BLUEPRINT
BRYAN JOHNSON

SPEED OF AGING REPORT

EVERETT ROETH · 0001-53038-2MC9AZV
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Speed of Aging Report

KIT ID 2MC9AZV
REPORTED 2025-02-20
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Table of Contents

BLUEPRINT BIOMARKERS

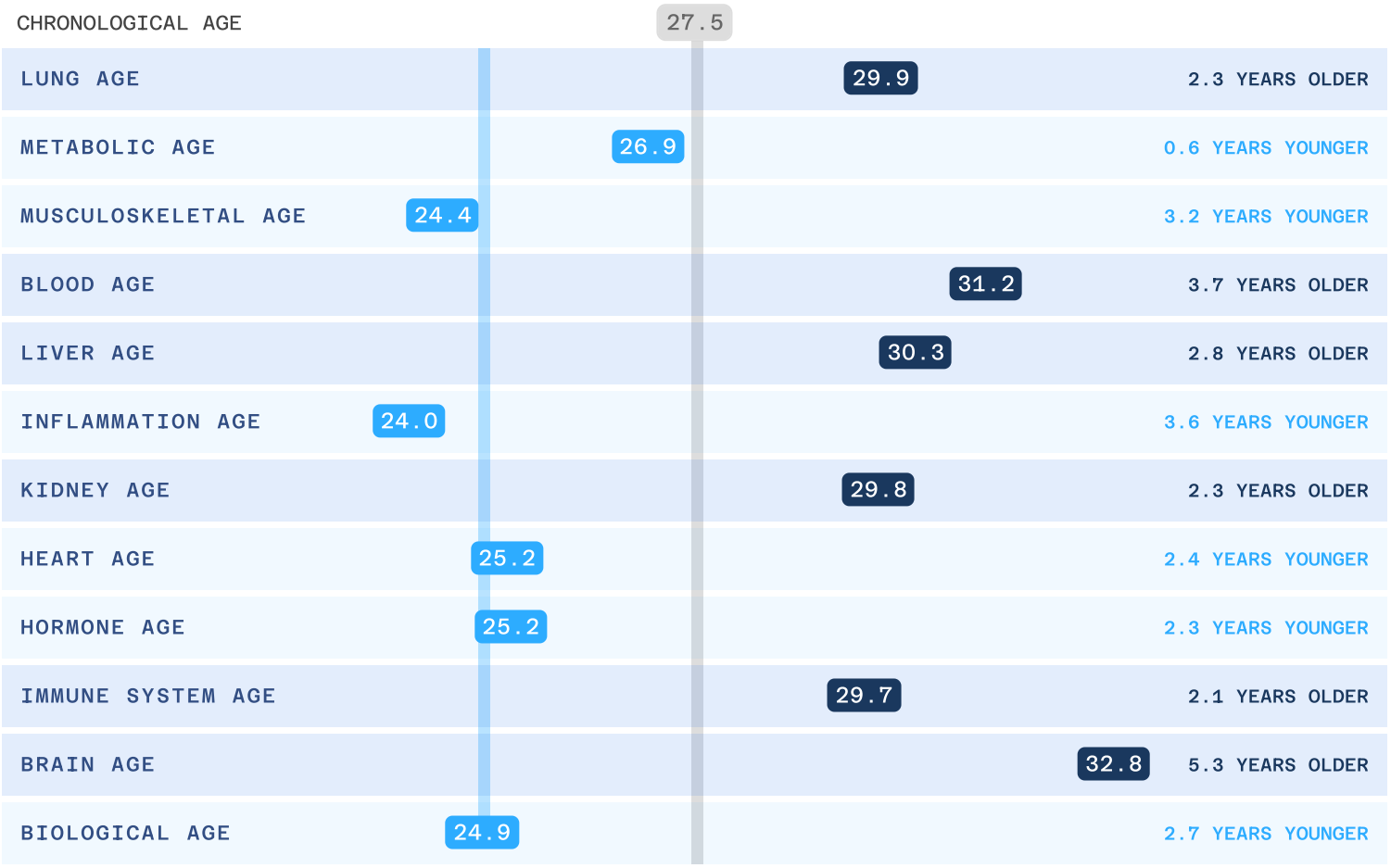
Speed of Aging Report

KIT ID	2MC9AZV
REPORTED	2025-02-20
COLLECTED	2025-01-07

0.74 AGING SLOWER
PACE OF AGING

24.9 YOUNGER
BIOLOGICAL AGE

27.5
CHRONOLOGICAL AGE



You are aging **slower** than **86.48%** of the population who took this test with the same chronological age as you.

Taking action to counter your Biological Aging makes a huge difference

Bryan Johnson has the best aging score in the entire world (slowest speed of biological aging), with a personal best of 0.48 and an average pace of 0.53 (starting from a PACE greater than 1 four years ago), now Bryan celebrates his "biological Birthday" once every 24 months.

This document is designed to get you up to speed with our Speed of Aging tests, to teach you how to interpret your results, and give you proven action points inspired by Bryan's journey in slowing down his biological age, so that you too can achieve similar remarkable results.

Keen in mind: Biological Aging is mostly driven by the environment, habits and lifestyle choices and is malleable to interventions.

Unlike chronological aging, biological aging is malleable and is a direct outcome of your behaviour and lifestyle choices. A seminal study [3] in over 2000 twins (gold standard for studying genetic effects) found that longevity was only 25% hereditary. In other words, your genes determine only 25% of your biological aging speed and patterns, while the rest (75%) is up to you to decide and influence.

