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Factors Affecting Healthy Aging and Its Interconnected Pathways

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ABSTRACT

The process of aging is influenced by factors across different aspects of life including biology, lifestyle, and the surrounding environment. As the global population continues to age it is crucial to understand the complexities involved in maintaining the health and quality of life of adults. This article offers an overview of the dimensions of aging by examining the key factors and demonstrating how they are interconnected in shaping the aging process. Biological factors play a role at molecular and systemic levels. Lifestyle choices also have an impact with regular physical activity, a balanced diet, sufficient sleep, and cognitive engagement all contributing to overall well-being.

Social support networks, community resources and access to healthcare services are environmental factors that also influence healthy aging trajectories. In addition, socioeconomic circumstances contribute to disparities in aging outcomes with individuals from poorer backgrounds often facing greater challenges in accessing resources and healthcare services. Genetic predisposition can play a role in determining how well we are with certain genes and molecular pathways associated with age related diseases that can affect longevity.

In order to comprehensively explore the literature on aging, this study employed the methodological approach of a scoping review to identify topics and evidence types, and also a rapid review to systematically map current knowledge. This combination provides a focus on qualitative summaries rather than exhaustive analysis and enabled a systematic search for relevant papers while ensuring rigorous screening processes for categorizing and synthesizing the findings. It involved searching the PubMed database by scanning titles and abstracts for relevance and then organizing information based on the dominant themes. A qualitative analysis of the evidence was then carried out, related to the concept of healthy aging, while also identifying gaps in the research.

The result is an overview of the evidence surrounding aging and areas that require investigation. To summarize, this innovative approach using scoping and rapid review methodologies enabled a systematic mapping of current knowledge about aging. By examining these factors, and understanding their interconnectedness, approaches can be developed that will be effective in helping to promote healthy aging and thereby enhance the quality of life for older adults. This article aims to provide insights into the influencers of the aging process while also highlighting potential avenues for future research and interventions.

Keywords: Healthy aging, lifestyle choices, environmental factors.

Introduction

The aging process has become a focal point in medical research attracting the attention of scientists from various disciplines. The aim is to understand the underlying mechanisms that promote well-being as people grow older. With increasing life expectancies, it has become crucial to identify strategies that can extend the years of good health and enhance the quality of life during a person's later years. This phenomenon, which is complex and multifaceted, requires an approach that integrates insights from biology, psychology, sociology, and public health.¹

While chronological aging simply refers to the passage of time, healthy aging goes beyond that by focusing on preserving functionality and promoting well-being. This distinction recognizes that individuals can still age successfully even with a decline in physiological function associated with age.²

What does it mean to be healthy, in old age? How can we achieve it? Conceptual models of aging emphasize the importance of avoiding diseases while maintaining cognitive abilities and nurturing engagement and well-being.³ Rowe and Kahn's influential model classify adults into three categories: agers, who experience disease and disability; frail but surviving individuals, who have chronic conditions but maintain functionality; and ideal agers, who prevent disease and disability through health promoting behaviours.² Expanding on this framework, multidimensional models recognize factors that affect outcomes, such, as personal growth, and life satisfaction.¹

Attaining a healthy life requires a "longevity dividend" by delaying the onset and progression of age-related conditions to shorten the period of illness in stages of life.⁴ However, aging follows paths influenced by psychological, behavioural, and socioeconomic factors. Understanding this complexity is crucial for promoting healthy aging.

Exploring the realm of physiology unravels the workings behind maintaining health as people age. Studies examining changes in the size, shape and pumping function of the ventricle offer information about how cardiac physiology changes with age and its impact on cardiovascular health in older individuals. Neurophysiological changes also occur as people age and can have an impact on functions such as memory and attention.⁵

Research focusing on event related potentials, theta oscillations and resting state electroencephalography power provides insights into how these neurophysiological processes relate to aging and gives an understanding of brain function in older adults.⁶ Additionally, researchers are interested in understanding the role of neurotransmitters and neuromodulators in aging. Studies exploring dopamine, serotonin and other neurotransmitters delve into their influence on motivation, cognition, and emotional well-being among individuals.⁷

Research has discovered determinants of successful aging trajectories encompassing genetic factors as well as lifestyle choices. For instance, certain gene variants, in the Apolipoprotein E (APOE) and FOXO3A genes are linked to longevity.^{8,9} Hormonal changes play a role in aging physiology within the endocrine system. Studies investigate alterations in hormone levels like testosterone and oestrogen and their effects on aspects of health as well as conditions associated with aging.¹⁰ Moreover, extensive research on mitochondria function, cellular metabolism and oxidative stress can offer insights into the cellular processes that drive the aging process and determine lifespan.¹¹

As the global population continues to age it becomes increasingly important to prioritize well-being and independence in all stages of life. This goal has implications for individuals, communities, healthcare systems and economies. Achieving this requires research that unravels the underlying principles of healthy aging and by integrating insights with cognitive, behavioural, and sociocultural perspectives, scientists can gain a deeper understanding of the complex factors that shape the aging process. Such discoveries will inform practices and public health initiatives aimed at improving health outcomes throughout one's lifetime. The study of aging has evolved from scientific curiosity to a

global priority with extensive benefits for humanity. This study offers an exploration of aging to shed light on promising avenues in this critical area of research.

