Description of Additional Supplementary Files

File Name: Supplementary Data 1

Description: 325 NMR biomarkers included in this study

File Name: Supplementary Data 2

Description: Pearson's correlation among 325 NMR biomarkers

File Name: Supplementary Data 3

Description: The raw two-sided *p*-value matrix of Pearson's correlation among 325 NMR biomarkers (without adjustment for multiple comparisons)

File Name: Supplementary Data 4

Description: 54 representative aging-related NMR biomarkers associated with all-cause mortality risk

File Name: Supplementary Data 5

Description: Overlap between 54 aging-related NMR biomarkers identified in this study with previously reported ones

File Name: Supplementary Data 6

Description: Odds ratio matrix between 54 aging-related biomarkers and 50 frailty-related health deficits (with chronological age adjusted as a covariate)

File Name: Supplementary Data 7

Description: The raw two-sided *p*-value matrix calculated from multivariable logistic regressions between 54 aging-related biomarkers and 50 frailty-related health deficits (with chronological age adjusted as a covariate and without adjustment for multiple comparisons)

File Name: Supplementary Data 8

Description: Genetic correlation matrix among 325 NMR biomarkers

File Name: Supplementary Data 9

Description: The raw two-sided *p*-value matrix calculated from LDSC of genetic correlation among 325 NMR biomarkers (without adjustment for multiple comparisons)

File Name: Supplementary Data 10

Description: Details on the GWAS summary statistics of 20 aging-related diseases

File Name: Supplementary Data 11

Description: Harmonized instrumental variables (2,164 genetic variants)

File Name: Supplementary Data 12

Description: 439 candidate “Biomarker-Disease” causal pairs (Results are estimated from MVMR-IVW, MVMR-Egger, MVMR-Lasso, MVMR-Median. Raw *p*-values are two-sided and not corrected for multiple comparisons.)

File Name: Supplementary Data 13

Description: 185 “Biomarker-Disease” colocalized pairs with PPH4 > 80%

File Name: Supplementary Data 14

Description: VEP annotation of top colocalized variants for 185 “Biomarker-Disease” pairs

File Name: Supplementary Data 15

Description: Predictive performances of different aging metrics on all-cause mortality risk across different follow-up intervals (Two-sided *p*-values are calculated from the Delong's test without adjustment for multiple comparisons.)

File Name: Supplementary Data 16

Description: Correlation matrix of residuals of four biological aging metrics independent of chronological age (Two-sided *p*-values are calculated from the Pearson's correlation without adjustment for multiple comparisons.)

File Name: Supplementary Data 17

Description: Age-stratified analysis on the predictive performance of Metabolomic Aging Score residuals regressed against age across different follow-up intervals (Two-sided *p*-values are calculated from Delong's tests without adjustment for multiple comparisons.)

File Name: Supplementary Data 18

Description: Multinomial logistic regressions adjusting potential confounders to evaluate the discrimination of Metabolomic Aging Score on early-onset, other-onset and disease-free groups (Two-sided *p*-values are calculated using Kruskal-Wallis rank sum tests and Pearson's Chi-squared tests without adjustment for multiple comparisons.)

File Name: Supplementary Data 19

Description: Age-stratified survival analysis assessing different mortality risk across different rate residual groups with chronological age adjusted as a covariate

File Name: Supplementary Data 20

Description: 15 pro-aging and 25 anti-aging biomarkers annotated with relevant biological functions and disease associations

File Name: Supplementary Data 21

Description: GWAS Catalog study accession IDs for 325 NMR biomarker GWAS summary statistics