1-1-2016

Adherence to dietary guidelines and successful aging over 10 years

Bamini Gopinath
University of Sydney, bamini.gopinath@sydney.edu.au

Joanna Russell
University of Wollongong, jrussell@uow.edu.au

Annette Kifley
University of Sydney

Victoria M. Flood
University of Wollongong, vflood@uow.edu.au

Paul Mitchell
University of Sydney, paul_mitchell@sydney.edu.au

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Abstract

Background. We aimed to prospectively examine the relationship between overall diet quality (reflecting adherence to dietary guidelines) and successful aging in a population-based cohort of older adults. Methods. In this population-based cohort study, we analyzed 10-year follow-up data from 1,609 adults aged 49 years and older, who were free of cancer, coronary artery disease, and stroke at the baseline and who had complete dietary data. Dietary data were collected using a semiquantitative food frequency questionnaire. Total diet scores (TDS) were allocated for intake of selected food groups and nutrients for each participant as described in the national dietary guidelines. Higher scores indicated closer adherence to dietary guidelines. Successful aging was defined as the absence of disability, depressive symptoms, cognitive impairment, respiratory symptoms, and chronic diseases (cancer, coronary artery disease, and stroke). Results. At 10-year follow-up, 610 (37.9%) participants had died and 249 (15.5%) participants aged successfully. After multivariable adjustment, each 1-unit increase in TDS at baseline was associated with a 8% increased odds of successful aging 10 years later, odds ratio 1.08 (95% confidence interval 1.00-1.15). Participants in the highest (high adherence to dietary guidelines) versus lowest quartile (poor adherence to guidelines) of TDS at baseline had 58% higher odds of successful aging after 10 years, odds ratio 1.58 (95% confidence interval 1.02-2.46). Conclusions. Greater compliance with recommended national dietary guidelines (higher diet quality) was associated with an increased likelihood of successful aging, as determined through a multidomain approach.

Keywords

aging, years, adherence, dietary, 10, guidelines, over, successful

Disciplines

Education | Social and Behavioral Sciences

Publication Details

Gopinath, B., Russell, J., Kifley, A., Flood, V. M. & Mitchell, P. (2016). Adherence to dietary guidelines and successful aging over 10 years. Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 71 (3), 349-355.

OXFORD UNIVERSITY PRESS | Journal of Gerontology: Medical Sciences

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Journal:	*Journal of Gerontology: Medical Sciences*
Manuscript ID:	JGMS-2015-RES-313
Manuscript Type:	Research Article
Date Submitted by the Author:	18-Jun-2015
Complete List of Authors:	Gopinath, Bamini; University of Sydney, Centre for Vision Research Russell, Joanna Kifley, Annette Flood, Victoria; University of Sydney, Faculty of Health Sciences Mitchell, Paul
Keywords:	Epidemiology, Morbidity, Normative Aging, Nutrition, Public Health, Successful Aging

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Running title: Diet quality and successful aging

Bamini Gopinath[1]

Joanna Russell[2]

Annette Kifley[1]

Victoria M Flood[3,4]

Paul Mitchell[1]

[1]Centre for Vision Research, Department of Ophthalmology and Westmead Millennium Institute, University of Sydney, NSW, Australia.

[2]Faculty of Health and Behavioural Sciences, University of Wollongong, Sydney, NSW, Australia

[3]Faculty of Health Sciences, University of Sydney, Sydney, NSW, Australia

[4]St Vincent's Hospital, Sydney, NSW, Australia

Correspondence to:

Dr Bamini Gopinath, PhD

Centre for Vision Research, Westmead Millennium Institute, University of Sydney, Westmead Hospital, Hawkesbury Rd, Westmead, NSW, 2145, Australia.

Telephone: 61 2 8627 3368 Fax: 61 2 8627 3099

Email: bamini.gopinath@sydney.edu.au

Sources of support

The Blue Mountains Eye and Hearing Studies were supported by the Australian National Health and Medical Research Council (Grant Nos. 974159, 991407, 211069, 262120).

Abstract

Background. We aimed to prospectively examine the relationship between overall diet quality (reflecting adherence to dietary guidelines) and successful aging in a population-based cohort of older adults.

Methods. In this population-based cohort study, we analyzed 10-year follow-up data from 1609 adults aged 49+ years, who were free of cancer, coronary artery disease and stroke at the baseline and who had complete dietary data. Dietary data were collected using a semi-quantitative food-frequency questionnaire. Total diet scores (TDS) were allocated for intake of selected food groups and nutrients for each participant as described in the national dietary guidelines. Higher scores indicated closer adherence to dietary guidelines. Successful aging was defined as the absence of: disability, depressive symptoms, cognitive impairment, respiratory symptoms and chronic diseases (cancer, coronary artery disease and stroke).