Method

A systematic scoping review was used to identify, categorize and map research studies. An extensive search was conducted on the PubMed database in January 2024 using the search term "healthy aging." The types of studies that were considered included qualitative research papers such as randomized controlled trials, cohort studies, cross sectional studies and systematic reviews. The screening process involved assessing the relevance of each study to the topic of aging and its potential contribution to our understanding of factors that influence longevity and well-being among adults. To be included in the analysis, studies had to be research articles, review papers or meta-analyses exploring lifestyle and socio-environmental determinants of aging. We excluded studies that focused solely on age related diseases or conditions unless they offered insights into aspects of healthy aging.

The initial search yielded a substantial 15,810 results, forming the foundational pool of literature for the review. To refine and focus the dataset, a series of filters were applied and included restricting the results to English language, human studies, and full-text articles. These sequential filters progressively narrowed down the search results to a curated set of 11,091 relevant articles.

PubMed has an export limit of 10,000 citations per search, so a strategic approach was adopted. The first 10,000 articles, sorted alphabetically by title, were exported into RefWorks. Simultaneously, to capture additional relevant articles beyond this limit, the remaining articles (1,200) were exported in reverse alphabetical order. Within RefWorks, a de-duplication process was undertaken to eliminate redundancies, resulting in a final dataset of 9,944 unique articles. The dataset was then transferred to Microsoft Excel, streamlining further screening and analysis.

During the screening phase, articles were filtered to include only those containing the term "healthy aging" in any search field. This refined the dataset to a focused 1,376 articles. The subsequent manual review by the research team involved scrutinizing titles and abstracts, leading to the categorization of study topics and the grouping of articles into key areas. This is presented in Table 1.

This meticulous process led to the identification of 17 focus areas in healthy aging research. These areas span a diverse range, including but not limited to nutrition, physical activity, cognitive health, social and environmental, genetics and physiology of healthy aging. Subsequently, these categories were consolidated into 10 overarching themes, which are expounded upon in this review.

Data synthesis involved thematic analysis to identify recurring themes and patterns across the literature. Key findings were synthesized to elucidate the interconnectedness of several factors influencing healthy aging, including physical activity, nutrition, sleep, cognition, genetics, socio-environmental factors, and biomarkers. The synthesis aimed to provide a comprehensive overview of the current state of knowledge on healthy aging and highlight gaps and areas for future research.

Table 1. Frequency table of articles after initial categorization

Category based on article title	Number of articles
Cardiovascular Health	21
Longevity	18
Sleep and healthy aging	22
Healthy aging models	24
Physiology of healthy aging	57
Molecular aspects of healthy aging	59
Physical activity in healthy aging	51
Technology in healthy aging	22
Biomarkers	33
Brain and Neurological aspect of healthy aging	143
Social and environmental contributors	73
Cognitive aspect of healthy aging	82
Measures and indices	29
Comorbidities in Healthy aging	32
Genetics of healthy aging	50
Diet and nutrition	99
Others	561
Total	1376

Data Extraction

We selected 14 full-text articles spanning various categories for data extraction. This decision was based on careful consideration of practical factors, the complexity and depth of each theme, the availability of literature, and their relevance to the aims of this study. Our objective was to ensure a comprehensive representation across all categories. The inclusion and exclusion criteria applied are outlined below.

Inclusion Criteria:

1. Articles must directly address one or more aspects of healthy aging, encompassing topics such as nutrition and diet, physical activity, cognitive function, genetic and molecular aspects, cardiovascular health, biomarkers and neuroimaging, sleep, longevity, physiology, and social/environmental factors.
2. Articles must be published in peer-reviewed journals to ensure the quality and reliability of information.
3. Articles must have been published within the last 10 years.
4. Articles must be available in English.
5. Articles must be accessible through institutional subscriptions, open-access journals, or reputable databases to ensure availability for review.

Exclusion Criteria:

1. Articles not directly related to any aspect of healthy aging, or the specified themes will be excluded.
2. Articles from non-peer-reviewed sources such as magazines, blogs, or non-academic websites will be excluded.
3. Articles published more than 10 years ago will be excluded.
4. Articles not available in English.
5. Non-research articles such as editorials, commentaries, letters, and opinion pieces will be excluded.

The selected studies for extraction are as follows: ^{4,5,12-23}

Results

A manual thematic analysis was conducted on the entirety of the selected articles, organizing them below according to factors associated with healthy aging.

Themes in Healthy Aging

Nutrition and Diet

Maintaining good nutrition and diet are crucial for healthy aging. These practices help the body's cells to function properly, prevent age related diseases, preserve abilities, and enhance well-being as we grow older. It is important to consume sufficient amounts of nutrients like vitamins, minerals, antioxidants, and macronutrients. These nutrients play a role in repairing cells by reducing inflammation, and protecting against stress and in so doing, can help prevent age related decline and diseases.¹² They can be obtained from consuming dense foods such as fruits, vegetables, whole grains, lean proteins, and healthy fats. For adults, it is especially important to ensure protein intake. Including high quality protein sources like meat, fish, poultry, eggs, dairy product legumes, and nuts, in the diet can help maintain muscle mass and strength. Additionally, protein helps support bone health and promotes functioning.

Micronutrients like vitamin D, calcium and B vitamins play a role in maintaining bone health, cognitive function, and cardiovascular health as people age. Dietary patterns such as the Mediterranean Dietary Approaches to Stop Hypertension (DASH) and Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND) diets have been shown to provide health benefits. These include reducing the risk of disease, improving cognition, and promoting longevity. It is important for older adults to stay properly hydrated as dehydration can worsen age related conditions. Encouraging them to drink water, tea and consume hydrating foods is crucial. However, even though nutrition plays a role, various barriers like changes in appetite, taste preferences and socioeconomic factors can also affect the dietary intake of adults.¹⁴

By addressing these challenges through nutrition education, counseling, and community programs we can optimize their status (Figure 1).

