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Review

Carotenoids and health in older people

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ABSTRACT

As the proportion of older people increases, so will chronic disease incidence and the proportion of the population living with disability. Therefore, new approaches to maintain health for as long as possible in this age group are required. Carotenoids are a group of polyphenolic compounds found predominantly in fruit and vegetables that have been proposed to have anti-inflammatory and antioxidant effects. Such properties may impact on the risk diseases which predominate in older people, and also ageing-related physiological changes. Working out the effect of carotenoid intake versus fruit and vegetable intake is difficult, and the strong correlation between individual carotenoid intakes also complicates any attempt to examine individual carotenoid health effects. Similarly, research to determine whether carotenoids consumed as supplements have similar benefits to increased dietary intake through whole foods, is still required. However, reviewing the recent evidence suggests that carotenoid intake and status are relatively consistently associated with reduced CVD risk, although β-carotene supplementation does not reduce CVD risk and increases lung cancer risk. Increased lycopene intake may reduce prostate cancer progression, with a potential role for carotenoids at other cancer sites. Lutein and zeaxanthin have a plausible role in the maintenance of eye health, whilst an association between carotenoid intake and cognitive and physical health appears possible, although research is limited to date. Given this accruing evidence base to support a specific role for certain carotenoids and ageing, current dietary advice to consume a diet rich in fruit and vegetables would appear prudent, and efforts maintained to encourage increased intake.

Contents

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1. Introduction

In the developed world, as life expectancy increases and the birth rate declines, the proportion of older people is increasing, with the number of people aged >60 years expected to account for approximately one-fifth of the world's population by 2050 [1]. As the proportion of older people increases, so will the incidence of chronic diseases and the proportion of the population living with disability. Therefore, health and social policy makers will need to develop new strategies to overcome the challenges this ageing population presents. Healthy ageing is defined as the ability to maintain three key behaviours: low risk of disease and disease related disability, high mental and physical function, and active engagement of life [2]. Strategies that could reduce age-related morbidity and reduce chronic disease prevalence are therefore important for healthy ageing, and are likely to have financial and societal benefits. Lifestyle factors, including diet, have been suggested to play a role in chronic disease prevention [3,4] and to promote healthy ageing. One group of polyphenolic compounds proposed to contribute to healthy ageing are the carotenoids [5].

2. Carotenoids

Carotenoids are a group of organic compounds composed of two or more units of hydrocarbons. They are generally referred to as pigments, due to their characteristic colours ranging in the yellow to red spectrum. Carotenoids are synthesised by all photosynthetic organisms and some non-photosynthetic bacteria and fungi, although they cannot be synthesised in vivo by humans and are consumed only through diet [6].

Carotenoid derivatives are valuable for many biological functions. In plants, carotenoids primarily function as essential components required for photosynthesis, photoprotection and the production of phytohormones [6]. In animals, carotenoids have been proposed to promote health through their antioxidant and anti-inflammatory activity and ability to enhance immune response [5], with such biological activity being linked to an ability to prevent chronic diseases, such as cancer and cardiovascular disease (CVD) [7], in preserving visual function and protecting against age-related macular degeneration (AMD) [7]. An impact of carotenoid intake on other ageing-related functions, such as cognitive function and muscle strength, has also been suggested [8,9].

Carotenoids can be categorised into carotenes, hydrocarbons that can be cyclized at one or both ends of the molecule, or xanthophylls, oxygenated derivatives of carotenes [6]. Carotenes are fat-soluble and thus tend to be localised in LDL in circulation [7]. Xanthophylls contain at least one hydroxyl group, so are more polar than carotenes and more evenly distributed between LDL and HDL [7].

Several hundred carotenoids have been characterised in nature, but only 40 are present in a typical human diet, and approximately 20 have been identified in human blood and tissues [5]. In serum, there are six major carotenoids found in considerable concentrations: β-cryptoxanthin, lutein, lycopene, zeaxanthin, α-carotene and β-carotene [7]. Only two accumulate in the macula and, together with meso-zeaxanthin (a synthesis product of lutein), comprise the macular pigment [7]. β-carotene is the most widely researched carotenoid and, of the 50 carotenoids that can be metabolised into vitamin A, it has the highest provitamin A activity [7].

After ingestion, carotenoids are incorporated into micelles and are actively taken up by mucosal cells of the small intestine [10]. In the intestinal mucosa, β-carotene and other pro-vitamin A carotenoids are partly converted to vitamin A, primarily as retinyl esters [10]. Both carotenoids and retinyl esters are packaged into chylomicrons for release into the lymphatic system and eventual transport to the bloodstream [10].

3. Food sources of carotenoids

The principal dietary source of the carotenoids is from fruit and vegetables (FV) [7,11]. As carotenoids are unable to be synthesised in the human body, carotenoids are potentially useful biomarkers reflecting FV intake [11], and an association between FV consumption and blood concentration of total and individual carotenoids has been demonstrated [11,12].

Dietary sources of β-carotene include yellow and orange FV, as well as green leafy vegetables, whilst α-carotene is predominantly found in carrots. Tomatoes and tomato based foods account for over 85% of all dietary sources of lycopene. Spinach and kale provide the highest levels of lutein and zeaxanthin, although these carotenoids are also found in egg yolks. Orange fruits, such as tangerine and papaya, contain the largest amounts of β-cryptoxanthin [7].

Whilst main food sources are known, factors affecting content, such as seasonal variation, agricultural practices (such as organic methods) and food processing, are less well studied, although common household cooking does not have major effects [5]. Similarly factors affecting bioavailability are only starting to be explored; dietary fat ingested in the same period of consumption as the carotenoid seems to aid absorption, whilst there may be competition for absorption between carotenoids when consumed in the same meal [13]. The extent to which genetic polymorphisms affect bioavailability and the response to increased dietary intake has also yet to be confirmed [5].

In spite of the potential beneficial role of carotenoids in promoting health, currently there are no dietary intake guidelines in the UK or the US.

4. Carotenoid intake versus FV intake

Protective effects of FV consumption on chronic disease risk have been observed in many observational studies [14–16]. Current UK recommendations are to consume five portions of FV/day [17], although population intakes are still low, with latest National Diet and Nutrition Survey data suggesting that 59% of older adults do not meet this recommendation [18].

Micronutrients found within FV have been a key focus of research exploring the health benefits of FV. A diverse range of minerals, antioxidant vitamins, phytochemicals, flavonoids, folate, fibre, organic acids, potassium and carotenoids are contained within FV. Elucidating exactly what component of FV is responsible for the observed health benefits will be challenging, with carotenoids being one of these potentially protective groups of compounds. It is likely that it is the combination of these different nutrients and other compounds within the food group, rather than one particular component that will explain the beneficial effects. However, when considering the evidence for the health benefits of carotenoid intake in terms of ageing, it is important to also consider the evidence base for FV.

The aim of this review is to examine the evidence that carotenoid intake could protect against ageing by focusing on diseases which predominate in older people, and also ageing-related physiological changes. This was a narrative review; a search of recent scientific literature was undertaken in Pubmed using the search terms "carotenoids" and "mortality", "cardiovascular disease", "cancer", "age-related macular degeneration", "cognitive function" and "cognitive decline", and "physical function" and "muscle function". As the number of references was limited, preference was given to publications within the last four years and systematic reviews.