This guide highlights and summarizes research about the impact of what we eat on telomere length and aging. Some studies focus on specific nutrients, such as Vitamin B12, or foods, such as salmon (and other oily fish). Others focus on categories of foods, such as high antioxidant foods (e.g., blueberries), or dietary approaches, such as the Mediterranean diet. No surprises here—many of the foods documented to have a positive impact on telomere length are commonly recommended as good, healthy choices with other documented health benefits. However, the data summarized here will help you look at eating well through an anti-aging lens.

You may already be following a healthy diet that fits your needs—what you eat is ultimately up to you and your healthcare provider to determine. The information contained herein may confirm choices you are already making that are likely having a positive impact on your age in TeloYears. It may also give you some options to consider and provide new insights into foods that can have a detrimental effect on telomere length.

Specific foods and nutrients

Antioxidant-rich foods and nutrients

You have likely heard and read a plethora about the potential beneficial effects of foods that are rich in antioxidants. In terms of aging, antioxidants are thought to counteract the harmful effect of oxidative stress by helping to combat free radicals. Free radicals have been linked to damage to DNA and numerous diseases, including some of the most pervasive and deadly syndromes of our time: heart disease, cancer, diabetes, and Alzheimer's.

In addition, there are data that show a relationship between antioxidants and other foods that reduce oxidative stress and hence benefit telomere length, which we will focus on herein.

The Austrian Stroke Prevention Study published in 2014 found that concentrations of antioxidative micronutrients in the blood were associated with telomere length in older adults (for frame of reference, the mean age in the study was 66). What’s interesting here is that this study based their findings on plasma levels, not self-reported dietary questionnaires, and the source of antioxidants could have been foods, supplements, or both.

Specifically, researchers looked at vitamin C, lutein, zeaxanthin, b-cryptoxanthin, canthaxanthin, lycopene, a- and c-tocopherol, alpha and beta carotene, and retinol. Regardless of BMI, oxidative factors, and vascular risk factors, high concentrations of three antioxidants in particular were strongly associated with longer telomere length:

Lutein // Zeaxanthin // Vitamin C

The authors concluded that this was the first study to provide evidence that these three nutrients were associated with longer telomere length, and that these vitamins may have a “protective” role in telomere maintenance.¹

Every cell that uses enzymes and oxygen to function is exposed to oxygen free radical reactions that can potentially damage the cell. Antioxidants prevent these reactions by donating an electron to the free radicals without becoming destabilized themselves. An imbalance between oxidants and antioxidants is the underlying cause of oxidative stress.
### Antioxidants and examples of foods that contain each type

<table>
<thead>
<tr>
<th>Phytochemical</th>
<th>Foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allium sulphur compounds</td>
<td>Leeks, onions, garlic</td>
</tr>
<tr>
<td>Anthocyanins</td>
<td>Eggplant, grapes, berries</td>
</tr>
<tr>
<td>Beta carotene</td>
<td>Pumpkin, mangoes, apricots, carrots, spinach, parsley</td>
</tr>
<tr>
<td>Catechins</td>
<td>Red wine, tea</td>
</tr>
<tr>
<td>Copper</td>
<td>Seafood, lean meat, milk, nuts, legumes</td>
</tr>
<tr>
<td>Cryptoxanthins</td>
<td>Red peppers, pumpkin, mangoes</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>Tea, green tea, red wine, citrus fruits, onion, apples</td>
</tr>
<tr>
<td>Indoles</td>
<td>Cruciferous vegetables such as broccoli, cabbage, cauliflower</td>
</tr>
<tr>
<td>Lignans</td>
<td>Sesame seeds, bran, whole grains, vegetables</td>
</tr>
<tr>
<td>Lutein</td>
<td>Corn, leafy greens (such as spinach)</td>
</tr>
<tr>
<td>Lycopene</td>
<td>Tomatoes, pink grapefruit, watermelon</td>
</tr>
<tr>
<td>Manganese</td>
<td>Seafood, lean meat, milk, nuts</td>
</tr>
<tr>
<td>Polyphenols</td>
<td>Thyme, oregano</td>
</tr>
<tr>
<td>Selenium</td>
<td>Seafood, offal, lean meat, whole grains</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Oranges, berries, kiwi fruit, mangoes, broccoli, spinach, peppers</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>Vegetable oils, nuts, avocados, seeds, whole grains</td>
</tr>
<tr>
<td>Zinc</td>
<td>Seafood, lean meat, milk, nuts</td>
</tr>
<tr>
<td>Zoochemicals*</td>
<td>Red meat, offal, fish</td>
</tr>
</tbody>
</table>

