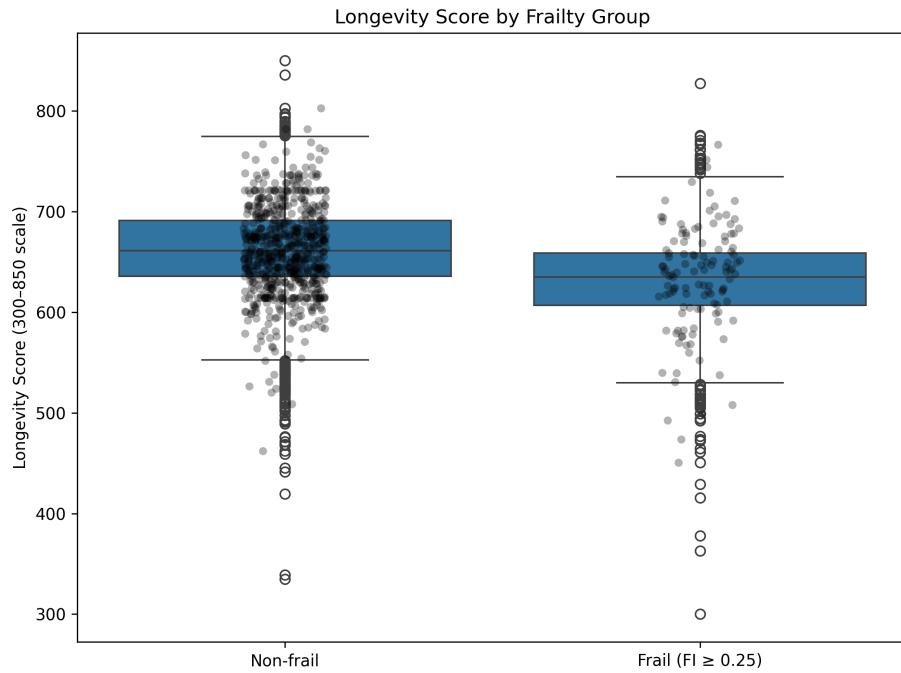


Figure 5: LS by Frailty Group

- Cohen's $d = 0.677$

Interpretation: Medium-to-large effect size. A randomly selected non-frail adult has about a **70% chance** of having a higher Longevity Score than a frail adult.

This is a strong signal for a cross-sectional population dataset.

7. Summary of Findings

- The Longevity Score **correlates moderately** with frailty ($r = -0.33$).
 - Quartile analysis shows **clean stepwise separation**.
 - The magnitude of difference between frail vs. non-frail adults ($d = 0.677$) is substantial.
 - Overall, the score demonstrates promising discriminative performance, even in a non-clinical dataset with limited biomarkers.
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