The Biology of Aging

Presented by:
Dr. Sarah Vadeboncoeur, Naturopathic Doctor
About Me

• BSc in Health Sciences, University of Waterloo

• Doctor of Naturopathic Medicine, Canadian College of Naturopathic Medicine

• General practice in Ottawa since 2011
  • Areas of speciality:
    • Fatigue
    • Hypothyroid
    • Intravenous (IV) vitamin therapies
Course Goals

• Gain a basic understanding of anatomical and physiological changes that take place during aging

• Explore nutrition, lifestyle, and exercise habits that can contribute to healthy aging

• To leave with a feeling of empowerment that health and wellness are achievable in elder years
Course Outline

• Mondays 10am-12:30pm
• 5 Weeks: January 12th – February 9th

• Each week we will explore 1-2 body systems
  • Basic review of anatomy and physiology
  • Explore changes taking place during aging
  • Review research relating to nutrition and lifestyle factors that can affect aging process
  • Resources for additional reading will be provided
Course Outline

• **Week 1:**
  • Introduction: What is Aging?
  • Explore Theories of Aging
  • Aging by the numbers/Demographics

• **Week 2:**
  • The impact of stress on aging
  • Brain health, cognition, and memory
  • Diabetes role in dementia risk
  • Nature Deficit, inactivity and mood disorders
Course Outline

• **Week 3:**
  - Heart Health & Blood Pressure
  - Age related changes in the cardiovascular system
  - Factors affecting cardiovascular disease risk
  - Hormonal changes & sexual health

• **Week 4:**
  - The digestive system
  - Nutrition changes over the adult lifespan
  - Nutrient deficiencies and their impact on health and disease prevention
Course Outline

- **Week 5:**
  - Bone health: arthritis & osteoporosis
  - Changes to bone structure
  - Risk factors and prevention of osteoporosis
  - Conclusion: embracing the aging process through nutrition and healthy lifestyle
What is Aging?

- Affects us from the day we are born
- Reflects all the changes that are taking place over the course of our lifetime
  - Cellular changes
  - Anatomical changes
  - Physiological changes
  - Physical changes
  - Mental/emotional changes
  - Performance changes
- Affects cells in every organ and body system
Attitudes towards aging

- **Recent study:**
  - Interviewed subjects < 50 years old

- 4 decades later:
  - Most negative stereotypes about older people = increased risk of heart attack or stroke
  - Negative group: 25% had cardiovascular events, versus 13% of the positive group.

- Viewed aging as a positive experience lived an average of 7.5 years longer
Attitudes towards aging

- Happy aging is called *eugenia* in Greek
  - Social support
  - Physical activity
  - Afternoon naps
  - Stress management with a positive attitude
What is “normal” aging?

• Hearing loss
  • Affects men > women
• Reduced brain volume
• No significant changes in personality
  • No excuse for being cranky and withdrawn!
  • May be a sign of disease or dementia
• Decline in cognitive abilities
  • Normally follows a gradual decline
  • In dementia: increased memory decline 7 years & 2-3 years before diagnosis
Chronological vs Biological Aging

• Biological aging ≠ chronological aging
  • Biological age is based on person’s functional capacity
  • Ability of our cells, tissues, and organ systems to function properly/optimally

• Human beings are extremely diversified in their physiological aging process in terms of:
  • The ONSET of the aging process
  • The RATE at which it progresses
  • The EXTENT to which it progresses
Biological Aging

• Body parts age differently
  • Healthy heart tissue 9 years younger than expected
  • Female breast tissue aged faster than the rest of the body, on average appearing two years older

• Diseased tissues age more quickly
  • Cancer: speeds up the clock by an average of 36 years
  • Brain cancer tissues taken from children had a biological age of more than 80 years
DEMOGRAPHICS: Aging by the numbers
A few definitions

- **Life Expectancy**: the average period that a person may expect to live (number of years remaining in life)

- **Lifespan**: the length of time for which a person lives

- **Healthspan**: the period of one's life during which one is generally healthy and free from serious disease
Aging by the numbers

- **Median age:** 39.9 years (2011)
- Expected to increase over time
  - Aging baby boomers
  - Increased life expectancy
  - Fertility rate below replacement

- Seniors (65+) = 14.8% of the population (5 million)
  - In 2011, the proportion of seniors in Canada was among the lowest of the G8 countries.
  - Parksville (Vancouver Island) and Elliot Lake had the highest proportion of seniors, at twice the national average
Aging by the numbers

- Source: Health Canada

Population 65 years and over, Canada, Historical (1971-2011) and Projected (2012-2061) (percent)
Aging by the numbers

• Current life expectancy (2014)
  • Women: 84 years
  • Men: 80 years

• By 2031
  • Women: 86.0 years
  • Men: 81.9 years

• Average maximum lifespan is 100 years

• Health expectancy: 70 of 80 years
How does Canada compare?