Results. At 10-year follow-up, 610 (37.9%) participants had died and 249 (15.5%) participants aged successfully. After multivariable-adjustment, each 1-unit increase in TDS at baseline was associated with a 10% increased odds of successful aging 10 years later, odds ratio, OR, 1.10 (95% confidence intervals, CI, 1.03-1.18). Participants in the highest (high adherence to dietary guidelines) versus lowest quartile (poor adherence to guidelines) of TDS at baseline had 62% higher odds of successful aging after 10 years, OR 1.62 (95% CI 1.04-2.53).

Conclusions. Greater compliance with recommended national dietary guidelines (higher diet quality) was associated with an increased likelihood of successful aging, as determined through a multi-domain approach.

Introduction

The ageing demographics of most developed countries is one of the most challenging public health and policy issues, and hence, it has become critical to identify prognostic markers of remaining free of disease and in good functional health for as long as possible (1). It has been suggested that a multi-domain approach of successful aging, rather than research focused on risk factors for single health outcomes, such as chronic diseases or functioning, could be more informative (1,2). However, there has been considerable research on disability outcomes at older ages (3-5), but less attention has been focussed on successful aging combining favourable functioning outcomes with good mental health and the absence of chronic disease and disability (1,6).

While dietary patterns are associated with healthy aging (7), eating patterns and behaviors have rarely been included as a component of successful aging (2,8). *Sabia et al*. (1) showed that daily consumption of fruits and vegetables was associated with a 35% increased odds of aging successfully in UK adults who were followed over 16.3 years. However, this UK study did not explore the associations between total diet and successful aging. More recently, a Australian cohort study showed that a fruit-based eating pattern was positively associated with a successful aging outcome (i.e. lack of chronic disease, little limitation in physical function and good mental health) over 12-years (9). In contrast, an eating pattern based on meat and other fatty foods was negatively associated with successful aging (9). This study used factor analysis to determine diet quality and subsequently its association with successful aging.

In the current study, we have taken the approach of grouping foods 'a priori' that are representative of current nutrition knowledge in the form of dietary guidelines or other dietary recommendations i.e. diet quality (10,11). This may be a more useful tool in public health practice to assess a population's adherence to current dietary guidelines based on empirical

evidence (12). To our best knowledge, no population-based studies have assessed the effect of diet quality in terms of adhering to dietary guidelines, on successful aging. In this cohort of older adults aged ≥50 years, we used a tool modelled on both Australian and US diet quality indices (13,14), to examine the independent relationship between overall diet quality (an assessment of adherence to national dietary guidelines) and a comprehensive definition of successful aging that included being free of disability and chronic disease (coronary artery disease, stroke, diabetes, cancer), having good mental health and functional independence, and having good physical, respiratory and cognitive function, over 10-year follow-up period.

Methods

Study population

The Blue Mountains Eye Study (BMES) is a population-based cohort study of common eye diseases and other health outcomes in a suburban Australian population located west of Sydney. Study methods and procedures have been described elsewhere (15). Baseline examinations of 3654 residents aged >49 years were conducted during 1992-4 (BMES-1, 82.4% participation rate). Surviving baseline participants were invited to attend examinations after 5- (1997-9, BMES-2), 10- (2002-4, BMES-3), and 15 years (2007-9, BMES-4) at which 2334 (75.1% of survivors), 1952 participants (75.6% of survivors) and 1149 (55.4% of survivors) were re-examined, respectively, with complete data. The University of Sydney and the Western Sydney Area Human Ethics Committees approved the study, and written, informed consent was obtained from all participants at each examination.

Nutritional assessment

Dietary data were collected using a semi-quantitative, 145-item self-administered food frequency questionnaire (FFQ) (16). At all BMES examinations, participants used a 9-

category frequency scale to indicate the usual frequency of consuming individual food items during the past year. For the current study, FFQ data collected at BMES-1 were used in the analyses. Most nutrient correlations were between 0.50 and 0.60 for energy-adjusted intakes (17). A dietitian coded data from the FFQ into a customized database that incorporated the Australian Tables of Food Composition 1990 (baseline FFQ data) and follow-up FFQ data used NUTTAB95 (18,19).

A modified version of the Australian diet quality index (14), based on the Dietary Guidelines for Australian Adults (20) and the Australian Guide to Healthy Eating (21), was used to establish the total diet score (TDS), assessing adherence to the Australian dietary guidelines, which was the study factor. The methodology used to develop TDS has been previously reported (12), please see Supplementary Material 1 and Supplementary Table S1.