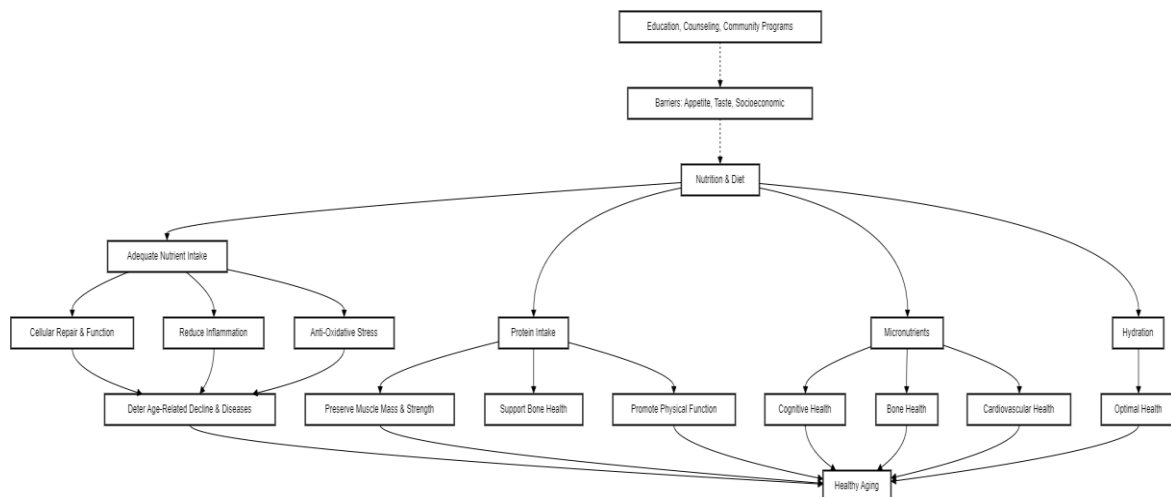


Figure 1. Diagram Showing the Relationship Between Nutrition, Diet, and Healthy Aging.

Physical Activity and Fitness

Engaging in activity offers a wide range of benefits for older individuals. It improves general health, enhances muscle strength, boosts balance and increases flexibility. Aerobic exercises, for example, play a role in maintaining fitness and reducing the risk of chronic diseases as well as enhancing mobility. Strength training is also vital as it helps preserve muscle mass and bone density consequently lowering the chances of falls and fractures.¹⁴

Physical activity positively impacts on function and the mental well-being of adults. Exercise has been shown to enhance memory, attention span and overall cognitive abilities. Additionally, it triggers the release of endorphins that can reduce the risks of depression and anxiety.

Fitness plays a role in aging by encompassing both cardiovascular endurance and muscular strength. By maintaining or improving fitness levels through exercise routines, older adults can experience enhanced cognitive health while improving functionality. Assessments such as the 6-minute walk test for endurance or grip strength evaluations for fitness can measure one's level of fitness accurately.

Incorporating activity into life is key for older adults to reap its benefits. Even moderate exercises like walking when done consistently can have positive effects on health. It is important to choose activities that are sustainable over time to ensure adherence to exercise regimens. Promoting activity among adults requires addressing various barriers such as access to facilities or transportation limitations while also providing social support systems. Community programs offering specialized classes that are tailored to need and personalized exercise plans can help overcome these barriers.¹²

To sum up, it is evident from Figure 2 (below) that engaging in activity and maintaining fitness levels have an impact on promoting healthy aging. This is because they enhance not only the well-being but also the cognitive and emotional aspects of a person's life. Taking part in exercise, actively encouraging fitness and removing any barriers that hinder participation are crucial factors for individuals to age actively and healthily.

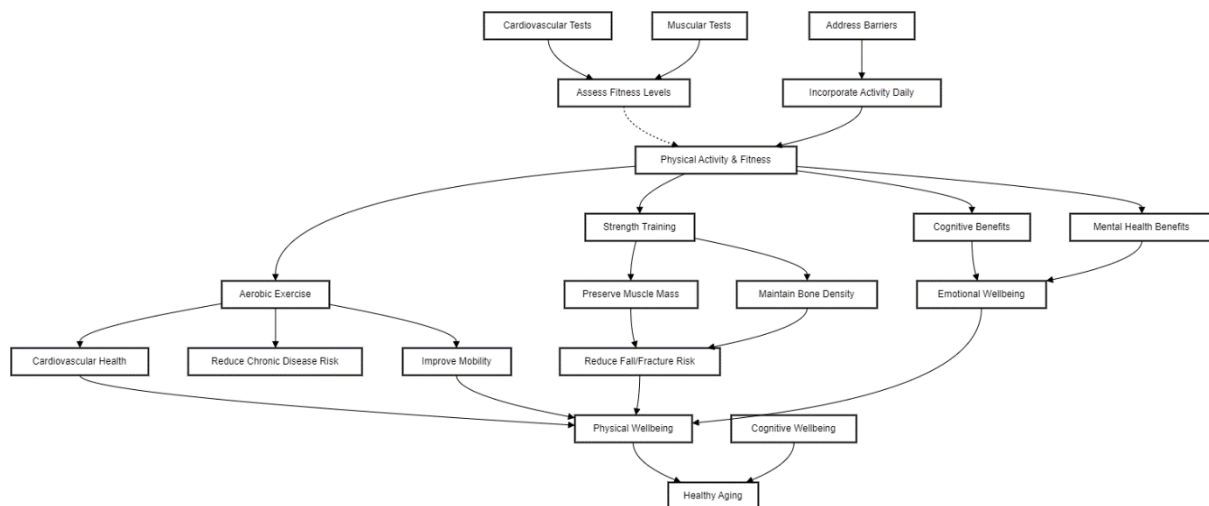


Figure 2. Physical Activity, Fitness, and Healthy Aging

Cognitive Function and Healthy Aging

Maintaining function is crucial for maintaining independence and a high quality of life as people grow older. When it comes to aging, it is important to preserve abilities and be able to adapt to changes in the aging brain. Extensive research has shown that the relationship between cognition and healthy aging is multifaceted, influenced by factors such as genetics, lifestyle choices and socioeconomics. By using neuroimaging techniques and studying biomarkers researchers have gained insights into the processes underlying cognitive decline and mental well-being in older adults.