While all three markers of biological age are responsive, speed of aging is more dynamic in its response as it relies on estimating the speed of aging from a snapshot in time, hence allowing quick feedback to new interventions and lifestyle adjustments.

Biological Age will normally follow the speed of aging, with some delay for trends to appear.

Imagine a car changing its speed, you will be able to see the change directly at the speedometer (speed of aging) much faster than seeing when you reach your destination based on the new speed.

Organ and System-specific biological age can show how certain interventions impact specific systems. For example, exercise tends to have the most significant and rapid effect on musculoskeletal age and heart age, while dietary improvements primarily influence liver and inflammation-related aging.

Speed of Aging (Pace)

What does it test and how to interpret your results?

Think of this as the rate at which your body is aging, it is the speed at which your body and cells are epigenetically aging, in other words it represents the speed at which your cells are accumulating methylation changes associated with biological aging.

A pace of 1 means you are aging 1 year per calendar year, lower than 1 means you are aging slower, and higher than 1 means you are aging faster.

Example: a PACE of 0.5 means that you celebrate your "biological" birthday only once every two calendar years.

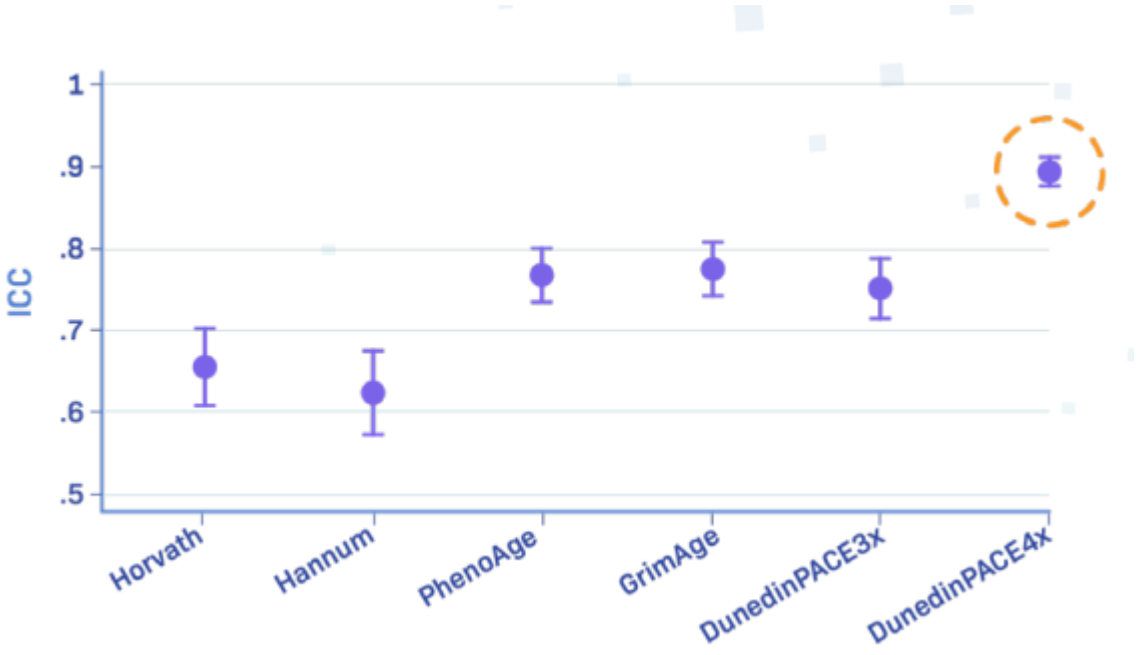
Purpose: Quantifies the rate at which your body is aging in months per year.

Mechanism: Uses a machine-learning algorithm developed by researchers at Duke University and Columbia University, which was trained on longitudinal data (the Dunedin Study) to evaluate hundreds of DNA methylation marks.

Performance: Offers high test-retest reliability (with intra-class correlation values above 0.98) and is sensitive to lifestyle modifications.

How is PACE better than earlier generations of epigenetic age clocks?

PACE has higher association size with both physiological and self-assessed health markers. (1)