Assessment of study outcomes (aging status and mortality)

The normal aging group in the context of this study included all participants who were alive at the end of the 10-year follow-up, but who were not classified as aging successfully (see definition below) (1). Among surviving participants aged 60+ years, we used a definition similar to that used by *Sabia et al*. (1), to defined successful aging as satisfying each of the following criteria: no history of cancer, coronary artery disease, stroke, angina, acute myocardial infarction (AMI), or diabetes; good cognitive, physical, respiratory and cardiovascular functioning; and the absence of disability; good mental health and functional independence (see Supplementary Material 1).

To identify and confirm persons who died after BMES-1, demographic information including surname, first and second names, gender and date of birth of the participants were cross-matched with Australian National Death Index (NDI) data, as previously described (22). Validity of NDI data has been reported to have high sensitivity and specificity for

cardiovascular mortality (92.5% and 89.6%, respectively) (23). The census cut-off point for deaths was end of December 2004 (i.e. a 10-year period from BMES-1 or the baseline examination).

Statistical Analysis

SAS 9.2 software (SAS Institute, Cary, NC, USA) was used for statistical analyses. Study factor was TDS and three categories of study outcome were defined: successful aging (key study outcome), death during follow-up and normal aging. Baseline characteristics of study participants who were followed over 10 years were compared using χ^2-tests and general linear model. Multivariable logistic regression analyses for the outcome of aging status (successful aging, normal aging, and having died) used the generalized logit link and adjusted for: age, sex and smoking. Participants self-reported history of smoking as never, past, or current smoking. Current smokers included those who had stopped smoking within the past year. We did not adjust for alcohol consumption or physical activity as there were included as components of the TDS. TDS was analyzed as a continuous variable (per 1-unit) and categorical variable (quartiles). When examining the association between baseline TDS (diet quality) and the 3 categories of outcomes (normal aging, successful aging and death) 10 years later, we used polytomous logistic regression with a generalized logit link.

Results

Of the 3654 participants aged 49 years and over examined at the baseline examination (BMES-1), 1116 were excluded as they had cancer, coronary artery disease and/ or stroke at the baseline examination. A further 929 were excluded as they did not have diet quality data or information on TDS at baseline, and had insufficient information to characterize their aging status 10 years later, leaving 1609 participants for longitudinal analyses. Of these 1609

participants, 610 (37.9%) had died, 750 (46.6%) aged normally; and 249 (15.5%) were successful agers, 10 years later. The majority of participants who aged normally were not functionally independent, had chronic illnesses (e.g. stroke, AMI, diabetes), and had self-reported heart and respiratory problems (e.g. continual shortness of breath) (Supplementary Table S2). At baseline, those who aged successfully compared to non-participants or those who aged normally or had died were more likely to be younger and less likely to smoke (Table 1). Persons who aged normally were less likely to be male compared to non-participants, and those who died or aged successfully. Persons who died had significantly lower mean TDS compared to participants and non-participants (Table 1).

After adjusting for age, sex and smoking, each 1-unit increase in the TDS was associated with a 10% increased likelihood of aging successfully, OR 1.10 (95% CI 1.03-1.18). Table 2 shows that those in the highest (greater adherence to recommended dietary guidelines) compared to the lowest quartile (poorer adherence to dietary guidelines) of TDS had a 62% increased likelihood of aging successfully rather than aging normally 10 years later, multivariable-adjusted 1.62 (95% CI 1.04-2.53). The temporal association between each component of the TDS (analyzed as quartiles, with the 2nd and 3rd quartiles combined to form a 'middle' group) and aging status over 10 years was analyzed (Table 3). Participants in the middle group of fruit consumption compared to the lowest group of consumption had 67% increased odds of aging successfully than aging normally. No other individual TDS components were associated with successful aging. Participants in the highest group versus lowest group of breads/ cereal consumption and total METs had 41% and 35% reduced odds of dying rather than aging successfully, respectively (Table 3).

Of the 203 study participants who consistently remained above the median TDS (i.e. a score of ≥10.9) at all 3 BMES examinations: 17 (8.4%) had died, 118 (58.1%) aged normally and 68 (33.5%) aged successfully. Of the 607 participants below the median TDS at any time

point over the 10 years: 58 (9.6%) had died, 394 (64.9%) aged normally and 155 (25.5%) aged successfully. Table 4 shows that participants who maintained a TDS above the median compared to those who had a TDS below the median were more likely to age successfully rather than age normally after 10 years, multivariable-adjusted OR 1.45 (95% CI 1.01-2.09).

