

A high-angle, top-down view of a woman and a man using rowing machines in a gym. The woman is on the left, wearing a grey sports bra and shorts, with her hair in a ponytail. The man is on the right, shirtless and wearing light blue shorts. Both are seated on their respective rowing machines, which are positioned on a dark grey tiled floor. The machines have digital displays and resistance rollers. The overall scene is dimly lit, with a soft, diffused light source. The text is overlaid in a bright yellow color, making it stand out against the muted background.

**Exercise,  
Epigenetics, and  
Healthy Ageing:**

**The New Science  
Behind Longevity**

**The fitness industry has long focused on strength, endurance, and body composition—but new research is uncovering how exercise also influences ageing at the molecular level.**

**This field, called epigenetics, looks at chemical “switches” that control how our genes work.**

**These switches don't change DNA itself, but they can affect recovery, energy levels, resilience, and even how quickly we age.**



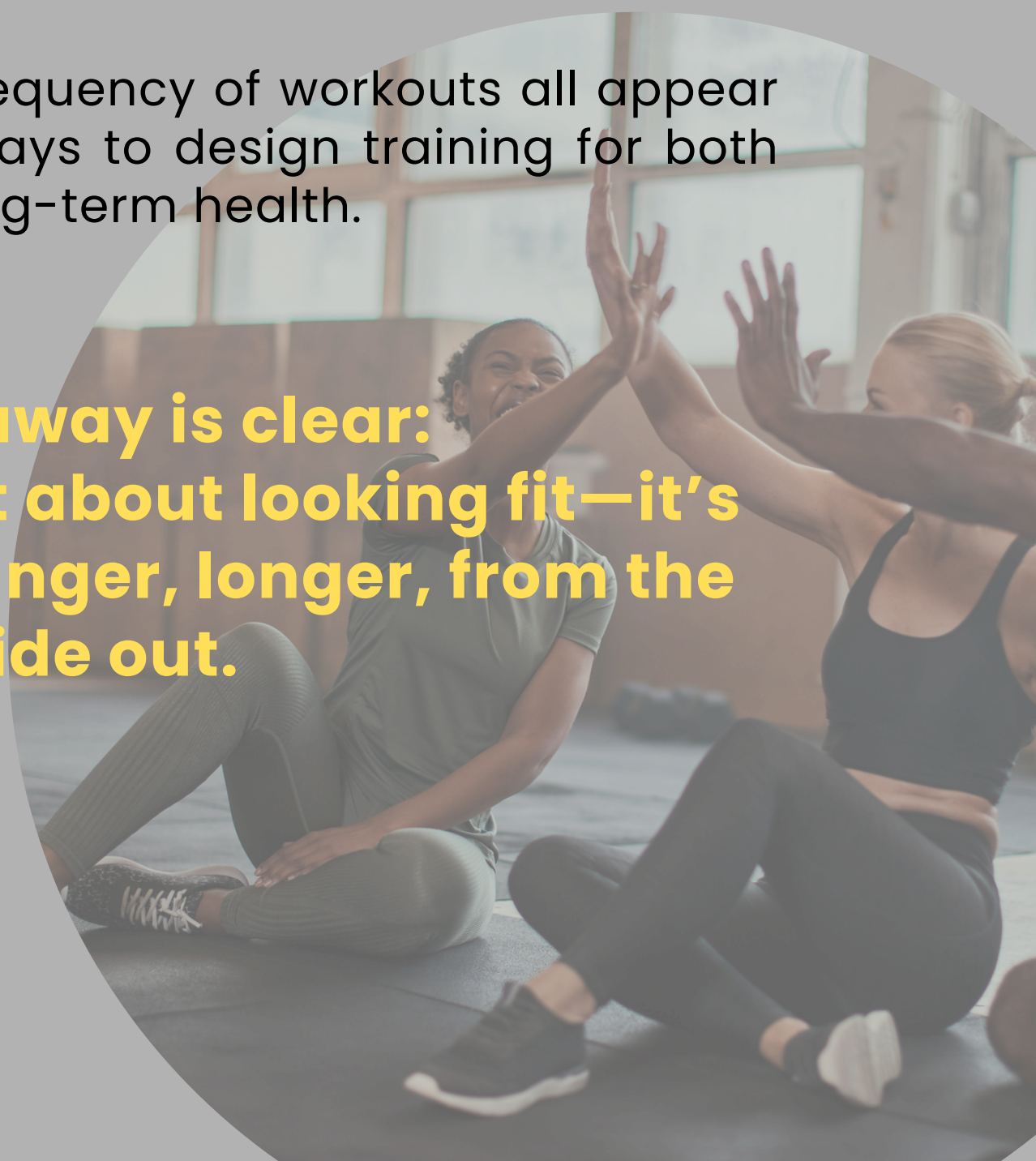
Recent studies (see *Papers Reviewed* at the end of this document) show that regular physical activity can slow down biological ageing, measured through “epigenetic clocks.” **In other words, people who train consistently often have a younger biological age than their birth certificate would suggest.**