• Highest life expectancy
  • Women: Japan (86 years)
  • Men: Iceland (79 years)

• Lowest life expectancy
  • Women: Turkey (74 years)
  • Men: Hungary (69 years)
### Global Life Expectancy

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Life Expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monaco</td>
<td>89.57</td>
</tr>
<tr>
<td>2</td>
<td>Macau</td>
<td>84.48</td>
</tr>
<tr>
<td>3</td>
<td>Japan</td>
<td>84.46</td>
</tr>
<tr>
<td>14</td>
<td>Canada</td>
<td>81.67</td>
</tr>
<tr>
<td>223</td>
<td>Chad</td>
<td>49.44</td>
</tr>
</tbody>
</table>
Life Expectancy Over Time

1991 to 2005: CANSIM Table 102-0511, Life expectancy, abridged life table, at birth and at age 65, by sex, Canada, provinces and territories, annual.
Historical Causes of Death

![Chart showing historical causes of death and their prevalence in 1900 and 2010. The chart indicates that heart disease, cancer, and tuberculosis were prominent causes of death in 1900, while in 2010, heart disease, cancer, and noninfectious airways diseases were the leading causes.]
Life Expectancy over Time

- Improved nutrition
- Better hygiene
  - 1847: Dr. Ignaz Semmelweis
- Access to safe drinking water
  - Responsible for up to ½ of overall reduction in mortality
- Effective birth control
- Immunization
- Other medical interventions
  - Most available only since World War 2
We’re living longer, but are we living in HEALTH?
Health Span Stats

• Health-adjusted life expectancy (HALE) is an indicator of the average number of years that an individual is expected to live in a healthy state

• HALE = life expectancy - the years of ill health

• It is a summary measure that combines both quantity of life and quality of life
Health Span Stats

• Percentage of life in good health:
  • Men: 88.8% (68.3 years)
  • Women: 86.3% (70.8 years)

• Affected by income
  • Top income tier:
    • Women: 72.3 years
    • Men: 70.5 years
  • Bottom income tier:
    • Women: loss of 3.2 years
    • Men: loss of 4.7 years
Impact of Chronic Disease on Healthspan

![Bar chart showing average life expectancy and health-adjusted life expectancy (HALE) by disease status and sex in Canada. The chart compares women and men with various health conditions. The chart highlights the impact of chronic diseases on healthspan.]

*Average time a person lives in a healthy state, i.e. free of serious diseases like diabetes, high blood pressure, cancer etc.

SOURCE: PUBLIC HEALTH AGENCY OF CANADA

ANDREW BARR / NATIONAL POST
Deaths due to chronic disease are increasing.
Chronic Disease rates rising by 14% per year
# Top 10 Causes of Death in Canada

<table>
<thead>
<tr>
<th>Rank</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Malignant neoplasms (cancer)</td>
</tr>
<tr>
<td>2</td>
<td>Diseases of heart (heart disease)</td>
</tr>
<tr>
<td>3</td>
<td>Cerebrovascular diseases (stroke)</td>
</tr>
<tr>
<td>4</td>
<td>Chronic lower respiratory diseases</td>
</tr>
<tr>
<td>5</td>
<td>Accidents (unintentional injuries)</td>
</tr>
<tr>
<td>6</td>
<td>Diabetes mellitus (diabetes)</td>
</tr>
<tr>
<td>7</td>
<td>Alzheimer's disease</td>
</tr>
<tr>
<td>8</td>
<td>Influenza and pneumonia</td>
</tr>
<tr>
<td>9</td>
<td>Intentional self-harm (suicide)</td>
</tr>
<tr>
<td>10</td>
<td>Nephritis, nephrotic syndrome and nephrosis (kidney disease)</td>
</tr>
</tbody>
</table>
Why are chronic disease rates increasing?