Discussion

Understanding the aging process as regulated by a modifiable factor such as nutrition should facilitate the development of targeted strategies for promoting successful aging (24). This cohort study shows that older adults who more closely followed recommended national dietary guidelines at baseline had a greater likelihood of aging successfully at the 10-year follow-up. Further, those who maintained optimal diet quality, that is, remained above the median TDS during the 10 years had 45% increased odds of aging successfully at follow-up. These epidemiological data are novel in that diet quality was assessed by level of adherence to national dietary guidelines and successful aging was determined through a multi-dimensional approach.

The proportion of successful agers in our cohort was 15.5% and is slightly lower than the 18.7% observed in the UK study by *Sabia et al.* (1), which used a similar comprehensive definition of successful aging to ours. An Australian study which used a slightly different definition of healthy aging, also showed that 18.6% of their cohort were successful agers (9). Our observed proportion is, however, within the range of 0.4% to 95% of successful agers indicated by recent reviews (8). The large variability in the range of healthy agers is likely to be due to the lack of a common definition, different sample and measurement procedures, and existing biases (2,8).

It is well known that dietary habits are strongly associated with health (2,25). There are, however, few reports on the association between diet and healthy aging, despite the numerous

studies of eating pattern measures, such as the Mediterranean Diet Score and various health outcomes (9). A UK (2) and Australia cohort study (9) both showed that dietary patterns based on frequent consumption of fruits and vegetables were positively associated with a comprehensive definition of successful aging. We also previously showed that higher TDS scores were associated with reduced all-cause mortality risk (26) and better functional ability and quality of life in this cohort of older adults (27). Observed findings from the present study are in accordance with this published literature, as it underscores the importance of a healthy dietary pattern (i.e. closely following national dietary guidelines) in the process of successful aging. Specifically, we show that older adults in the highest (greater adherence to dietary guidelines) versus lowest quartile (poor adherence to dietary guidelines) of the TDS had a 62% increased likelihood of aging successfully over the 10 years. Moreover, participants who consistently demonstrated close adherence to the national dietary guidelines during the 10-year follow-up also had significantly increased odds of healthy survival.

The only component of the TDS which was independently associated with successful aging was fruit consumption, and this is in agreement with a previous Australian study (9). These findings suggest that individual components of dietary recommendations e.g. single foods groups, specific nutrients, and physical activity levels are not strongly associated with successful aging, however, their combined or cumulative impact is likely to be substantial. These concur with previous research which suggests that nutrients reported to be associated with better outcomes in observational studies could be serving as biomarkers for the whole diet, and the benefits observed are likely to be associated with the whole dietary pattern which may promote successful aging, and less illness and disablement (9).

BMES participants with higher levels of diet quality or TDS were shown to be consuming greater quantities of a range of recommended optimal food choices in their diets, including fruits and vegetables, fish, whole-grain breads and cereals (12). This is in agreement

with observations in populations with higher than average proportions of centenarians, whose diets are typically rich in fruits, vegetables, legumes and whole grain, and reduced saturated fat (28). It is likely that such a healthy dietary pattern is associated with significantly lower levels of lipid peroxidation and free-radical-induced damage (28), which in turn could facilitate successful aging transitions. Specifically, a higher diet quality is typified by lower concentrations of inflammatory markers such as C-reactive protein (29). Moreover, fruits and vegetables are high in antioxidants such as vitamin C and carotenoids, which may also reduce oxidative damage (30,31).

These study findings are of importance for public health, since demographic aging is one of the most challenging policy issues of the 21st century for developed countries, and targeted health policies are required (2). Moreover, understanding health benefits of following dietary guidelines is essential for setting up effective behavioral interventions (32). Our study moves the research forward by providing novel empirical evidence, which suggests that maintaining good functional status combined with the absence of chronic diseases in older ages, could be improved by geriatricians and dieticians targeting the overall diet of older adults. For example, dietary counselling to maintain close adherence to recommended dietary guidelines could lead to appreciable improvements in the multi-dimensionally successful aging parameters.