*Phytochemicals describe naturally occurring chemicals found in plant foods which are beneficial when consumed. Similarly, zoochemicals describe beneficial chemicals found in animal foods.*
**Omega-3 fatty acids**

Both omega-3 and 6 fatty acids have documented benefits to our health. Omega-3 comes primarily from salmon and oily fish, and to a lesser extent, walnuts and flaxseed, while omega-6 comes from nuts, seeds, and plant-based oils (eg, soybean, sunflower). However, it’s not simply getting enough omega-3 and 6 fatty acids in our diets—the ratio of omega fatty acids may also be important in terms of nutrition and play a role in telomere length. And, targeting oxidative stress through diet may target mechanisms that contribute to the development of diseases.

A randomized controlled trial that examined omega-3 fatty acids, oxidative stress, and telomere length in sedentary, middle-aged and older adults who received an omega-3 supplements at two dose levels, compared with a placebo supplement that contained a ratio of fatty acids (omega-3 and 6) similar to what an adult eats who follows the typical American diet. Those in both omega-3 supplement groups showed lowered oxidative stress compared with placebo. Differences in telomere length in the three groups were not statistically significant; however, telomere length increased with lower omega-6:3 ratios. The authors noted that oxidative stress and cellular aging may be important pre-disease mechanisms that can be targeted with nutritional interventions. 

**And what about fish oil?** A 2010 study published in JAMA looked at the effect of marine omega-3 fatty acids on telomere length in patients with coronary heart disease. This study focused on DHA+EPA fish oil, but did not distinguish between supplements and dietary consumption of high-omega-3 containing fish (most often cited as salmon, sardines, and herring); however, the study only included fish oil omega-3, and not omega-3 from plant-based sources such as walnuts or flaxseed. In that study, those who had the lowest level of DHA+EPA at baseline experienced the fastest rate of telomere shortening when they measured telomere length at 5 years. Conversely, those who experienced the slowest rate of telomere shortening had the highest levels of DHA+EPA at baseline.

**Multivitamins**

An epidemiological study that examined multivitamin use, nutrient intake, and telomere length among women found a strong association between multivitamin use and longer telomere length. Specifically, telomeres were 5.1% longer in women who took a multivitamin compared with those who did not. When researchers examined their intake of micronutrients in the foods that they ate, higher intake of vitamins C and E were likewise associated with longer telomeres, even after they adjusted for multivitamin usage. And, longer telomere length was associated with higher intakes of vitamin C and E from food among women who did not take multivitamins.

**High-sugar beverages and soda**

Not all research is focused on determining which foods and nutrients might be beneficial to telomere length and aging. Multiple studies have examined the association between sugar-sweetened beverages and telomere lengths, and as you might expect, the news in terms of impact on aging is not good.

A study in Europe looked at telomere length and the consumption of sugary foods and beverages over time in a cohort of overweight and obese pregnant women. Decreasing sugary beverages increased telomere length from baseline to 9 months postpartum (no association was found with sugary foods).

An American study examined the association between sugar-sweetened beverages and maintaining telomere length by conducting a cross-sectional data analysis.
of a large population of adults in the National Health and Nutrition Examination Survey. After adjusting for socio-demographic and health-related characteristics, consuming sugar-sweetened sodas were associated with shorter telomeres, while consuming 100% fruit juice had a “marginal” association with longer telomeres. Diet sodas had no effect. The authors concluded that “regular consumption of sugar-sweetened sodas might influence metabolic disease development through accelerated cell aging.”

The telomere length of heavy drinkers was found in one study to be half that of social drinkers, and the more drinks per day, the shorter the telomere length. Those who drank more than 4 drinks a day had substantially shorter telomeres. The effects persisted even when researchers controlled for other known factors that potentially impact telomeres, such as BMI, vegetable intake, and genotoxic dietary exposure.

Overall dietary factors and approaches

Mediterranean diet

A lot has been written about the Mediterranean diet in general; likewise, researchers have examined the association of following a Mediterranean diet on telomere length. The Nurses’ Health study, which is a very large cohort study of more than 120,000 women middle-aged and older, looked specifically at telomere length and following this very popular and well-known way of eating.

