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

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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

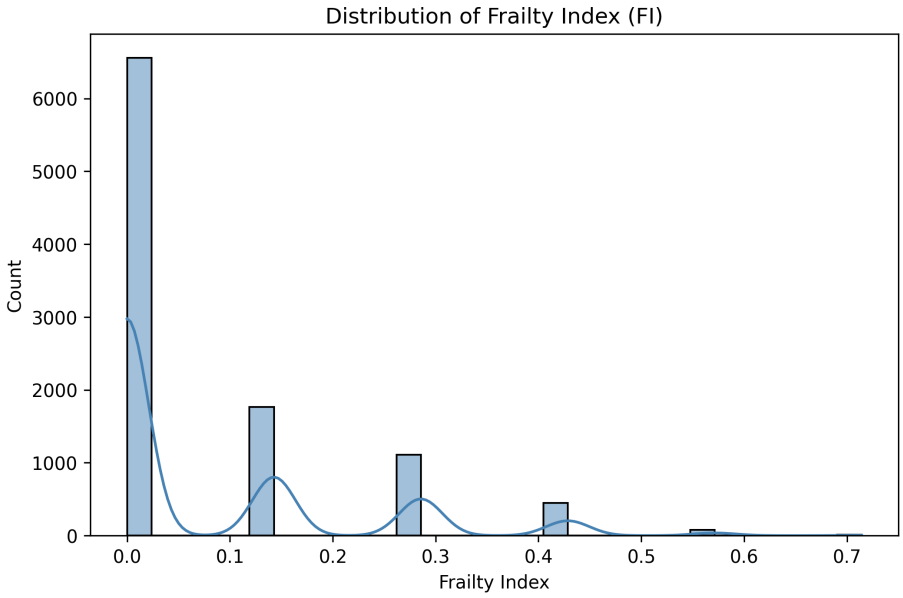

Figure 1: FI Histogram

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

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3. Distribution of Longevity Score

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

Longevity Score Distribution

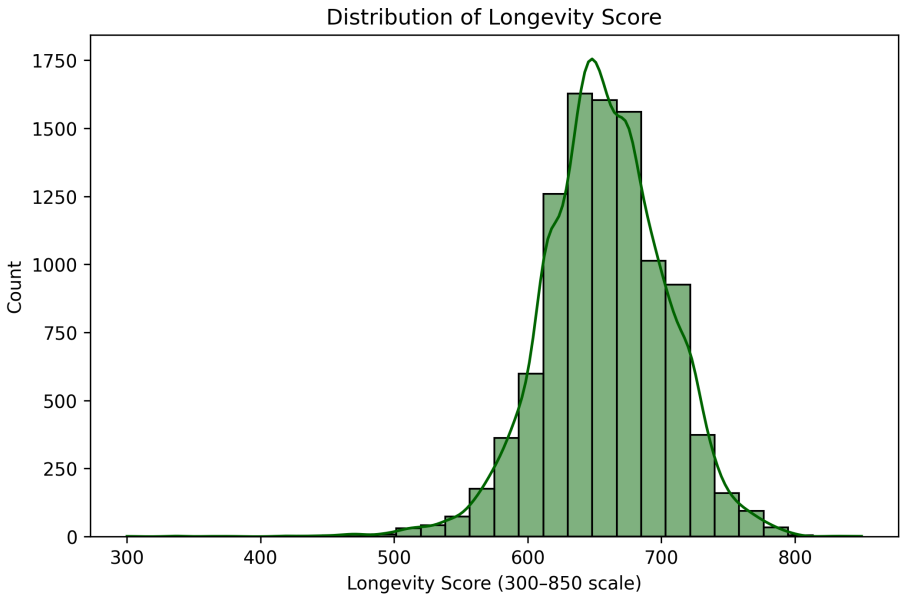

Figure 2: Longevity Histogram

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

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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.