Strengths of this study include its representative population-based sample with relatively high participation minimizing selection bias, prospective study design, use of a validated food questionnaire to collect dietary data and a comprehensive definition of successful aging. Hence, our findings are applicable to general older Australians and could also be applicable to older adults in Western countries. Second, using FFQs for self-reported dietary intake can underestimate energy intake or overestimate fruit, vegetable and dairy intakes (33). However, a comprehensive assessment of the whole diet is less subject to

measurement error than is the assessment of energy intake alone (34,35). That is because even when people under-or over-estimate the total amount they consume, the ratios of the foods that they self-report is still likely to be reflective of actual consumption (34). Nevertheless, several components of the total dietary score were designed to account for misreporting, for example, we increased the cut-point for fruit and vegetable intake per day to 3 serves and 7 serves, respectively (26). An additional limitation is the assumption that the dietary guidelines used to define diet quality indexes are based on the best available scientific knowledge, which may not necessarily be correct as it is difficult to keep dietary guidelines up to date (36). Also, because of the collinearity among foods and nutrients, we are not able to accurately determine which specific components of the total dietary score are driving the observed associations (26). Further, some of the aging outcomes were self-report and not objectively measured (e.g. respiratory function), hence, it could be subject to potential measurement errors. Also, participants compared to non-participants differed in several of the baseline characteristics (e.g. age, sex and smoking status). Hence, we cannot disregard the possibility of selection bias influencing observed associations. Finally, the variables used to construct the multidimensional successful aging outcome were available at different times e.g. chronic diseases throughout the 10 years while cognitive measures were available only at the end of follow-up. Hence, we were not able to assess the link between duration of exposure and successful aging. Such analyses may have been biased by reverse causation (1).

In summary, we show that close adherence to recommended dietary guidelines significantly increases the likelihood of reaching old age disease-free and fully functional. These findings could stimulate targeted intervention strategies that modify dietary practices of the aging population, thereby potentially preserving good functional and mental health status, and an absence of chronic diseases and disability.

Acknowledgements

The authors' responsibilities were as follows—BG and PM: study concept and design; PM: acquisition of data; AK: analysis of data; BG, VMF, JR, AK, and PM: interpretation of data; BG: drafting of the manuscript; BG, VMF, JR, AK, and PM: critical revision of the manuscript.

Conflicts of interest

No authors declare a conflict of interest.

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Table 1. Comparison of baseline characteristics of Blue Mountains Eye Study participants and non-participants

Characteristics	Normal aging (n=750)	Successful aging (n=249)	Died (n=610)	Excluded* (n=1116)	Missing data† (n=929)	P-value
Age, *yrs*	61.9 (0.3)	59.9 (0.5)	71.2 (9.4)	68.9 (9.4)	64.8 (10.2)	<0.0001
Male sex	280 (37.3)	105 (42.2)	312 (51.2)	530 (47.5)	355 (38.2)	<0.0001
Current smoking	98 (13.2)	19 (7.8)	106 (18.0)	147 (14.0)	148 (17.2)	0.002
Mean Total Diet Score	11.0 (0.1)	11.3 (0.1)	10.5 (2.3)	11.2 (2.3)	11.0 (2.4)	<0.0001

Data are presented as mean (SE) or n (%).
*Participants who were excluded from further longitudinal analyses because they had cancer, coronary artery disease and stroke at baseline.
†Participants who were excluded from analyses as they had incomplete dietary data or did not have sufficient information to characterise aging status 15 years later.

Table 2. Association between quartiles of total diet scores (or diet quality) and aging status in the Blue Mountains Eye Study from 1992-4 to 2002-4 (n=1609)

	Total Diet Score, multivariable-adjusted OR (95% CI) *			
Aging Status	1st quartile (≤9.28) n=413	2nd quartile (9.30-10.90) n=421	3rd quartile (10.93-12.60) n=399	4th quartile (≥12.62) n=376
Normal aging (n=750)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Successful aging (n=249)	1.0 (reference)	1.24 (0.80-1.92)	1.29 (0.83-2.02)	1.62 (1.04-2.53)
Died (n=610)	1.0 (reference)	1.01 (0.72-1.43)	0.89 (0.62-1.28)	0.80 (0.55-1.16)

*Adjusted for age, sex, and smoking.

Table 3. Association between quartiles of individual components of the total diet score (TDS) and aging status* over 10 years in the Blue Mountains Eye Study (n=1609)