Neurobiological changes such as reductions in brain volume alterations in neurotransmitter activity and changes in connectivity can significantly impact cognition leading to decline. Lifestyle choices like engaging in activities or maintaining social connections along with a balanced diet, a regular exercise routine and managing cardiovascular health have been associated with better late life cognition outcomes. Education, occupation and engaging in activities help to develop cognitive resilience, which acts as a protective buffer against cognitive decline. Stress, depression, and anxiety have an impact on cognition. Managing health effectively contributes to the preservation of abilities.

Involvement in training programs enhances cognition and regular exercise, such as aerobic and resistance training, is associated with cognition, brain plasticity and reduced risk of decline. Following a good diet, getting enough sleep, managing stress effectively and refraining from substances like alcohol and tobacco are important factors that support cognitive health. Maintaining connections and participating in activities that provide stimulation also contribute to emotional well-being as well as cognitive health.

Promoting a healthy lifestyle has implications for enhancing overall well-being and independence while mitigating age related decline in cognitive function.

Genetic and Molecular aspects of Healthy Aging

Various genetic variations, such as Single Nucleotide Polymorphisms (SNPs) and copy number variations have been associated with longevity, cognitive abilities, and resilience to diseases in the context of aging. Genes related to inflammation oxidative stress and mitochondrial function have shown connections with aging traits. Epigenetic modifications like DNA methylation patterns play a role in regulating gene expression and cellular function during the aging process.

Senescence, mitochondrial dynamics and inflammatory signalling pathways influence how aging manifests itself and impacts on susceptibility to diseases. Imbalances between inflammatory and anti-inflammatory signals can accelerate cellular aging and increase the risk of age-related diseases. Additionally, mitochondrial biogenesis as fusion and fission processes affects cellular energy metabolism and resilience against stress.¹⁷

Maintaining health is a crucial aspect for aging and includes aspects such as glucose metabolism regulation, lipid profiles management and controlling oxidative stress levels. Dysfunctional metabolic pathways are linked to accelerated aging processes and higher risks of developing diseases. Factors such as diet choices, regular exercise routines, lifestyle changes along with the gut microbiota composition all contribute to modulating metabolic functions for promoting health outcomes.¹³

Lifestyle changes that improve metabolic health and decrease inflammation may also lessen the impact of age-related diseases. Additionally, pharmacological therapies can also be explored to enhance cognition abilities while improving wellbeing during stages of life.²⁰

Gaining an understanding of how genetics, biology and metabolism interact is crucial, in comprehending and fostering cognitive function metabolic health and overall well-being as people get older. Understanding the factors involved along with the mechanisms and metabolic determinants of

healthy aging provide insights for targeted interventions. These include personalized nutrition plans that are tailored to an individual's needs or specific exercise regimen.

Cardiovascular health in Healthy Aging

Maintaining good health is crucial for overall well-being and longevity as people get older. It is important to make changes that support cardiovascular function to help achieve it. When it comes to aging, lifestyle factors such as activity, nutrition and stress management play a role in influencing cardiovascular health. Exercise helps maintain blood pressure, improve circulation, and enhance the functioning of the heart while aerobic exercises and strength training activities are beneficial for promoting fitness and vitality.

A balanced diet that includes plenty of fruits, vegetables, whole grains, lean proteins, and healthy fats provides the nutrients and antioxidants to support heart health. It is also important to limit processed foods, sugary drinks, and sodium intake to prevent hypertension and cardiovascular issues. Taking care of well-being by managing stress is another aspect of maintaining good cardiovascular health. Chronic stress can contribute to an increased risk of hypertension and heart disease and practicing relaxation techniques such as meditation or mindfulness, can help reduce stress levels.¹⁵

Regular medical check-ups and screenings are essential for adults to monitor certain risk factors such as blood pressure as well as cholesterol and blood sugar levels. Early intervention based on these assessments can help prevent the progression of heart disease. Additionally, genetic factors, family history, existing conditions such as diabetes or obesity also influence cardiovascular health as people age. Providing care that considers these individual risk factors is key to promoting healthy aging and enhancing quality of life. It involves making lifestyle changes, engaging in activities, maintaining a diet, managing stress levels, and seeking appropriate medical attention when needed.