Exercise doesn't just sculpt the body—it helps reprogram the way our cells function for healthier ageing.

For fitness professionals, this is a game-changer. Whether it's resistance training, aerobic exercise, or simply reducing sedentary time, activity shapes the epigenetic profile linked to longevity, lower disease risk, and improved performance.

The type, intensity, and frequency of workouts all appear to matter, offering new ways to design training for both short-term results and long-term health.

**The takeaway is clear: exercise is not just about looking fit—it's about staying younger, longer, from the inside out.**



## What Is Epigenetics and Why Does It Matter for Fitness?

Epigenetics is the science of how lifestyle factors—like exercise, sleep, and nutrition—can switch genes on or off without changing the DNA itself. These changes affect how our bodies function, from muscle recovery to how we age.

## Exercise and the Epigenetic Clock: Staying Younger, Longer

Scientists measure “biological age” with epigenetic clocks. Research has shown that active people often have a younger biological age than their actual years, meaning exercise can literally help the body age more slowly.

## How Different Types of Exercise Reprogram Your Genes

Not all workouts affect the body in the same way. Endurance training, resistance work, high-intensity intervals, and simply breaking up sitting time each leave distinct “epigenetic signatures” that may protect against ageing and disease.

## **The Link Between Fitness, Longevity, and Ageing Well**

Epigenetic changes triggered by movement don't just influence lifespan—they improve healthspan. Regular exercise supports heart, brain, and muscle function while reducing the risk of age-related conditions.

## **From Science to Practice: What Trainers and Coaches Should Know**

For fitness professionals, this means workouts are more than programs for weight loss or strength—they're tools to shape long-term vitality. Guiding clients toward consistent, balanced training has benefits that reach down to the genetic level.

## **The Future of Fitness: Training for Genetic & Epigenetic Health**

The fitness industry is entering an era where training programs may be designed to optimise not just performance, but epigenetic health. Staying active could become the most powerful anti-ageing strategy available.

## Overall Synthesis & Themes

Following a review of papers published in 2025 and 2024 as well as other related papers, the current knowledge is:

### Support for epigenetic clocks / biomarkers:

Many studies use DNA methylation-based epigenetic clocks to quantify “epigenetic or biological age”, with **growing evidence that exercise/physical activity is associated with slower epigenetic aging.**

### Exercise reduces age acceleration / induces “younger” epigenetic profiles:

Both observational and some interventional studies show that **people who are more active, less sedentary, or have better cardiovascular fitness have epigenetic ages that lag behind chronological age** to a greater extent (i.e. slower ageing).

### Variability by tissue, exercise type, intensity, and individual:

The effects are not uniform across the human body. Differences show up depending on which tissue is measured (blood is most common; muscle and other organs are less frequently studied), what kind of exercise (aerobic, resistance, amount/intensity), and individual differences (genetics, baseline activity, age, etc.).

## Longitudinal evidence is still less abundant, but growing: :

Most studies only compare people at one moment in time, so they can say **exercise is linked to slower aging** but **cannot prove that exercise causes slower aging**.

Studies that track people over time (longitudinal studies) provide better evidence that staying active really slows aging, but scientists still need to rule out other influences (such as variations between test subjects in factors like diet, smoking or genetics) to be sure

## Gaps in mechanism:

While associations are clear, the molecular / causal pathways (how exercise causes epigenetic modifications, downstream effects on cell function, repair, senescence, etc.) are not fully elucidated. Also, reversibility/dose/duration/tissue specificity are still uncertain.

## Potential for exercise as geroprotective intervention:

These findings promote the idea that **exercise can be used deliberately to slow biological aging**, possibly to “rejuvenate” epigenetic markers, and improve healthspan.