Components of the TDS	Successful aging (%)	Normal aging (%)	Died (%)	Successful aging vs normal aging	Died vs normal aging
Vegetables					
Lowest	12.9	46.7	40.4	1.0 (ref)	1.0 (ref)
Middle	16.5	46.0	37.5	1.39 (0.95, 2.01)	0.91 (0.67, 1.23)
Highest	16.0	47.9	36.1	1.27 (0.83, 1.96)	0.83 (0.58, 1.19)
Fruits					
Lowest	11.0	47.8	41.2	1.0 (ref)	1.0 (ref)
Middle	16.7	44.4	38.9	1.67 (1.13, 2.48)	0.88 (0.65, 1.20)
Highest	17.6	49.9	32.5	1.53 (0.98, 2.37)	0.75 (0.53, 1.08)
Fish					
Lowest	12.2	45.5	42.3	1.0 (ref)	1.0 (ref)
Middle	17.3	48.0	34.8	1.35 (0.92, 1.97)	0.84 (0.62, 1.15)
Highest	15.4	45.1	39.6	1.22 (0.79, 1.90)	0.97 (0.68, 1.38)
Meat					
Lowest	14.4	49.1	36.5	1.0 (ref)	1.0 (ref)
Middle	17.4	45.7	36.9	1.33 (0.92, 1.90)	0.90 (0.66, 1.24)
Highest	12.6	45.9	41.5	0.86 (0.54, 1.35)	0.97 (0.67, 1.39)
Bread and cereals					
Lowest	10.3	44.2	45.4	1.0 (ref)	1.0 (ref)
Middle	17.0	47.4	35.6	1.44 (0.97, 2.14)	0.78 (0.57, 1.06)
Highest	18.0	47.7	34.3	1.55 (0.99, 2.40)	0.59 (0.41, 0.85)
Dairy					
Lowest	12.8	47.6	39.6	1.0 (ref)	1.0 (ref)
Middle	17.1	43.8	39.1	1.45 (1.00, 2.08)	1.03 (0.76, 1.40)
Highest	15.0	51.1	33.8	1.09 (0.71, 1.66)	0.83 (0.58, 1.17)
Biscuits and cakes					
Lowest	16.8	47.4	35.8	1.0 (ref)	1.0 (ref)
Middle	16.1	47.6	36.2	0.88 (0.61, 1.26)	0.87 (0.63, 1.19)
Highest	13.0	44.0	43.0	0.73 (0.47, 1.12)	1.05 (0.74, 1.51)
Sugar and confectionery					
Lowest	17.0	50.8	32.2	1.0 (ref)	1.0 (ref)
Middle	15.9	46.1	38.0	1.03 (0.72, 1.47)	1.01 (0.73, 1.38)
Highest	13.2	43.9	42.9	0.92 (0.59, 1.41)	0.87 (0.60, 1.27)
Non-alcoholic beverages					
Lowest	15.1	41.3	43.6	1.0 (ref)	1.0 (ref)
Middle	15.4	47.8	36.8	0.91 (0.63, 1.31)	0.67 (0.49, 0.92)
Highest	16.0	49.5	34.5	0.84 (0.55, 1.27)	0.94 (0.65, 1.34)
Kilojoules					
Lowest	15.9	47.4	36.7	1.0 (ref)	1.0 (ref)
Middle	14.9	47.4	37.6	0.85 (0.59, 1.23)	0.91 (0.66, 1.25)

Highest	16.1	44.4	39.5	0.89 (0.58, 1.37)	0.90 (0.63, 1.30)
Total METs					
Lowest	12.2	41.8	46.1	1.0 (ref)	1.0 (ref)
Middle	15.0	47.9	37.1	1.07 (0.71, 1.60)	0.80 (0.58, 1.09)
Highest	20.4	48.5	31.2	1.43 (0.93, 2.19)	0.65 (0.45, 0.93)

Metabolic Equivalents - METs
*Adjusted for age, sex and smoking status

Table 4. Association between total diet scores (TDS) and aging status in the Blue Mountains Eye Study over 10 years (n=810), presented as adjusted odds ratios and 95% confidence intervals*

	Normal aging	Successful aging	Died
TDS	n=512	n=223	n=75
Above the median (n=203)	1.0 (reference)	1.45 (1.01-2.09)	1.28 (0.69-2.37)
Below the median (n=607)	1.0 (reference)	1.0 (reference)	1.0 (reference)

*Adjusted for age, sex, and smoking.

Nutritional assessment

Briefly, TDS were allocated for intake of selected food groups and nutrients for each participant as described in the AGHE (1) (see Supplementary Table S1). The TDS is divided into ten components, and each component has a possible score ranging from 0 to 2. A maximum score of 2 was given to subjects who met the recommendations with prorated scores for lower intakes. These were then summed providing a final score ranging between 0 and 20 with higher scores indicating closer adherence to the dietary guidelines.