Biomarkers and Neuroimaging in Healthy Aging

Research conducted on aging has utilized neuroimaging techniques to gain valuable insights into the underlying biological processes related to aging and age-related cognitive decline. Biomarkers serve as indicators of conditions and they provide information about processes, disease risks and overall health status associated with healthy aging. Neuroimaging methods, like magnetic resonance imaging (MRI) and positron emission tomography (PET), enable researchers to visualize and measure changes in brain structure and function.²³

Neuroimaging techniques, such as structural MRI studies, have revealed age related modifications in brain volume, thickness and white matter integrity in regions associated with memory, executive function, and attention. Functional MRI (fMRI) studies have shown alterations in brain activation patterns and connectivity networks during tasks providing insights into the mechanisms behind cognitive aging.¹⁸

In terms of biomolecules related to brain aging and neurodegeneration risk, researchers have extensively studied the association of alpha synucleins with these phenomena. Inflammatory markers, like C reactive protein, have been extensively studied to understand their role in aging and their correlation with indicators of aging. This research has provided insights into the impact of inflammation. Metabolic markers, such as plasma acylcarnitines, can offer information about age related metabolic changes that may affect well-being. Vascular health markers, like lipoprotein(a) and interleukin 38, are being investigated to identify individuals who may be at risk for complications related to aging.

Long term studies have demonstrated that alterations in biomarker levels and neuroimaging measures can predict decline and the development of dementia. Moreover, combining biomarkers and

neuroimaging measures referred to as biomarker profiles or signatures, has shown promise in improving the accuracy of detection and prediction of cognitive decline.²³

These methods have the potential to identify signs of aging by detecting changes in biological markers and brain structure/function even before clinical symptoms appear. Through the analysis of biomarkers and neuroimaging measures, early indicators of cognitive decline associated with age and neurodegenerative diseases like Alzheimer's Disease, can be pinpointed.

Sleep and Healthy Aging

Sleep is a fundamental pillar, playing a crucial role in maintaining physical, cognitive, and emotional well-being as individuals advance in age. Adequate and restorative sleep is essential for supporting various physiological processes and promoting overall health throughout the aging process.

During sleep, the body undergoes important processes involved in tissue repair, muscle growth, and hormone regulation. Adequate sleep is essential for memory consolidation, supporting immune function and promoting physical resilience, particularly in older adults who may be more susceptible to illness and injury. Chronic sleep deprivation can impair immune function, increase inflammation, and compromise physical health, leading to an increased risk of chronic diseases and age-related conditions. It can also accelerate cognitive decline and increase the risk of developing neurodegenerative diseases such as Alzheimer's Disease and dementia. By prioritizing adequate and restorative sleep, individuals can support their own physical health and healthy aging.¹⁶

The COVID-19 pandemic shone a light on the relationship between sleep problems and psychological distress. Changes in sleep patterns and quality are common in aging and alterations in the circadian rhythm can affect sleep-wake cycles that cause stress and anxiety that may further affect mental wellbeing. Therefore, understanding the sleep-aging relationship is key for optimizing health in older adults.

Longevity and Healthy Aging

Longevity is not only about living for a long time but also about enjoying a good quality of life with vitality. Healthy aging emphasizes the importance of maintaining cognitive and emotional well-being as we grow older.⁴ To achieve both longevity and healthy aging it is necessary to consider factors that contribute to health and well-being throughout our lives.

Understanding the cellular mechanisms that lie behind aging and longevity is crucial in developing strategies to promote healthy aging. Research studies, such as the Longevity Study of Healthy Aging (CRELES), have examined telomere length over time to better understand its significance in the process of aging and longevity.²²

Adopting a good lifestyle is one element for promoting both longevity and healthy aging. This includes engaging in physical activity, maintaining a balanced diet, managing stress effectively, getting sufficient sleep, and staying socially engaged. Regular exercise helps preserve muscle mass, health, and cognitive function. All these approaches help promote healthy longevity while reducing the risk of age-related conditions such as disease, diabetes, or cognitive decline.

The study of individuals who have reached a great age and beyond provides insights into the secrets of healthy longevity. Addressing the challenges requires an approach that encompasses genetics, molecular biology, nutrition, exercise, as well, as community interventions. Increasing understanding of the underlying mechanisms can guide strategies aimed at improving the lifespan and quality of life as people grow older.

Physiology of Healthy Aging

Gaining an understanding of the process of aging involves studying aspects of how our bodies function and change as we get older and how this affects overall health and well-being.

One area of focus for researchers is on metabolic rate and oxidative damage. Studies like the Louisiana Healthy Aging Study examined resting metabolic rate changes as people aged and its connection to stress. It is well known that performance undergoes alterations during the aging process and changes in size, geometry, and pump function affect cardiac physiology and cardiovascular health in individuals as they age.

Neurophysiological changes which occur affect functions like memory and attention. Studies on event related potentials, theta oscillations and resting state EEG help us understand these aspects of aging and provide valuable insights into brain function in older adults.⁵

Hormonal changes are also a part of aging physiology within the endocrine system and numerous studies have delved into the effects of hormone levels like testosterone and estrogen. There is also interest in understanding the role of neurotransmitters and neuromodulators. Studies examining dopamine, serotonin and other neurotransmitters have uncovered how they influence motivation, cognition, and emotional well-being among individuals. Furthermore, investigations into dynamics, cellular metabolism and oxidative stress provide insights into the cellular processes that drive aging and longevity. Understanding these mechanisms is crucial for developing interventions that can promote healthy aging and extend the lifespan.

Physiology has played an important role in unraveling the mechanisms behind healthy aging. This knowledge serves as a foundation for devising and implementing strategies that improve quality of life during the aging process.

Social and Environmental factors affecting Healthy Aging

Aside from genetics and biology, external elements such as social and environmental factors play a role. This includes the environment surrounding individuals, the structures they live in and their exposure to pollutants. Social factors include support networks people have access to, their status, healthcare availability and cultural norms.¹⁹

The influence of environmental factors on aging can be both direct and indirect. For instance, the quality of air and water that people are exposed to as contact with harmful substances contained in either of them can directly affect physical health and contribute to age related illnesses. Certain environmental stressors like noise pollution or overcrowding can indirectly impact feelings of well-being.