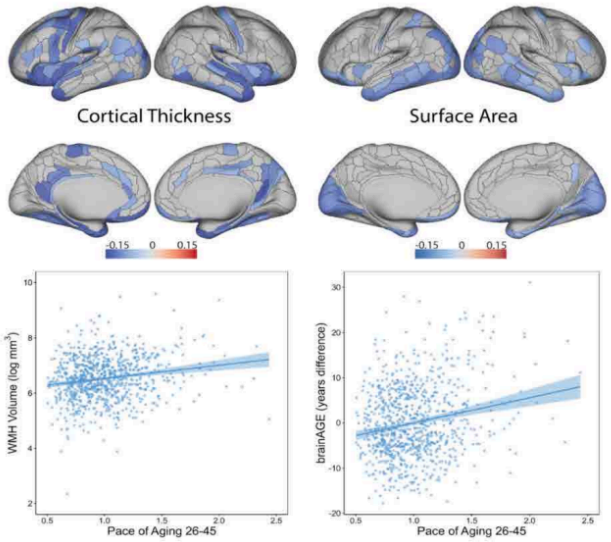
Speed of Aging Report

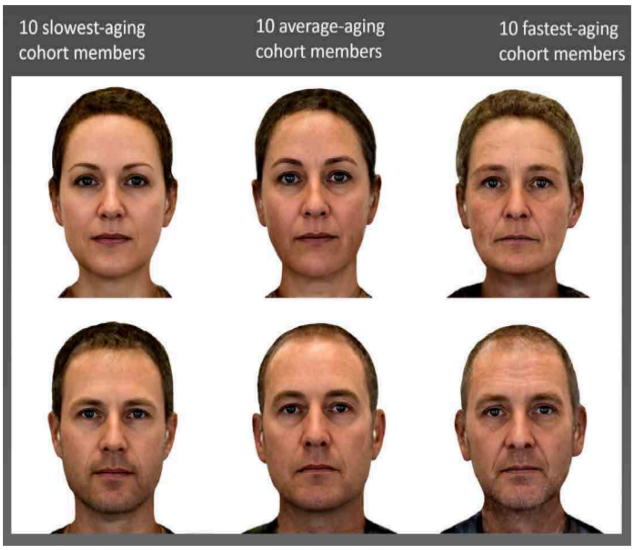
KIT ID	2MC9AZV
REPORTED	2025-02-20
COLLECTED	2025-01-07

PACE score predicts the physiological, structural, and biochemical markers of aging and damage in the body.

Two examples here:

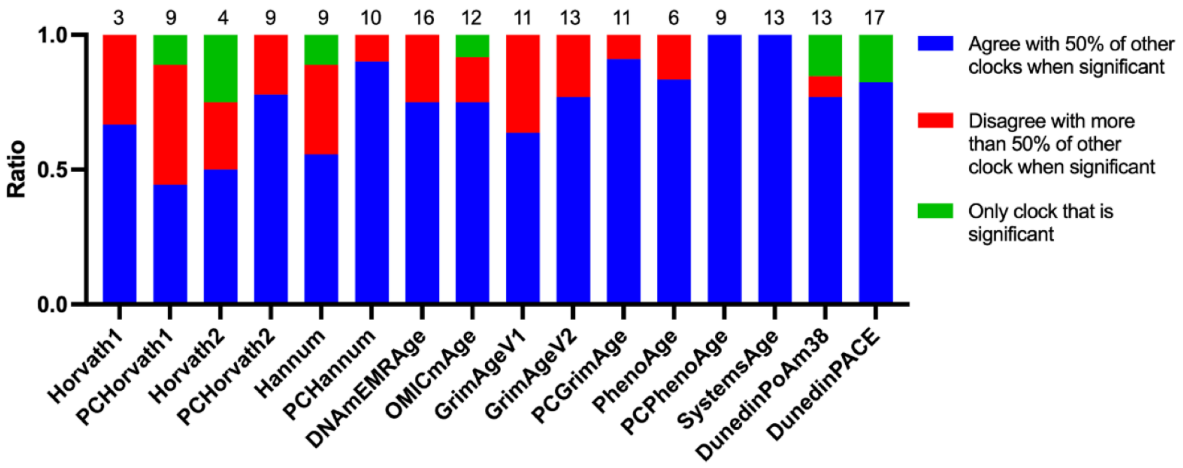
1. PACE predicts brain age (left) [(1)].
2. PACE predicts facial aging (right) [(1)], the picture is AI generated merging facial aging features of people all chronologically 45, with increasing pace rates)





Experimentally, DunedinPACE has been shown as the best predictor of mortality, and age related decline compared to earlier clocks.

In a recent evaluation of 16 biological aging clocks across 51 interventional studies, DunedinPACE stood out as most reliable by always being either in agreement with a majority of the remaining clocks, or uniquely detecting a change in biological age, where no other clock did [(2)].



Performance: Offers high test-retest reliability (with intra-class correlation values above 0.98) and is sensitive to lifestyle modifications.

What actions can you take to reduce your speed of biological aging (PACE score)?

Here are the top 5 supplements, lifestyle and dietary interventions to reduce your systemic speed of aging and get a better PACE score for your next test.

Top 5 Supplements

1. Spermidine – Supports autophagy, cellular repair, and longevity pathways. (Included in Blueprint Essential Capsules)
2. Nicotinamide Mononucleotide (NMN) or Nicotinamide Riboside (NR) – Boosts NAD+ levels, essential for mitochondrial and DNA repair. (Included in Blueprint Essential Capsules)
3. Quercetin + Dasatinib (D+Q Senolytics) – Helps clear senescent cells, reducing systemic inflammation and improving biological age markers.
4. Vitamin D3 + K2 – Supports immune function, bone health, and may influence gene expression related to aging. (Included in Blueprint Essential Softgels)
5. Omega-3 Fatty Acids (EPA & DHA) – Reduces inflammation, improves cardiovascular health, and supports cognitive function. (Blueprint EPA & DHA coming June 2025)

Top 5 Lifestyle Interventions

1. Caloric Restriction (CR) – One of the most well-documented longevity interventions, shown to slow biological aging and improve metabolic flexibility.
2. Strength & Resistance Training – Builds muscle mass, enhances mitochondrial function, and improves metabolic flexibility.
3. High-Intensity Interval Training (HIIT) – Increases cardiovascular efficiency, stimulates mitochondrial biogenesis, and enhances insulin sensitivity.
4. Hyperbaric Oxygen Therapy (HBOT – High & Mild Pressure) – Increases oxygen availability, promotes telomere lengthening, reduces inflammation, and enhances stem cell activity. (Bryan's HBOT protocol)
5. Prioritizing High-Quality Sleep (7–9 hours per night) – Crucial for epigenetic stability, immune function, and cognitive longevity.