The TDS accounts for both food intake and optimal choice with scores allocated to reflect intake characteristics from both sources. Food intake scores were based on total intakes of vegetables, fruit, cereals and breads, meat, fish, poultry and dairy as well as sodium, alcohol, sugar and discretionary foods intakes. Optimal choices scores determined intakes of foods with greater dietary benefits including servings of whole grain cereals, lean red meat, low or reduced fat milk versus whole milk, low saturated fat intake and fish consumption. Cut points for scores were determined from the recommended number of serves given in the AGHE with some exceptions (1). We replaced the AGHE's recommended two serves per day of fruit with three serves per day and the number of vegetables consumed per day from five serves to seven serves to allow for self-reported FFQ overestimation as determined by the validity study (2). Moderate intakes of sugar were determined from the DGAA and defined as consuming <15% of total energy from sugar.(3) Discretionary foods were defined as foods that were energy dense containing higher levels of sugar, fat or salt with one serve equivalent to 600 kJ (1). Examples described in the AGHE include biscuits, cakes, soft drinks, ice cream, pies, hot chips and high-fat takeaway items. The alcohol cut-points reflect guidelines about alcohol consumption in Australia, in which it is recommended that men consume a maximum 2 standard drinks per day and women 1 standard drink per day

(3). However, we need to highlight that the 2013 Australian dietary guidelines have stipulated new alcohol cut points i.e. about 2 serves for both men and women.

The non-dietary component of the AGHE, preventing weight gain, was included in the TDS. Half the score component was assigned to energy balance, calculated as the ratio of energy intake to energy expenditure with a maximum score given for ratios falling between 0.76 and 1.24 (Online Supplemental Table 1), defined as the 95% confidence levels of agreement between energy intake and expenditure (4). The other half of the score was assigned to leisure time physical activity. Details of walking exercise and the performance of moderate or vigorous activities were used to calculate metabolic equivalents (METs) (5). Tertiles were created based on the following MET cut points: ≤600; >600 to ≤1500; and >1500. These cut points were based on the International Physical Activity Questionnaire scoring protocol (5); 600 METs is equivalent to moderate physical activity i.e. 5 x 30 minutes of moderate activity per week, which is the minimum recommendation in Australia. Subjects in the highest METs tertile scored 1 point reducing to a 0 point score for subjects in the lowest METs tertile.

Assessment of study outcomes (aging status and mortality)

We assessed chronic diseases throughout the 10-year follow-up (i.e. from BMES-1 to BMES-3). Medical history was determined by interviewer-administered questionnaire at each visit. Participants were asked whether they had ever been diagnosed by a physician with cancer, angina, acute myocardial infarction (AMI), stroke or all coronary artery disease (all available information about coronary artery diseases) at each examination. Diabetes was defined either by history of diagnosis or from fasting blood glucose ≥7.0 mmol/L. Cardiovascular function was assessed using systolic and diastolic blood pressure (BP). BP was recorded from the right arm with a mercury sphygmomanometer using a cuff size appropriate for the participant's

arm circumference, after they had been comfortably seated for at least 10 min. Respiratory function was determined by either the trained examiner observing continual shortness of breath or coughing in the participant, or if the participant reported any heart or lung symptoms at the 10-year follow-up.

Disability in walking at baseline was based on the trained examiner's observation of the participant having walking difficulties or used walking aids or a wheelchair. Additionally, at the 10-year follow-up (we did not have this measure at baseline) we also assessed perceived difficulties in basic and instrumental activities of daily living (6). Participants with difficulties in one or more activities were considered to have a disability. Functional independence was determined from self-report after 10 years. Dependence on community support services was defined as self-reported regular use of meals on wheels, homecare or community nursing. Reliance on informal support was defined as receiving assistance from someone other than a spouse (family member/ friend) for cleaning or shopping. In addition, participants' ability to go out alone was also assessed. Participants who did not report dependence on formal and informal support and were able to go out alone were defined as having functional independence.

Cognitive decline was assessed using the mini mental state examination (MMSE) questionnaire and was only available at follow-up (7). The MMSE has test components covering concentration, language and memory. MMSE scores range from 0 to 30; scores ≥24 were considered as being in good cognitive function. We assessed mental health using the Mental Health Index (MHI) component of the 36-Item Short-Form Survey (SF-36), which has previously been validated as a screening instrument to detect depressive symptoms among elderly persons (8,9). A score of <59 on the MHI is indicative of having depressive symptoms (9). Also, we administered the 10-item version of the Centre for Epidemiologic Studies Depression Scale (CES-D-10) at follow-up only. The CES-D-10 measures depressive

feelings and behaviors experienced in the past week (10). A cut-off score of ≥10 out of a total possible score of 30 was used to define participants with significant depressive symptoms (10). Participants who did not have depressive symptoms according to the MHI or CESD-10 at follow-up were considered to be in good mental health.