Social factors such as having access to social support networks and active community engagement provide support, companionship and opportunities for interaction and physical activity. Older adults who experience isolation or lack connections face a higher risk of depression, cognitive decline, and overall poorer health outcomes.

People from poor socioeconomic backgrounds often encounter greater obstacles when it comes to accessing healthcare services, nutritious food choices, safe living environments as well as preventive healthcare services. They receive lower quality care and have higher rates of chronic conditions like diabetes, hypertension, and cardiovascular disease.²⁴ Socioeconomic disparities can intersect with determinants of health such as race/ethnicity, gender identity and education level. This intersection further amplifies existing health inequalities. For instance, older individuals belonging to racial and ethnic minority groups face an impact from socioeconomic disparities. They encounter obstacles due to discrimination, cultural barriers and systemic inequalities in healthcare access and quality.

To address the disparities in aging, a comprehensive approach is needed. This should encompass policy interventions at the level of community-based initiatives and individual level interventions. Policies that focus on reducing socio inequalities and improving healthcare access while creating age environments can play a crucial role in mitigating disparities and promoting healthy aging for everyone regardless of their socio-economic status. Community-based programs that offer support, provide affordable healthcare services as well as opportunities for physical activity and social engagement can empower older adults to age healthily and thrive within their communities. By comprehending the interactions between factors, social factors, and individual characteristics, we can design targeted interventions to foster healthy aging worldwide while reducing health disparities among older adults.

Discussion

This review provides a thorough exploration of the factors involved in aging in a healthy manner. These factors encompass changes, in biology, lifestyle choices and environmental influences.

As people age, various physiological changes occur that include alterations in brain structure, hormone levels, immune function, and sensory perception. These changes can impact health, metabolic function, immune response, and sensory abilities. It is important to note that these changes are interconnected within the body's systems and influence health and well-being. Understanding these interconnected changes is crucial for promoting healthy aging.

Changes in brain structure, for example, such as a decrease in brain volume or shifts in connectivity may contribute to cognitive decline. However, there are strategies commonly used to support aging that can address these issues effectively. These strategies include engaging in stimulating activities, maintaining physical activity routines, staying up-to-date on vaccinations and routine check-ups while following a balanced diet plan. These approaches not only promote health but also have positive effects on various physiological domains.

In addition, hormonal fluctuations occur as part of the aging process which influence aspects of health such as metabolism regulation, bone density maintenance, muscle mass preservation and cognitive function support.

As individuals age, hormonal imbalances may require hormone replacement therapy and the natural decline of bone density and muscle mass can lead to health risks like osteoporosis and sarcopenia. It is essential for older individuals to incorporate interventions such as resistance training, regular consumption of calcium and vitamin D and engaging in weight bearing exercises to maintain health and counteract the decline in bone density and muscle mass. Changes in hormone levels, including decreases in oestrogen and testosterone along with alterations in insulin sensitivity, can impact metabolic health and potentially result in weight gain. These metabolic changes are closely connected with lifestyle factors such as diet and physical activity highlighting the importance of both processes and lifestyle choices for aging.

Moreover, the immune system undergoes changes as individuals age that can affect its ability to respond effectively to infections while increasing the risk of developing various conditions. Older adults often experience alterations in function characterized by reduced responsiveness to infections and vaccines, increased inflammation and impaired wound healing. Embracing a lifestyle that includes exercise, proper nutrition and effective management of chronic conditions can strengthen immune function while reducing the risk of infectious diseases and inflammatory conditions.

It is important that older adults prioritize regular check-ups and take measures such as using hearing aids and corrective lenses to maintain sensory health as they are closely linked to health and well-being. The way the digestive system functions also undergoes changes as people get older that can affect absorption and the time it takes for food to pass through the tract. Diet and physical activity

influence health through the connections between what people eat, how active they are and the well-being of their gastrointestinal systems.

Managing stress levels, nurturing connections, staying engaged in activities, and prioritizing mental and emotional well-being are all crucial aspects of a comprehensive approach to healthy aging. It is important to recognize that these psychosocial factors are intertwined with processes and lifestyle behaviours; therefore, addressing emotional, social, and well-being factors, alongside physical health, is vital. Social interactions and environmental factors directly influence aspects of health including function and sleep quality.

Psychosocial factors also influence eating habits, nutritional well-being and levels of activity. It is interesting to note that there is a relationship between environmental factors and both longevity and cardiovascular health. For instance, individuals who have support networks and live in healthy environments tend to have better cardiovascular health and may even experience longer lifespans.

When exploring all the factors and their connections to health as people age, it became clear that the relationship is complex and multifaceted. Genetic predispositions, lifestyle choices and socio-economic status all contribute to the intricacies of aging and mental well-being. Through studies using biomarkers and neuroimaging techniques, scientists have gained insights into the underlying biological processes involved in cognitive decline among older adults as well as their mental health outcomes. Exploring factors such as amyloid burden, cerebral oxygen utilization and blood flow patterns in the brain enables researchers to better understand the implications of aging healthily.

Disparities in socio status can intersect with social determinants of health such as race/ethnicity, gender identity and education level, thus further exacerbating inequities in healthcare access and quality. Older adults from racial/ethnic minority groups are particularly susceptible to socio disparities while also facing challenges related to discrimination, cultural barriers, and systemic inequalities when it comes to accessing healthcare services.