- Increasing obesity rates
- Physical inactivity
- Poor nutrition habits
- Smoking
- Alcohol use
- Social factors
- Environmental health
Are men and women equally affected?
The Female Advantage

• Women still outlive men

• Women make up
  • 52% of seniors aged 65 to 74
  • 56% of seniors aged 75 to 84
  • 68% aged 85 or older

• Men are more likely to die at every age cycle
Why do women live longer?

• Big delay in development of heart disease, stroke, and heart attack
  • Estrogen = protective?

• Iron deficiency = less free radicals
  • Netherlands: reduced heart attack risk among non red meat eaters vs red meat eaters

• Genetic choice: XX vs XY
Why do women live longer?

• Higher suicide rates among older depressed men

• 70% of variation in life expectancy due to:
  • Environmental factors
    • Smoking
    • Dietary factors affecting high cholesterol
    • Different approach to stress management

• Better repair mechanisms?
Marriage favours men

- Married Men: live longer than single men
- Married Women: live slightly longer than single women
- Spouses provide social support
  - Married men have a 40% lower risk of death
  - No demonstrated benefits for women from spousal social support
  - Women often put off caring for their own health
Centenarians

How do you live to get really, really OLD?
The REALLY old...

- Maximum lifespan:
  - Women: 122.5 years
  - Men: 116 years

- 2011
  - 5,825 centenarians in Canada
  - Up 25.7% since 2006
  - 2nd most rapidly growing age group among all age groups after those aged 60 to 64
Where are the oldest people on Earth?

- Okinawa, Japan
  - Age more slowly, continue to enjoy health into old age
  - Higher levels of DHEA: the anti-aging hormone?
  - Highest intake of soya & tofu
  - Rainbow diet
  - Typical daily caloric intake ~ 1200 calories
Where are the oldest people on Earth?

- **Ovodda, Sardinia**
  - As many men reach 100 as women
  - Small genetic pool
  - G6PD deficiency
Where are the oldest people on Earth?

- Loma Linda, California
  - Seventh Day Adventists
  - Strong religious faith
  - Religion bans smoking, drinking, and encourages a vegetarian diet
  - Regular church attendance = reduced stress hormones, increased social connection
Factors that contribute to Aging

• Genetics
  • Believed to contribute 10-50% of our longevity
  • Most common finding = ~ 33%
Factors that contribute to Aging

• Environment
  • Environmental toxins/pollution
  • Nutrition
  • Fitness/movement/exercise
  • Stress
  • Sleep habits
  • Social engagement
  • Attitude
Factors that contribute to Aging

Harvard School of Public Health

- 4 Preventable factors that affect life expectancy
  - Smoking
  - High blood pressure
  - High blood sugar
  - Overweight/obesity

- Reduces life expectancy by:
  - 4.9 years (men)
  - 4.1 years (women)
Genetics 101

- Humans have ~ 25,000 genes
  - 3 billion letters of DNA
  - Small variations every ~ 1000 letters
    - Generate small genetic variants
    - Can be associated with certain traits or disease risk
Genetics Research

- Identify a group with similar characteristics
  - Seek common gene
- Scientists unlikely to find one “aging” gene
  - Several combinations of genes each having a small effect
  - 281 genetic markers that are 61% accurate in identifying centenarians
  - 130 genes involved in longevity
- Centenarians
  - Have as many genetic variants for disease
  - Protected by genetic variants for longevity?
Twin Studies

• Examine twins living to their mid 80s
  • 20–30% attributable to genetic variation
  • Suggests that the average genome + optimal health behaviors -> average life span of late 80s
  • Vast majority of why one lives to their 60s/70s versus these later octogenarian years would be explained by health habit choices
Twin Studies

• Exceptional longevity (100+ years) seems to be more the resultant of genetics rather than environment
• Environmental factors have little contribution to extreme longevity, so that most of the heritability of the trait is likely to have a genetic basis
Epigenetics

- Heritable changes in gene expression
- A change in phenotype without a change in genotype
  - Phenotype: the observable traits and characteristics that result from both genetic and environmental factors
  - Genotype: inherited genetic makeup of a cell
- The interaction between genes and the environment
- A regular and natural occurrence
- Can also be influenced by several factors including age, the environment/lifestyle, and disease state
Epigenetics

Genetics load the gun
The environment pulls the trigger
Theories of Aging
Disposable Body Theory

- Once an organism has produced viable offspring, its body is no longer needed.
- It then ages and dies.
  - Genes: immortal
  - Body: disposable
Loss of Homeostasis