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Supplementary Table S1. Scoring system for the Total Diet Score (TDS) based on Australian Dietary Guidelines and the Australian Guide to Healthy Eating

Dietary Guideline / Component	Score		Component Subscore	Total Score
1. Eat plenty of vegetables, legumes and fruit	Total vegetable serves/day *	7 serves	0.5	
		5.6 serves	0.4	
		4.2 serves	0.3	
		2.8 serves	0.2	
		1.4 serve	0.1	
	Vegetable variety score/day	≥1 serve green	0.1	
		≥ 1 serve orange	0.1	
		≥ 1 serve of cruciferous	0.1	
		≥ 1 serve of tuber or bulb	0.1	
		≥ 0.5 serves of legumes	0.1	
	Total fruit serves/day**	3 serves	1	
		2 serves	0.5	2
2. Eat plenty of cereals, preferably wholegrain/meal	Total cereals serves/day			
	Women	4 serves	1	
		3 serves	0.75	
		2 serves	0.5	
		1 serve	0.25	
	Men	6 serves	1	
		5 serves	0.83	
		4 serves	0.66	
		3 serves	0.5	
		2 serves	0.33	
		1 serve	0.166	
	Wholegrain cereal serves/day			
	Women	4 serves	1	
		3 serves	0.75	
		2 serves	0.5	
		1 serve	0.25	
	Men	6 serves	1	
		5 serves	0.83	
		4 serves	0.66	
		3 serves	0.5	
		2 serves	0.33	
		1 serve	0.166	2
3. Include lean meats, fish, poultry and/ or alternatives	Meat/alternative/day	≥1 serve	1.5	
	Lean red meat / week (ie. > 0.428 /day)	≥3 serves	0.5	2
4. Include milk, yoghurts, cheese	Total dairy serves/day	≥2-3 serves	1.5	
		>3-4 serves	1.0	

Dietary Guideline / Component	Score		Component Subscore	Total Score
and/or alternatives		1-<2 serve	1.0	
		>4 serves	0.5	
		0-<1 serves	0	
	Ratio of skim/low fat (S/LF) intake to whole milk intake	S/LF>whole milk	0.5	
		S/LF=whole milk	0.25	
		whole milk>S/LF	0	2
5. Limit saturated fat and moderate total fat intake	Percentage of energy from saturated fat	<10% energy	1	
		10-12% energy	0.5	
		>12% energy	0	
	Fish serves/week	≥ 2 serves	1	
		1-<2 serves	0.5	
		<1 serve	0	2
6. Choose foods low in salt	Sodium intake/day	≤ 40mmol (920mg)	2	
		> 40- ≤100mmol (920-2300mg)	1	
		>100mmol (2300mg)	0	2
7. Limit alcohol intake if you choose to drink	Alcohol intake/day			
	Women	≥0g – <10g	2	
		>10g - <20 g	1	
		>20g	0	
	Men	≥0g-<20g	2	
		>20g	0	2
8. Consume only moderate amounts of sugars and foods with added sugars	Percentage of energy from sugar	<15% total energy	2	
		≥15-<20% total energy	1	
		≥20% energy	0	2
9. Extra foods, not essential to provide nutrients and may be high in salt, fat or sugar	Extra food serves/day			
	Women	<2.5 serves	2	
		2.5 - <4 serves	1	
		≥4 serves	0	
	Men	< 3 serves/day	2	
		3 - <5 serves	1	
		≥5 serves	0	2
10. Prevent weight gain: be physically active and eat according to energy needs	Ratio of energy intake to energy expenditure	0.76 – 1. 24	1	
		<0.76 or >1.24	0	
	Physical activity (METs)	Lowest tertile	0	
		Middle tertile	0.5	
		Highest tertile	1	2

Dietary Guideline / Component	Score	Component Subscore	Total Score
Drink plenty of water	Not scored		
Care for food	Not scored		
Total score			**20**

*Vegetables: 7 serves, as indicated by weighed food records (FFQ over-estimates) (replacing 5 serves)

**Fruit: 3 serves, as indicated by weighed food records (FFQ over-estimates) (replacing 2 serves)

Supplementary Table S2. Description of contributing factors to normal aging 10 years later

Contributing factors	Participants who aged normally (n=750)
Presence of chronic illnesses[1]	309 (41.2)
Presence of walking disability	89 (11.9)
Lack of functional independence[2]	577 (76.9)
Cognitively impaired	22 (2.9)
Any heart or respiratory related problems	404 (53.9)
Impaired activities of daily living	45 (6.0)
MHI <59 (depressive symptoms)	112 (14.9)
CES-D-10 score ≥10 (depressive symptoms)	153 (20.4)

MHI - Mental Health Index; CES-D-10 - Centre for Epidemiologic Studies Depression Scale
[1]Cancer, coronary artery disease, stroke, angina, acute myocardial infarction, and/ or diabetes.
[2]Dependent on formal and/or informal support, and/or not able to go out alone.