This review strongly indicates the interconnectedness between factors that influence healthy aging (Figure 3). For example, cardiovascular health, physical activity, diet, and sleep all affect each other. Lifestyle choices such as being physically active, maintaining a healthy diet and getting quality sleep not only impact cognitive function but also contribute to cardiovascular health and longevity. Additionally, genetic and molecular factors intersect with physiology, biomarkers, cognition and other aspects of aging.

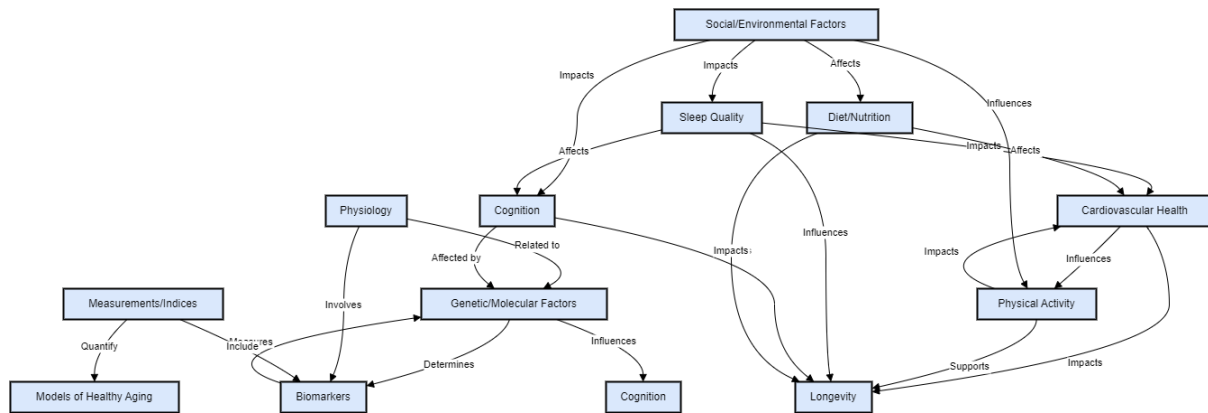


Figure 3. Interconnection of Healthy Aging Themes

Achieving a state of healthy aging requires an approach that considers the interactions between biology, lifestyle, and social/environmental factors. Adopting a way of life that manages stress, nurtures connections and addresses the social determinants of health will enable individuals to optimize their well-being and overall health.

Understanding the transformations associated with aging and the interconnectedness among the factors involved, provides valuable insights for adjusting lifestyles, developing targeted interventions, and creating models that promote healthy aging encompassing all aspects of well-being.

Conclusion

This review article has discussed findings about aging in a healthy manner across different areas. The interconnectedness between physiological, lifestyle and social/environmental factors and how they interact in complex ways has been highlighted.

These findings strongly indicate the importance of taking an inclusive approach in research and interventions to promote healthy aging. Understanding how different factors are interconnected is crucial for developing strategies that enhance the quality of life and well-being of adults. For instance, when addressing decline, interventions should consider not only genetic and molecular factors but also aspects like physical activity, diet, and sleep patterns.

This review underscores the need for collaboration and a holistic approach when dealing with the nature of healthy aging. Researchers, healthcare professionals, policymakers and community stakeholders must come together to develop interventions that cover nutrition, physical activity, mental stimulation, social engagement, and preventive healthcare. Addressing the multifaceted aspects of aging as a whole picture rather than isolated parts will enable better support for older adults in maintaining their physiological health, along with their cognitive abilities and emotional well-being, as they age.

Recommendations for Further Research

After a thorough exploration of the existing literature, several noteworthy gaps and areas for future research have emerged. Understanding these gaps is crucial for advancing knowledge of healthy aging and developing more targeted interventions. Here are key recommendations for future research directions and methodologies:

1. **Longitudinal Studies on Interconnected Factors:** Conducting long-term studies that track individuals across various age groups is essential. This will help unravel the complex interplay between different factors such as physical activity, nutrition, cognitive health, and socio-environmental influences over time.
2. **Diverse Population Representation:** There is a need for more inclusive research that involves diverse populations. Including individuals from different ethnicities, socioeconomic backgrounds, and geographical locations will contribute to a more comprehensive understanding of healthy aging and ensure that interventions are applicable to a broader range of individuals.
3. **Intervention Studies:** Future research should focus on intervention studies that explore the effectiveness of targeted strategies for healthy aging. This includes personalized approaches based on genetic and molecular markers, socio-economic status, and individual health profiles.
4. **Technology Integration:** Investigate the role of technology in promoting healthy aging. This includes exploring the impact of digital interventions, wearable devices, and telehealth solutions on physical activity, cognitive function, and overall well-being in older adults.
5. **Comprehensive Biomarker Panels:** Develop comprehensive biomarker panels that capture the diverse aspects of aging, including genetic, molecular, and physiological markers. This will aid in creating more accurate models for predicting and assessing healthy aging.
6. **Knowledge Translation:** Emphasize knowledge translation strategies to bridge the gap between research findings and practical applications. This involves developing clear guidelines and resources that can be easily understood and implemented by older adults, healthcare professionals, and caregivers.
7. The effect of the **menopause issues** on women's health and aging particularly for ethnicities may be an important topic for future research in Turkey.