Top 5 Dietary Interventions

1. Green Mediterranean Diet – A more polyphenol-rich version of the Mediterranean Diet, shown to have superior anti-aging effects.
2. Polyphenol-Rich Foods (Berries, Dark Chocolate, Green Tea, Olive Oil, Red Wine in Moderation) – Reduce oxidative stress and inflammation.
3. Cruciferous Vegetables (Broccoli, Brussels Sprouts, Kale, Cauliflower) – Contain sulforaphane and other bioactive compounds that enhance detoxification and DNA repair.
4. Adequate Protein Intake (Pea/Hemp Protein, Grass-Fed Meat, Fatty Fish) – Supports muscle maintenance and metabolic function, critical for longevity.
5. Prebiotic & Fermented Foods (Kimchi, Sauerkraut, Yogurt, Garlic, Onions) – Enhance gut microbiome diversity, which is linked to immune function and longevity.

All these aspects and many more dietary requirements are covered in the Blueprint diet.

Organs and Systems age clock(s)

What does it test and how to interpret your results?

These methylation scores have been validated to correlate with biological markers of various organs and systems in a representative cohort of 5000 participants. These scores help identify the drivers of overall speed of biological aging and detect early risk factors for organ-specific diseases that might still be undetected through conventional biomarkers.

Biological Age Clock (Organ Age Clock):

- **Purpose:** Estimates overall biological age and the relative "age" of 11 organ systems, comparing these to chronological age.
- **Mechanism:** This clock analyzes methylation patterns at over 170 sites across the genome, integrating system-specific clinical chemistry and functional measures. It was developed in collaboration with Yale University scientists.

The Biological Age Score measures your overall epigenetic age up to the point of the test. Ideally you want to have a biological age as low as possible, and definitely lower than your chronological age. This is based on all components of 11 organs/systems biological aging clocks

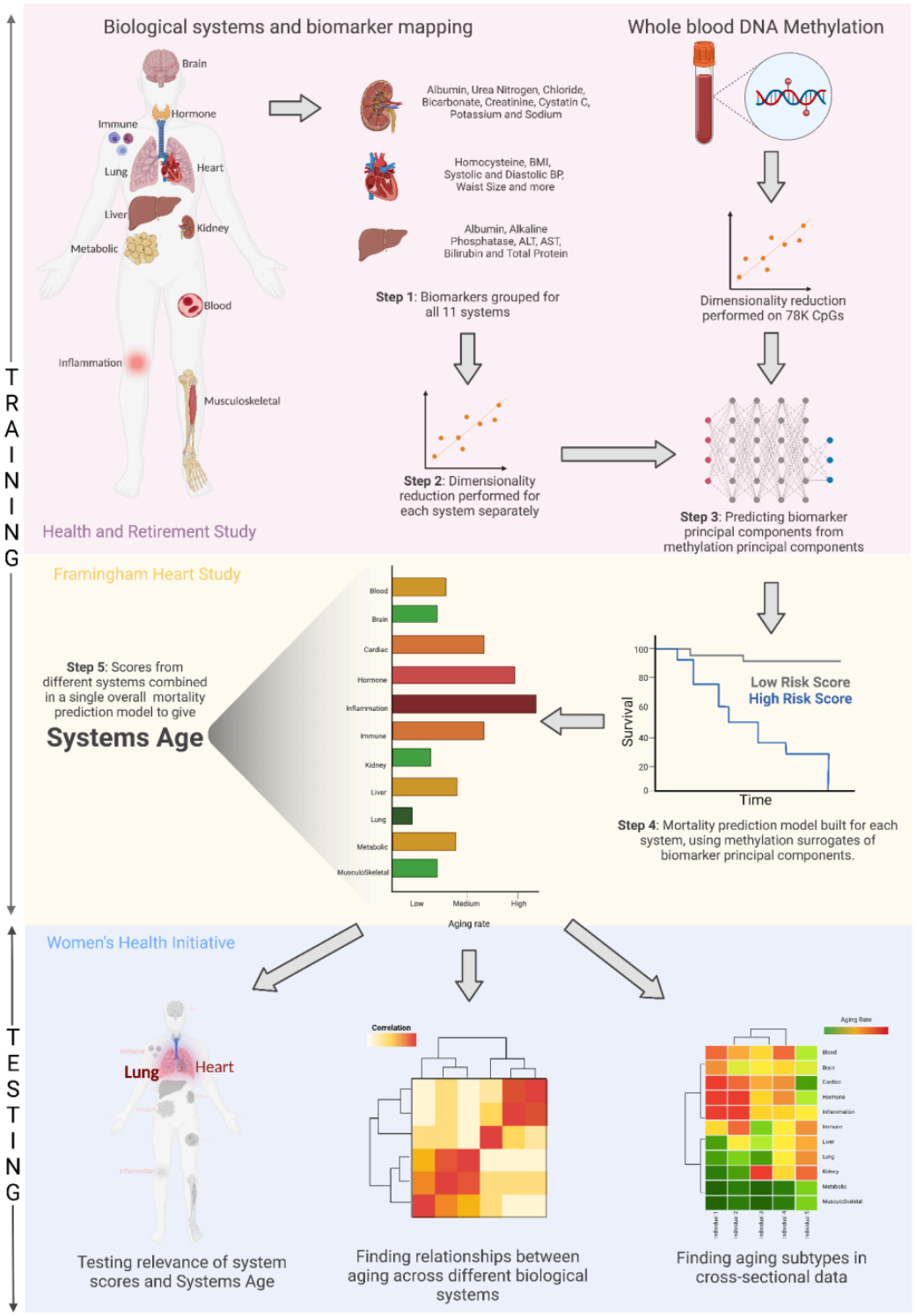
The following figure shows the 3 steps of training of the clocks based on relevant markers for each organ/system. These are a combination of phenotypic, structural, and biochemical markers.