The Mediterranean Diet is based on the traditional diet in the countries surrounding the Mediterranean Sea, including France, Italy, Spain, Morocco, and Greece. It was once considered a “poor man’s” diet, developed over the centuries as people labored to create sustenance in less hospitable terrain. It is not a traditional “diet,” but rather a lifestyle that has been widely researched and accepted as a healthy approach to living well.

How do I follow a Mediterranean diet?

- **Eat mostly plant-based foods:** fruits and vegetables, whole grains, legumes and nuts
- **Replace** butter with healthy fats, such as olive oil and canola oil
- **Flavor foods with herbs,** such as fresh basil, mint, and dill, and spices, such as cinnamon and red pepper flake, instead of salt
- **Limit** how often you eat red meat (several times a month)
- **Eat fish and poultry** at least twice a week
- **Enjoy meals** with family and friends
- **Drink red wine,** but only in moderation (optional)
- **Get plenty of exercise**
The investigators reported that longer telomere length was associated with greater adherence to a Mediterranean diet among women in the study, even when they adjusted for confounding factors.\textsuperscript{10}

Three other studies that analyzed data from the Nurses’ Health Study found similar associations between following a Mediterranean diet and telomere length in women.

A study that looked specifically at biological predictors of cancer: diet, body composition, and lifestyle factors found that the following dietary factors were positively associated with telomere length:
- Dietary fiber intake (specifically from cereal)
- Polyunsaturated fatty acid intake (but not total fat intake)

• Linoleic acid (inversely associated, meaning more was better)
• Waist size (inversely associated, the smaller the better)

No association was found between smoking, physical activity, or postmenopausal hormone use and telomere length.\textsuperscript{11}

Another analysis of Mediterranean diet looked closely at gender and sources of oil—namely extra virgin olive oil and nut-based oils. That study found a positive association between longer telomeres and following a Mediterranean diet among women but not men, and those in the nuts group had a higher risk of telomere shortening after 5 years. They also reported no beneficial effect of the diet on preventing telomere shortening compared with a low-fat diet.\textsuperscript{12}

The impact of how we eat now and telomere length later

In a study of Korean adults, researchers looked at the association between dietary patterns in middle age, including consuming certain foods, on telomere length later in life. Researchers collected baseline data about diet via a questionnaire, and tested telomere length a decade later. Controlling for age, gender, body mass index, researchers were able to isolate and compare two different diet types:
- “Prudent dietary pattern,” consisting of a high intake of whole grains, seafood, legumes, vegetables, and seaweed
- “Western dietary pattern,” consisting of a high intake of refined grain, red meat or processed meat, and sweetened carbonated beverages (much like the typical “American” diet)

As you might expect, the prudent dietary pattern was positively associated with telomere length, as were certain food items. Longer telomere lengths were associated with
- higher consumption of legumes, nuts, seaweed, fruits, and dairy products
- lower consumption of red meat or processed meat and sweetened carbonated beverage\textsuperscript{14}
The same researchers published a longitudinal study in 2016 using the same cohort of Korean men, also looking at their baseline diet and telomere length 10 years later, this time examining the association between specific micronutrients, including antioxidants, B vitamins, and telomere length.

Specifically, they looked at the following micronutrients:

- Vitamin A, B-1, B-2, B-3, B-6, and folate (B-9)
- Vitamin C and E
- Calcium, phosphorus, potassium, iron, and zinc

After adjusting for possible confounding factors, telomere length was positively associated with consuming vitamin C, folate, and potassium among all study participants taken together (these findings reached statistical significance). When they stratified by age, the positive association of vitamin C, folate, and potassium and telomere length was only statistically significant among men who were older than 50.

Authors concluded that consumption of these three nutrients (vitamin C, folate, and potassium), which are abundant in fruits and vegetables, may “delay biological aging in middle-aged and older adults.”

### Anti-inflammatory diet

There are established relationships between oxidative stress and telomere lengthening; likewise, oxidation and inflammation are related. Persistent, low-grade inflammation that is not in response to any internal threat such as infection or injury can damage healthy tissues and cells. Advancing age has been shown to increase this inflammatory response, a process that has been coined “inflammaging.” A recently published study reported results of a 5-year follow up on a Mediterranean diet intervention which examined if a Dietary Inflammatory Index (DII) could elucidate the effect that a diet’s inflammatory potential may have on telomere shortening.