References

1. López-Otín C, Blasco MA, Partridge L, Serrano M, Kroemer G. The hallmarks of aging. *Cell*. Jun 6 2013;153(6):1194-217. doi:10.1016/j.cell.2013.05.039
2. Depp CA, Jeste DV. Definitions and predictors of successful aging: a comprehensive review of larger quantitative studies. *Am J Geriatr Psychiatry*. Jan 2006;14(1):6-20. doi:10.1097/01.JGP.0000192501.03069.bc
3. Rowe JW, Kahn RL. Successful aging. *Gerontologist*. Aug 1997;37(4):433-40. doi:10.1093/geront/37.4.433
4. Urtamo A, Jyväkorpi SK, Strandberg TE. Definitions of successful ageing: a brief review of a multidimensional concept. *Acta Biomed*. May 23 2019;90(2):359-363. doi:10.23750/abm.v90i2.8376
5. Jabès A, Klencklen G, Ruggeri P, Antonietti JP, Banta Lavenex P, Lavenex P. Age-Related Differences in Resting-State EEG and Allocentric Spatial Working Memory Performance. *Front Aging Neurosci*. 2021;13:704362. doi:10.3389/fnagi.2021.704362
6. Lakatta EG, Levy D. Arterial and cardiac aging: major shareholders in cardiovascular disease enterprises: Part I: aging arteries: a "set up" for vascular disease. *Circulation*. Jan 7 2003;107(1):139-46. doi:10.1161/01.cir.0000048892.83521.58
7. Veldhuis JD. Aging and hormones of the hypothalamo-pituitary axis: gonadotropic axis in men and somatotrophic axes in men and women. *Ageing Res Rev*. Jul 2008;7(3):189-208. doi:10.1016/j.arr.2007.12.005
8. Olshansky SJ, Goldman DP, Zheng Y, Rowe JW. Aging in America in the twenty-first century: demographic forecasts from the MacArthur Foundation Research Network on an Aging Society. *Milbank Q*. Dec 2009;87(4):842-62. doi:10.1111/j.1468-0009.2009.00581.x
9. Brooks-Wilson AR. Genetics of healthy aging and longevity. *Hum Genet*. Dec 2013;132(12):1323-38. doi:10.1007/s00439-013-1342-z
10. Garrett M. The Handbook of Aging and Cognition by F. I. M. Craik and T. A. Salthouse, eds. *Activities, Adaptation & Aging*. 11/30 2009;33:267-268. doi:10.1080/01924780903295796
11. Mather M, Harley CW. The Locus Coeruleus: Essential for Maintaining Cognitive Function and the Aging Brain. *Trends Cogn Sci*. Mar 2016;20(3):214-226. doi:10.1016/j.tics.2016.01.001

12. Arem H, Moore SC, Patel A, et al. Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship. *JAMA internal medicine*. 2015;175(6):959-967.
13. Biagi E, Franceschi C, Rampelli S, et al. Gut Microbiota and Extreme Longevity. *Curr Biol*. Jun 6 2016;26(11):1480-5. doi:10.1016/j.cub.2016.04.016
14. Brancaccio M, Mennitti C, Cesaro A, et al. The Biological Role of Vitamins in Athletes' Muscle, Heart and Microbiota. *Int J Environ Res Public Health*. Jan 23 2022;19(3)doi:10.3390/ijerph19031249
15. Darooghegi Mofrad M, Naghshi S, Lotfi K, et al. Egg and Dietary Cholesterol Intake and Risk of All-Cause, Cardiovascular, and Cancer Mortality: A Systematic Review and Dose-Response Meta-Analysis of Prospective Cohort Studies. *Front Nutr*. 2022;9:878979. doi:10.3389/fnut.2022.878979
16. Dzierzewski JM, Dautovich N, Ravyts S. Sleep and Cognition in Older Adults. *Sleep Med Clin*. Mar 2018;13(1):93-106. doi:10.1016/j.jsmc.2017.09.009
17. Jones MJ, Goodman SJ, Kobor MS. DNA methylation and healthy human aging. *Aging Cell*. Dec 2015;14(6):924-32. doi:10.1111/accel.12349
18. Kawagoe T. Overview of (f)MRI Studies of Cognitive Aging for Non-Experts: Looking through the Lens of Neuroimaging. *Life (Basel)*. Mar 12 2022;12(3)doi:10.3390/life12030416
19. Kendig H, Browning CJ, Thomas SA, Wells Y. Health, lifestyle, and gender influences on aging well: an Australian longitudinal analysis to guide health promotion. *Front Public Health*. 2014;2:70. doi:10.3389/fpubh.2014.00070
20. Kennedy BK, Berger SL, Brunet A, et al. Geroscience: linking aging to chronic disease. *Cell*. Nov 6 2014;159(4):709-13. doi:10.1016/j.cell.2014.10.039
21. Ravyts SG, Dzierzewski JM. Sleep and Healthy Aging: A Systematic Review and Path Forward. *Clin Gerontol*. Apr 21 2022;1-13. doi:10.1080/07317115.2022.2064789
22. Ruiz-Narváez EA, Baylin A, Azofoifa J, Leal A, Rosero-Bixby L. Diet and Leukocyte Telomere Length in a Population with Extended Longevity: The Costa Rican Longevity and Healthy Aging Study (CRELES). *Nutrients*. Jul 28 2021;13(8)doi:10.3390/nu13082585
23. Spencer BE, Jennings RG, Brewer JB. Combined Biomarker Prognosis of Mild Cognitive Impairment: An 11-Year Follow-Up Study in the Alzheimer's Disease Neuroimaging Initiative. *J Alzheimers Dis*. 2019;68(4):1549-1559. doi:10.3233/jad-181243
24. Li Y, Cui M, Pang Y, et al. Association of physical activity with socio-economic status and chronic disease in older adults in China: cross-sectional findings from the survey of CLASS 2020 after the outbreak of COVID-19. *BMC Public Health*. 2024/01/02 2024;24(1):37. doi:10.1186/s12889-023-17492-9