Each organ clock analyzes a distinct combination of DNA methylation signatures to estimate an aging score for that organ or system. Combining these scores across all systems provides a single biological age.

Speed of Aging Report

KIT ID	2MC9AZV
REPORTED	2025-02-20
COLLECTED	2025-01-07

The training and testing work flow for Systems Age is depicted in the figure below [(4)]



How do Organ and System Age Clocks differ from systemic epigenetic aging clocks?

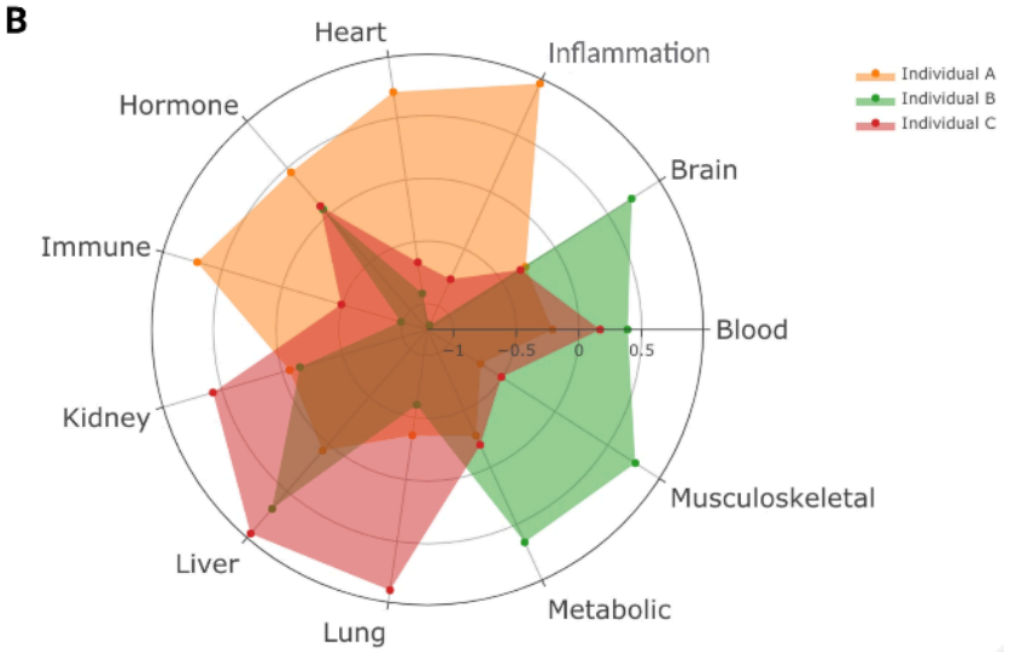
Understanding your aging type:
Imagine your organs and systems aging like a row of dominoes, except the sequence is unique to each person. When one system begins aging more rapidly, it can set off a chain reaction, accelerating the aging of the next system, and so on.

Organ age clocks identify your unique aging type, the sequence of your "aging dominoes". By understanding which organs or systems are most vulnerable, you can take proactive steps to slow their decline and prevent premature failure.

The problem with relying on a single Biological Clock measure is that it can mask the aging of individual organs, potentially delaying intervention until it's too late. Once the domino effect starts, reversing the decline of the weakest link may become impossible.

The following figure shows an example of three individuals all having comparable chronological and overall biological (as a single measure) age. However, each individual has a very distinctive aging type affecting different organs and systems.

Moreover, unlike conventional biomarkers, these novel organ age clocks offer a fully standardized and unified measure of organ and system health and age for the first time. In comparison, conventional biomarkers can vary in measurement methods between labs, leading to inconsistencies. Biological age clocks, on the other hand, all rely on the same fully quantifiable DNA methylation signals, using standardized methods and algorithms for quantifications. This ensures that your biological age tests will always be consistent and comparable [(4)].



What actions can you take to reduce your organs and systems biological age?

1. Cardiovascular System (Heart Age)

- Increase Zone 2 Cardio → Engage in 150+ minutes/week of moderate-intensity exercise (e.g., cycling, brisk walking) to improve mitochondrial efficiency and vascular health.
- Optimize ApoB & LDL Levels → Aim for ApoB < 60 mg/dL using diet (e.g., plant-based, Mediterranean) and pharmacologic interventions if needed (statins, PCSK9 inhibitors).
- Improve Nitric Oxide Production → Consume beetroot, dark leafy greens, and citrulline/magnesium to enhance vasodilation and endothelial function.

2. Metabolic System (Glucose & Insulin Sensitivity)

- Time-Restricted Eating (TRE) → Eat within a 6–10 hour window to improve insulin sensitivity and metabolic flexibility.
- Strength Training → Perform 2–3 sessions/week of resistance training to increase glucose disposal and lean muscle mass.
- Optimize Magnesium & Berberine → Supplement with magnesium (400 mg/day) and berberine (500 mg 2–3x/day) to enhance insulin signaling and glucose metabolism.

3. Liver Age

- Reduce Processed Carbohydrates & Alcohol → Minimize fructose, refined grains, and alcohol to lower liver fat and improve lipid metabolism.
- Support Detox Pathways → Increase intake of sulforaphane (broccoli sprouts), NAC, and taurine to enhance phase 2 liver detoxification.
- Monitor ALT, AST, and GGT → Regular blood testing and liver ultrasound (if necessary) to detect early signs of fatty liver or fibrosis.