However, moving from markers to functional outcomes (frailty, morbidity, mortality) remains a key challenge.

## Gaps, Limitations & Open Questions

The research to date has been promising, but many questions remain unanswered.

Two of the most pressing questions are:

**How long lasting are the epigenetic changes induced by exercise? Do they reverse quickly when exercise is stopped?**

**Which types, intensities, durations of exercise are optimal for slowing epigenetic ageing, and do different organs respond differently?**

# Papers reviewed for the preparation of this document

Zheng, X., Liu, X., Guo, Y. et al. **Physical exercise and epigenetic modifications in skeletal muscle, brain, and heart.** Epigenetics & Chromatin 18, 12 (2025). <https://doi.org/10.1186/s13072-025-00576-8>

Review synthesizing work (human / animal) on how exercise affects epigenetic features (DNA methylation, histone mods, non-coding RNAs etc.) in muscle, brain, heart.

**Key Findings:** Exercise induces epigenetic modifications in these organs; evidence of tissue-specific and exercise-type specific responses; suggests that some exercise regimens may help mitigate age-related epigenetic drift or changes

**Limitations:** Being a review, the data come from heterogeneous studies; not always longitudinal; many animal studies; human evidence is still sparser.

Kawamura T, Higuchi M, Radak Z, Taki Y. **Exercise as a geroprotector: focusing on epigenetic aging.** Aging (Albany NY). 2025 Jul 8; 17:1583-1589 . <https://doi.org/10.18632/aging.206278>

Perspective article: collates observational and interventional studies in humans and animals, focusing especially on DNA methylation clocks etc.

**Key Findings:** Observational studies show that higher cardiorespiratory fitness / more physical activity tends to correlate with slower epigenetic age acceleration; intervention studies show structured exercise can “rejuvenate” epigenetic measures, especially in blood & muscle. There is organ-specific and interindividual variability.

**Limitations:** Still many unknowns around causal mechanisms; magnitude of effect; what type/dose of exercise is optimal; how lasting effects are; which tissues matter most.

Nagata, M., Komaki, S., Nishida, Y. et al. **Influence of physical activity on the epigenetic clock: evidence from a Japanese cross-sectional study.** Clin Epigenet 16, 142 (2024). <https://doi.org/10.1186/s13148-024-01756-1>

Cross-sectional study among Japanese adults (age 40–69); measured physical activity (accelerometer) and epigenetic clocks (PhenoAge, GrimAge) in blood.

**Key Findings:** More objectively measured physical activity (less sedentary time, more moderate-vigorous physical activity) was associated with slower epigenetic age acceleration; sedentary time associated with faster epigenetic aging. Self-report measures were less reliable.

**Limitations:** Cross-sectional design limits causal inference; blood is accessible but not necessarily representative of other tissues/organs; effects size modest.

Zheng, H.T., Li, D.L., Lou, M.W.C. et al. **Physical activity and DNA methylation-based markers of ageing in 6208 middle-aged and older Australians: cross-sectional and longitudinal analyses.** GeroScience 47, 2263–2274 (2025). <https://doi.org/10.1007/s11357-024-01408-5>

Large sample (~6200), middle-aged/older Australians; both cross-sectional and longitudinal data; looked at DNA methylation based “markers” of aging / epigenetic ageing, physical activity.

**Key Findings:** Confirmed that higher physical activity associates with “younger” methylation-based age; longitudinally, PA seems to slow epigenetic ageing. Suggests physical activity may have protective or slowing effect over time.

**Limitations:** Its observational design (though the longitudinal component helps), opens the possibility of confounding; “younger” methylation age is a proxy, not a direct measure of function; variation by tissue type not fully addressed.

Nong, J., Wang, Y. & Zhang, Y. **Association between pace of biological aging and cancer and the modulating role of physical activity: a national cross-sectional study.** Clin Epigenet 17, 103 (2025). <https://doi.org/10.1186/s13148-025-01912-1>

Large (national) cross-sectional in China; looked at biological ageing (via epigenetics), cancer prevalence/risk, and how physical activity modulates this.

**Key Findings:** Found that faster biological/epigenetic aging is associated with higher cancer risk; physical activity appears to modulate (attenuate) this association. So PA might buffer some detrimental effects of accelerated epigenetic aging.

**Limitations:** Cross-sectional, so causality can't be firmly established; PA measured probably via self-report in some cases; cancer outcomes are varied; might have recall or reporting bias.