Participants in the study had a high risk for cardiovascular disease. Researchers calculated their DII based on a validated questionnaire about 137 foods, called the Food Frequency Questionnaire, which had been previously published (see list of foods and nutrients included in the table below). Those who followed a more anti-inflammatory diet had the longest telomeres at baseline. A longitudinal analysis showed that a lower DII (indicating a greater anti-inflammatory diet) could significantly slow down the rate of telomere shortening. Conversely, a 5-year follow-up showed a two-fold higher risk of accelerated telomere shortening among those who had the highest DII (and thus followed the “pro-inflammatory” diet) compared with those who had the lowest DII (and thus followed the anti-inflammatory diet).

### Foods and nutrients researchers included when calculating the Dietary Inflammatory Index (DII)

<table>
<thead>
<tr>
<th>Overall composition and macronutrients: calories, fat, carbohydrates, protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific vitamins and nutrients: A, C, D, E, thiamin, riboflavin, niacin, B-6, B-12, folic acid, carotene, iron, magnesium, zinc, selenium</td>
</tr>
<tr>
<td>Fatty acids, particularly those that make up triglycerides (SFA, MUFA, PUFA)</td>
</tr>
<tr>
<td>Fats, including cholesterol, linoleic acid, trans fat</td>
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<tr>
<td>Alcohol consumption</td>
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<tr>
<td>Fiber</td>
</tr>
<tr>
<td>Garlic</td>
</tr>
<tr>
<td>Onion</td>
</tr>
<tr>
<td>Coffee</td>
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<tr>
<td>Tea</td>
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</table>
Researchers of this cross-sectional and longitudinal study stopped short of saying that following an anti-inflammatory diet showed a beneficial effect on aging and health by slowing the rate of telomere shortening. However, they did note that the findings suggest that diet may indeed play a role in determining telomere length via pro-or anti-inflammatory mechanisms.

**Diet combined with other lifestyle modifications**

And finally, consider the now famous Dean Ornish study published in Lancet in 2013 that looked at the effect of comprehensive lifestyle changes on telomere length among men with prostate cancer over a 5-year period. Specifically, the comprehensive lifestyle changes consisted of several interventions clustered in four areas: diet, physical activity, stress management, and social support, as shown in the graphic that follows.

The findings clearly showed a positive effect among those who followed the diet, exercised, managed stress, and increased social support, with a statistically significant increase in telomere length from baseline among men in the lifestyle intervention group and decrease among those in the control group. The findings held even when researchers adjusted for age and length of follow-up.

“Whole foods” describes foods that have been processed or refined as little as possible and are free from additives or other artificial substances.

Participants in the Ornish study made lifestyle changes in four categories: diet, exercise, stress management, and increased social support.

A diet HIGH in:
- Whole foods
- Plant-based protein (eg, quinoa, pumpkin seeds, kale) and legumes (eg, beans, peanuts, soybeans)
- Fruits and vegetables

A diet LOW in:
- Fat (10% of calories)
- Refined carbohydrates, including added sugar and sweeteners, such as fructose or corn syrup; refined grains such as white rice; white and other refined or processed flours; refined starches added to foods

Regular aerobic activity, WALKING:
- Moderate intensity
- 30-minutes a day, 6 days per week

Stress management techniques, practiced for 1-hour/day, including:
- Gentle, yoga-based stretching
- Meditation
- Relaxation techniques, such as breathing, guided imagery, progressive relaxation

Weekly support group sessions that included:
- Moderate exercise
- Stress management training
- Counseling

Increased Social Support
The TeloYears test is not intended for screening, diagnosing, treating or preventing diseases or medical conditions.

The information provided by the TeloYears test should not be used to replace medically appropriate screening tests recommended based upon actual age or other risk factors, nor should the information be used to make decisions about diagnosis or treatment of diseases or medical conditions.

The TeloYears Guide to Eating Well, Aging Well is intended to be informational in nature and is not an attempt to practice medicine or provide specific medical advice, and it should not be used to substitute for, replace, or overrule a qualified health care provider’s judgment. Always consult with a qualified and licensed physician or other health care provider regardless of anything read within this guide.

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