4. Kidney Age

- Maintain Optimal Hydration → Drink at least 2.5–3L of filtered water/day, especially if protein intake is high.
- Reduce Sodium & Balance Electrolytes → Keep sodium under 2,300 mg/day while optimizing potassium (3,500–4,700 mg/day) and magnesium intake.
- Limit NSAID Use → Avoid chronic NSAID use (e.g., ibuprofen) due to nephrotoxicity risks; consider alternatives for pain management.

5. Pulmonary System (Lung Age)

- Increase VO2 Max → Perform high-intensity interval training (HIIT) 2x/week to enhance pulmonary efficiency.
- Nasal Breathing & Air Filtration → Use HEPA filters indoors and focus on nasal breathing to reduce particulate exposure.
- Reduce Inflammatory Foods & Toxins → Minimize omega-6 seed oils, environmental pollutants, and smoke exposure.

6. Brain Age (Cognitive Function)

- Optimize BDNF & Neuroplasticity → Do aerobic exercise (Zone 2 & HIIT), cold exposure, and intermittent fasting to upregulate BDNF.
- Improve Omega-3 & Choline Levels → Take DHA/EPA (2-3 g/day) and phosphatidylcholine to support neuronal membrane integrity.
- Prioritize Deep Sleep → Get 7-9 hours of sleep per night, optimizing melatonin, magnesium, and blue-light exposure.

7. Musculoskeletal System (Bone & Muscle Age)

- Strength Train 3-4x/Week → Prioritize progressive overload, compound movements, and eccentric training.
- Optimize Protein Intake → Consume 1.6-2.2 g/kg of protein daily, emphasizing leucine-rich sources.
- Monitor & Supplement Vitamin D3/K2 → Keep Vitamin D >50 ng/mL and supplement D3 with K2 (MK-7) for bone health.

8. Blood System

- Optimize Iron Levels → Maintain ferritin between 50-100 ng/mL; if high, donate blood; if low, increase heme iron and vitamin C intake.
- Support Red Blood Cell Production → Ensure adequate B12, folate, and riboflavin to improve oxygen delivery and prevent anemia.
- Enhance Blood Flow & Reduce Clotting Risk → Increase omega-3 intake (DHA/EPA), stay hydrated, and use nitric oxide boosters (beets, citrulline).

9. Immune System Age

- Cold Exposure & Sauna Use → Incorporate cold plunges (2–3x/week) and sauna therapy to modulate immune function.
- Increase Polyphenols & Zinc → Consume quercetin, EGCG (green tea), and zinc lozenges (15–30 mg/day) for immune resilience.
- Optimize Gut Health → Take spore-based probiotics and prebiotic fiber to enhance immune regulation via the gut microbiome.

10. Hormonal System Age

- Regulate Circadian Rhythm & Light Exposure → Get morning sunlight, reduce blue light at night, and maintain consistent sleep timing.
- Strength Train & Increase Testosterone Precursors → Use heavy resistance training, Tongkat Ali, and boron to support hormone balance.
- Monitor & Optimize Thyroid Function → Ensure iodine, selenium, and tyrosine intake is adequate while testing TSH, Free T3/T4, and Reverse T3.

11. Inflammatory System Age

- Adopt an Anti-Inflammatory Diet → Minimize processed foods, seed oils, and refined sugars, favoring a Mediterranean or anti-inflammatory diet.
- Reduce Chronic Stress & Improve HRV → Use breathwork, meditation, and parasympathetic activation techniques (HRV training).
- Optimize Omega-3 to Omega-6 Ratio → Increase EPA/DHA intake (2–4 g/day) while reducing linoleic acid sources (vegetable oils, ultra-processed foods).

KIT ID	2MC9AZV
REPORTED	2025-02-20
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Track your health biomarkers

Biological aging is the sum-up of thousands of biochemical processes occurring in the body, these are measured by tracking other biochemical, environmental, and structural markers.

Take more tests to evaluate overall health and pinpoint actual conditions contributing to your aging process, and wider health issues.

https://blueprint.bryanjohnson.com/pages/biomarkers

FAQ

How often should I re-test?

Generally retesting every year at least is recommended.

If you are making lifestyle improvements (e.g. starting the Blueprint Protocols and Stack) or if you are undergoing new rejuvenation therapies (e.g. plasma exchange, HBOT) you might want to test more often to measure the effect of these interventions on your biological age. In that case, testing twice a year or quarterly is preferred.

This is especially true for some interventions that have shown mixed results when put to test with epigenetic clocks (e.g. Rapamycin, senolytics) or dietary or supplemental choices with varying effect based on genetics or environmental factors (e.g. diets rich in red meat, antioxidant supplementation).

How is Pace different from previous clocks like Horvath or GrimAge?

Here is what distinguishes each of the 3 generation of epigenetic age clocks

1st Generation (Horvath, Hannum): created from data sets on people at different chronological ages (single snapshot). While this clock predicts chronological age accurately, it is not strongly correlated to health and longevity outcomes.

2nd Generation (GrimAge PhenoAge): created from data on different people (single snapshot) and trained beyond chronological age to predict health biomarkers and mortality risk.