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5. Quartile Analysis

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

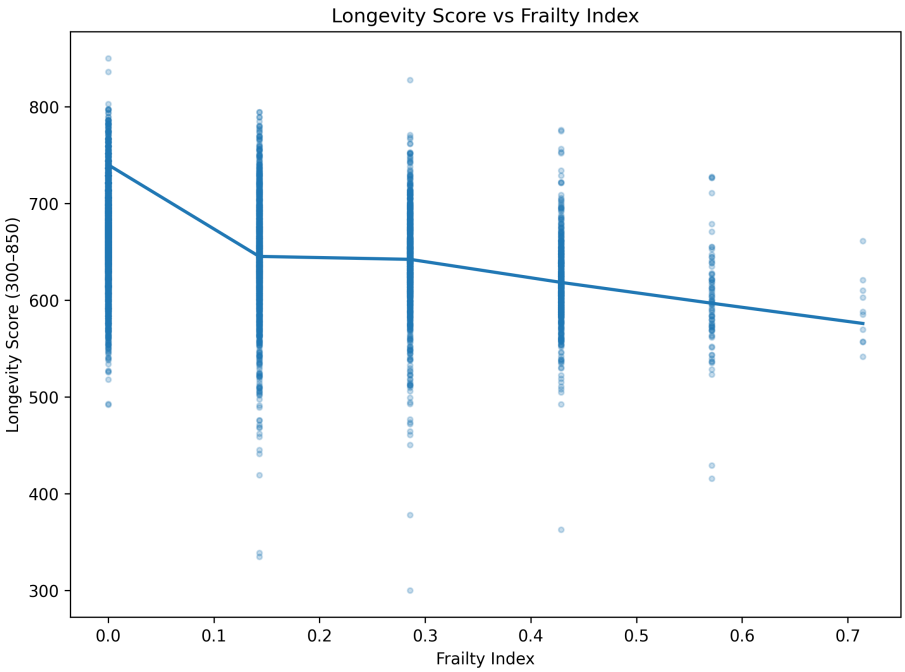

Figure 3: LS vs FI Scatter

Frailty Index Across Longevity Score Quartiles

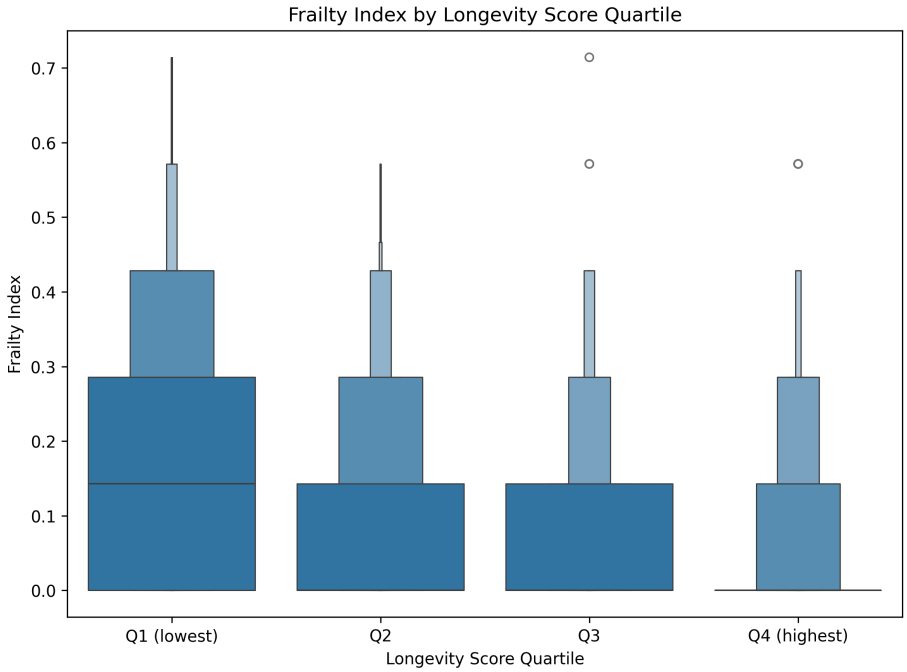

Figure 4: Quartile Boxplot

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.

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6. Effect Size (Cohen's d)

We dichotomized frailty using the standard cutoff (FI 0.25 = "frail").

Longevity Score Differences by Frailty Group

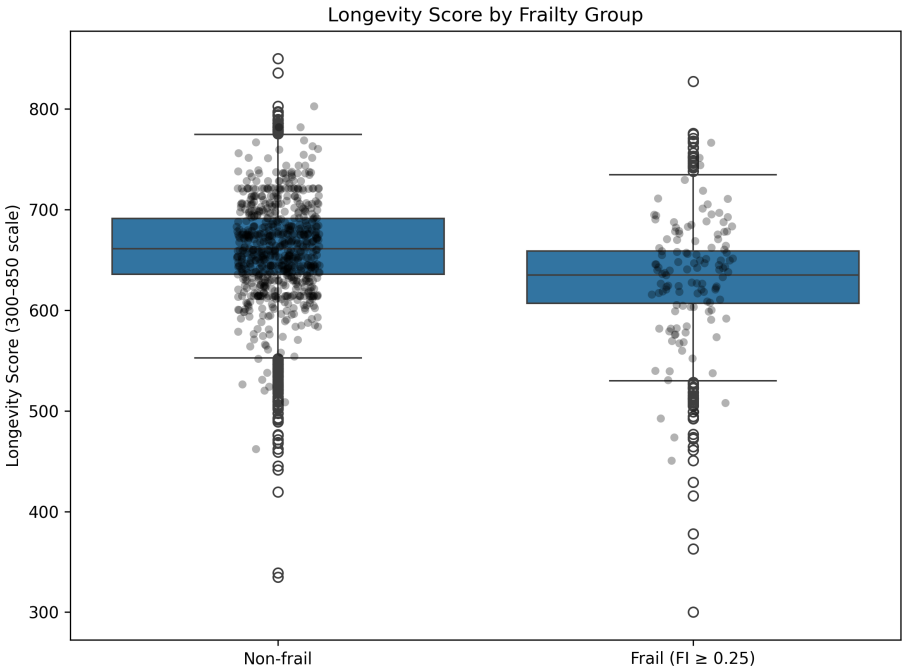

Figure 5: LS by Frailty Group

- **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.

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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.
