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Perspective

Prolonging the Lifespan of an Individual is Possible through a Number of Strategies

Scott Brown*

Department of Chemical and Systems Biology, Stanford University, Stanford, CA 94305, USA

DESCRIPTION

Extending lifespan, the duration of an individual's life, and health span, the period of life spent in good health, has been a longstanding goal in medical and scientific research. The activity of longevity involves understanding the underlying mechanisms of aging and developing interventions that can delay aging processes and mitigate age-related diseases. Here, we explore several key approaches that researchers are investigating to potentially extend human lifespan and improve overall health outcomes.

Genetic interventions

Genetic factors play a fundamental role in determining lifespan, influencing various biological processes that impact aging:

Longevity genes: Studies in model organisms like worms (*Caenorhabditis elegans*) and flies (*Drosophila melanogaster*) have identified specific genes, such as *Daf-2* (insulin/IGF-1 receptor) and *sir-2.1* (a histone deacetylase), that regulate lifespan. These genes are involved in metabolic regulation, stress response pathways, and cellular maintenance processes. Manipulating these genes in animal models has demonstrated significant extensions of lifespan, providing insights into potential genetic targets for human longevity.

Genome editing: Recent advancements in genome editing technologies, particularly CRISPR/Cas9, hold potential for manipulating genes associated with aging and age-related diseases. Researchers are exploring ways to modify genetic pathways involved in cellular senescence, DNA repair mechanisms, and mitochondrial function to promote healthy aging and potentially extend lifespan. While the application of genome editing in humans is still in its early stages, it represents a innovative approach to studying and potentially modulating the genetic determinants of longevity.

Caloric restriction and dietary interventions

Caloric Restriction (CR), reducing calorie intake without malnutrition, is one of the strongest interventions known to extend lifespan across a wide range of species:

Mechanisms of CR: Caloric restriction activates molecular pathways such as AMP-Activated Protein Kinase (AMPK) and sirtuins, which enhance cellular stress resistance, improve mitochondrial function, and promote longevity. Studies in animals, from yeast to mammals, consistently show that CR can delay the onset of age-related diseases and extend lifespan by up to 30%-50%. The metabolic and cellular adaptations induced by CR contribute to its anti-aging effects, making it a focus of ongoing research for its potential application in humans.

Dietary mimetics: Researchers are exploring calorie restriction mimetics—compounds that represent the effects of CR without the need for severe dietary restrictions. Examples include resveratrol (found in red wine), metformin (an anti-diabetic drug), and rapamycin (an mTOR inhibitor). These compounds activate similar pathways as CR, such as enhancing mitochondrial function and promoting cellular stress resistance. Clinical trials are underway to evaluate their efficacy in extending health span and lifespan in humans.

Pharmacological interventions

Pharmacological approaches to extending lifespan involve targeting specific biological pathways implicated in aging and age-related diseases:

Senolytics: Senescent cells accumulate with age and contribute to tissue dysfunction and inflammation. Senolytic drugs selectively eliminate senescent cells, thereby reducing the burden of these cells in tissues and improving overall health outcomes. Clinical trials are investigating senolytics for their potential to treat age-related conditions such as osteoarthritis, cardiovascular disease, and frailty. By targeting senescent cells, these interventions aim to restore tissue homeostasis and promote healthy aging.

Correspondence to: Scott Brown, Department of Chemical and Systems Biology, Stanford University, Stanford, CA 94305, USA, E-mail: sbrown@gmail.com

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Metformin: Metformin, a widely prescribed drug for type 2 diabetes, has gained attention for its potential anti-aging effects beyond its glucose-lowering properties. Metformin activates AMPK and enhances mitochondrial function, leading to improved metabolic health and potentially extending lifespan. Ongoing research is exploring metformin's effects on aging-related pathways and its potential to delay age-related diseases in humans.

Lifestyle interventions

Behavioral and lifestyle factors significantly influence aging processes and overall health outcomes:

Exercise: Regular physical activity has extreme benefits for health span and longevity. Exercise improves cardiovascular function, enhances cognitive function, and reduces the risk of chronic diseases such as diabetes and cardiovascular disease. Aerobic exercise and resistance training are particularly effective in maintaining muscle mass, metabolic health, and cognitive function with age. The mechanisms underlying exercise's anti-aging effects include promoting neuroplasticity, reducing inflammation, and enhancing mitochondrial biogenesis.

Intermittent fasting: Intermittent fasting, which involves alternating periods of fasting and eating, has emerged as another dietary strategy to promote longevity. Fasting induces metabolic and cellular adaptations, including enhanced autophagy (cellular recycling), reduced oxidative stress, and improved insulin sensitivity. Studies in animal models suggest that intermittent fasting can extend lifespan and protect against age-related diseases. Clinical trials are underway to investigate its potential benefits in humans.

CONCLUSION

Extending lifespan and improving health span are complex goals that require interdisciplinary collaboration and innovative approaches. By advancing our understanding of aging biology and translating scientific discoveries into practical interventions, researchers aim to enhance the quality of life for aging populations and reduce the burden of age-related diseases globally. Continued research and public engagement are essential for addressing the challenges and opportunities in extending lifespan and promoting healthy aging in the 21st century.