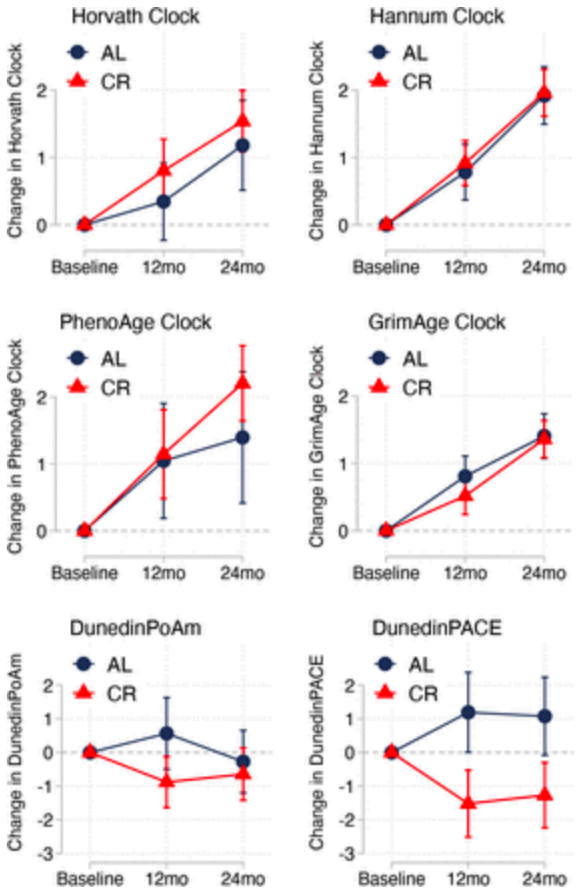
3rd Generation (DunedinPACE): the first to track the aging outcomes of participants across their lifespan based on data from the same individuals from the age 3 to age 51.

Advantages of DunedinPACE:

- Rules out noise in the data due to environmental exposures resulting from people living through different times and in various places.
- Instead of reporting biological age, or time to death, DunedinPACE reports the rate of decline and aging experienced in the recent past (PACE: >1 aging fast, <1 aging slow), which makes it very responsive to interventions and ideal for evaluating them with minimal lag and turnover time.
- Experimentally, DunedinPACE has been shown as the best predictor of mortality, and age related decline compared to earlier clocks.
- In a recent evaluation of 16 biological aging clocks across 51 interventional studies, DunedinPACE stood out as most reliable by always being either in agreement with a majority of the remaining clocks, or uniquely detecting a change in biological age, where no other clock did.

Speed of Aging Report

The figure below shows the higher responsiveness of the DunedinPACE clock compared to all earlier generations (Gen 1 and 2) to a calorie restriction (the most established longevity intervention).



How do we determine Organ and System ages from blood samples?

System Age algorithms are trained using markers specific to each organ or system. These markers are then transformed into "Principal Components" which allow the algorithm to focus on detecting relevant methylation signals for each component. For example, for the heart, relevant markers like BMI, lipids, and heart rate are included. Each organ's clock is then abstracting several relevant markers, e.g. for heart: BMI, Lipids, heart rate, etc..

The clock for each organ is then trained to give a single marker for each participant, which is then used to estimate the age of the organ/system.

How is DNA methylation different from a DNA test?

Think of DNA as a printed book, with the sequence representing the letters and worlds of the book. DNA methylation (epigenetic signals) can be interpreted as a pencil or sticky notes with instructions on which paragraphs to concentrate on or skip.

A DNA test (e.g. genome sequencing) measures the sequence (alphabet of 4 bases A,G,C, and T) of the DNA and detects mutations (e.g. polymorphisms) and genotypes that change genetic predisposition to health and disease.

DNA methylation testing measures changes in the epigenetic regulation of the DNA, which controls gene expression by turning genes on or off and adjusting their activity levels. In the context of aging, these changes can cause cells to lose or "forget" their original identity and function, contributing to the aging process.

The Speed of Aging test algorithm measures the methylation level of DNA units that are linked to aging decline and damage, and age related disease. (Refer to Q1 for more details)

How are telomere length tests different from epigenetic aging tests?

Telomeres are sequence repeats flanking the chromosomes and keeping the edges from being damaged, when telomeres get too short, cells go into senescence. This drives aging both by hindering tissue regeneration and by secreting damaging pro-aging signals known as SASP.

Telomere tests predict aging based on the length of the telomeres or the activity of the telomerase enzyme responsible for regenerating the telomeres at every cell division.

What are the interventions that decrease or increase biological age?

While the current aging clocks allow us to measure and predict biological aging at unprecedented accuracy and detail, this field is still in its infancy. One reason is the existence of various generations of clocks. As explained earlier, many studies in the scientific literature relied on 1st generation clocks in evaluating potential anti-aging interventions, which lead to biases that still persist till today.

As an example, very recent research from Yale (a pre-print report 2)) evaluated various interventions (some therapeutic for particular diseases and some with rejuvenation potential) using 16 epigenetic biological age clocks. Besides showing that PACE was the most consistent and reliable clock in general, this research also uncovered some surprising biases due to the over use of 1st generation clocks in the scientific literature.

Among the biggest surprises was that rapamycin seemed to accelerate biological aging on average, when evaluated using all 16 clocks.

Here are some of the interventions that appeared to slow down aging according to this evaluation across 16 epigenetic clocks

1. Pharmacological Interventions: Anti-TNF therapy (anti-inflammatory), Metformin (Anti-diabetes, AMPK activation),Ketamin (antidepressant psychedelic, dissociative).
2. Supplements: AC11 supplement (natural DNA repair booster), TruLacta (a human-milk based supplement).
3. Lifestyle Adjustments & Surgeries: Gastric Bypass (weight reduction), smoking cessation, kidney transplant, hyperbaric oxygen therapy HBOT (large average effect, but no statistical significance)
4. Diets: Vegan Diet, Green Mediterranean Diet, Mediterranean Diet, low fat and low carb diets.