• Homeostasis = balance
  • Chronic anemia -> increase EPO
  • Early diabetes -> increased insulin production
• Entropy = disorder
• Tenet of Naturopathic Medicine: Vis Medicatrix Naturae
  • “Healing Power of Nature”
Loss of Homeostasis

- Entropy
- Homeostatic Mechanisms
- Failure to thrive (failure of the homeostatic mechanisms)
  - Homeostasis chronically unstable
  - Fragility, homeostasis compromised under stress
  - Stress and healing response slightly reduced
  - Robust Homeostasis
  - Death
Telomere Length

• Telomeres are caps on the end of our chromosomes

• Don’t contain any genetic information

• Telomeres shorten with each cell division

• Once the telomere shortens, the laces start to fray and shorten (aka DNA damage)
Telomere Length

- Short telomeres:
  1. Gene turns off (senescence)
     - Can still send faulty signals -> disease
  2. Gene dies (apoptosis)
  3. Gene continues to divide -> abnormal cells -> cancer
Telomere Length

• Associated with lifespan AND health span
  • Healthy centenarians have longer telomeres than unhealthy centenarians

• Good news- we may be able to increase our telomere length with healthy diet, exercise, and meditation

• Telomerase
  • Inactive in healthy cells
  • Increased activity in cancer cells
Lipofuscin

• Cellular waste that can’t be degraded or ejected from cells
• Can only be diluted through cell division and growth
• May be caused by damaged mitochondria
• Affects cell function
  • May be involved in macular degeneration
• Increases with
  • Oxidative stress
  • Exposure to iron
Cross Linking Theory

- Cross linking between or within molecules
- Alters mobility and elasticity

- Normally damaged cells are broken down
  - Cross-linkage prevents proper break-down

- Cross-linkage occurs due to:
  - Glycation
  - Glycosylation
Cross Linking Theory

• Glucose molecules bind to proteins
  • Create Advanced Glycation End products (AGEs)
  • Sticky ends of AGEs bind to nearby proteins -> permanent cross links
  • Similar process to browning of food
Neuroendocrine Theory

• Neuroendocrine = complex system between our brain and nervous system & endocrine system

• Endocrine system -> produces hormones

• Brain -> pituitary gland -> hormone producing glands

• With aging system loses function
  • Sleep abnormalities, blood sugar imbalances, high blood pressure
Neuroendocrine Theory

- For example: IGF-1
  - “Insulin growth factor 1”
- Production stimulated by growth hormone
- Studies show that lower levels associated with longevity
Programmed Theory

- Body is pre-programmed to age

- Occurs through
  - Switching genes on/off
  - Our biological clock which affects hormonal balance
  - Decline of our immune system
Cell Damage

- Every day: millions of DNA damaging events
- Body equipped with repair mechanisms
- Over time: damage > ability to repair
Cell Damage

• Mitochondria = energy producing centres
  • Take oxygen to turn food into energy

• Can produce free radicals (harmful molecules)
  • Triggered by: cigarette smoke, sun exposure

• Free radicals create instability in surrounding molecules
  -> oxidation

• Oxidation = damage to other molecules
  • E.g. DNA
Cell Damage

- Free radicals associated with disease
  - Cancer
  - Neurodegeneration
  - Atherosclerosis
  - Cataracts

- Antioxidants fight free radicals
  - E.g. vitamin C, vitamin E, glutathione
Hayflicks limit

- Dr. Leonard Hayflick (1965)
  - Cells reproduce by dividing themselves
  - Cells divide a number of times and then stop and die (apoptosis)
  - Cells that are frozen start back where they left off
    - Cell memory?
  - Cells with nucleus inserted from younger cells lived and replicated longer
Hayflicks limit

- **Hayflicks Limit**
  - All of the cells created in the human body before birth (and all of the cells these cells produce) $\times$ the average time it takes for cells to reach the end of their lives

- Hayflicks Limit $\approx$ 120 years.
  - The maximum number of years that a human can possibly live
How am I aging?

- Aging Biomarkers
  - Contrast sensitivity: eye’s ability to pick out very lightly shaded images on white backgrounds
    - among the most predictive of the 377 factors
  - Maximum # of rapid step-ups on a low platform in 10 seconds
  - Epigenetic markers (SNPs)
  - Telomere length
Next Week

- The impact of Stress on the Aging Process
- Brain Health, Cognition and Memory
- Diabetes role in Dementia risk
- Nature Deficit, inactivity and mood disorders

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