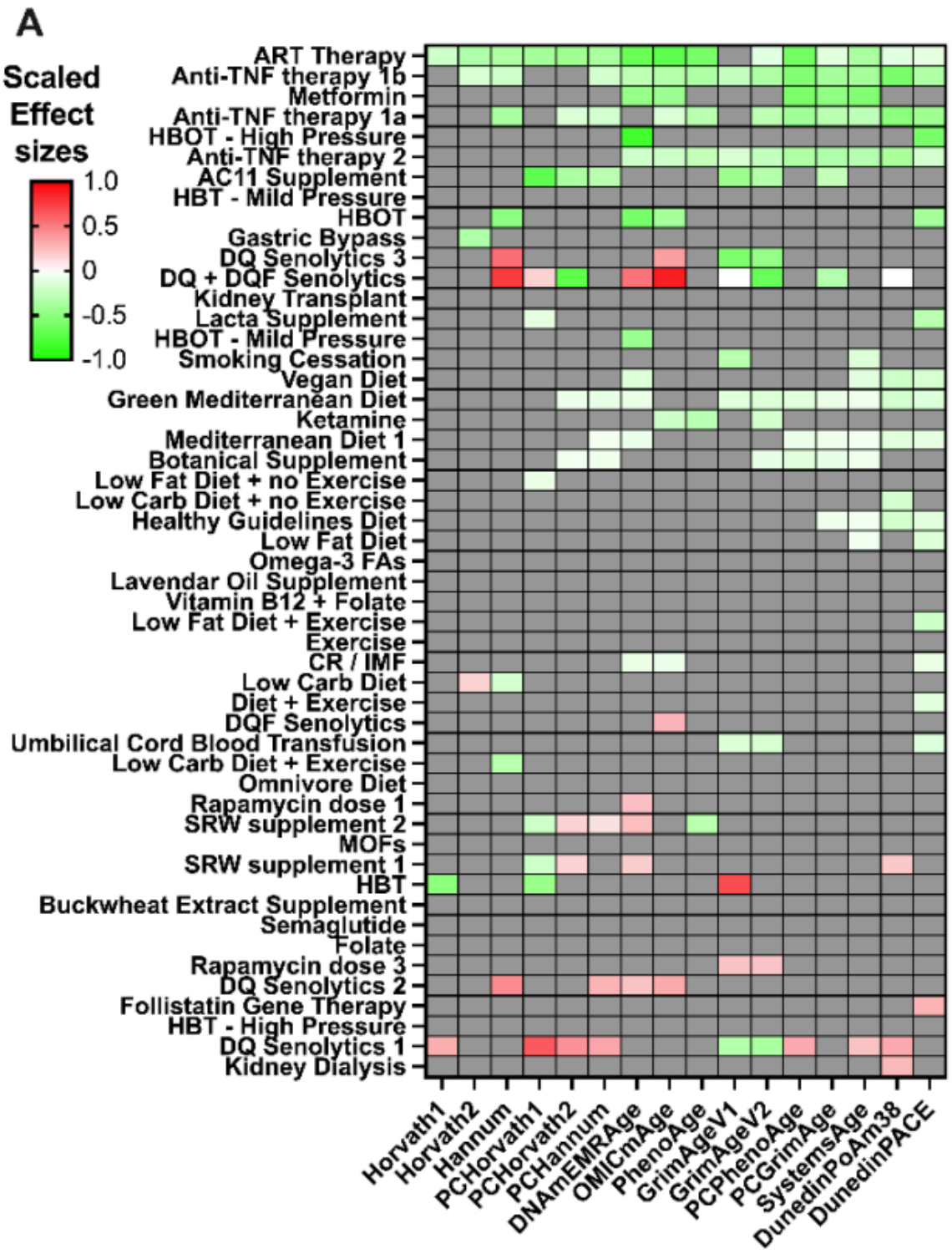
Here are some of the interventions that appeared to accelerate aging according to this evaluation across 16 epigenetic clocks

1. Pharmacological Interventions: Rapamycin (mTORC1 inhibitor, immunosuppressant), senolytics.
2. Supplements: Buckwheat Extract (rich in B vitamins)
3. Gene Therapies: Follistatin (myostatin inhibition, muscle growth)
4. Lifestyle Adjustments, procedures & surgeries: Kidney Dialysis

Speed of Aging Report

KIT ID	2MC9AZV
REPORTED	2025-02-20
COLLECTED	2025-01-07

Important: DunedinPACE results for all these evaluations were consistent with the average of all clocks, and often PACE was the only one to detect an effect [(2)].



How is my Pace of Aging low, but my biological age is high relative to my chronological age?

Think of Pace as a speedometer and the biological age an overall result. As an example, we see a lot of low rates of aging but high biological ages in ex-emergency medicine physicians. These physicians have had long shift-based work and as a result, often poor nutrition and overall aging. However, when they get into the integrative medicine space, their Pace starts to go down. However, it takes a longer time to correct the "aging damage" on the overall biological age algorithms. In summary, the overall age is not the same output as the PACE.

How is my Pace of Aging high, but my biological age is low relative to my chronological age?

The inverse of the previous FAQ could also be true. You might have accumulated a low amount of "aging damage" throughout most of your life because you had low stress, were sleeping well, and eating a diet that promotes healthy aging, leading to a low biological age. However, due to recent changes in your lifestyle or nutrition, your Pace might be a lot higher at the time you took the test.

References

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