European Journal of Clinical Nutrition (2020) 74:588–597
https://doi.org/10.1038/s41430-019-0478-x

ARTICLE

Food and health

Older Australians are eating more protein: Secondary analysis of the 1995 & 2011/12 national nutrition surveys

Fiona O'Leary[1] · Amanda Grech[1] · Zhixian Sui[1] · Heilok Cheng[1] · Anna Rangan[1] · Vasant Hirani[1]

Received: 2 September 2018 / Revised: 3 July 2019 / Accepted: 15 July 2019 / Published online: 5 August 2019

Abstract

Background/Objectives Diet is important in healthy ageing. Protein is essential for physical function, immunity, maintaining quality of life and ability to live independently.

Subjects/Methods Protein intakes, sources and the protein content of meals and snacks among adults aged ≥65 years from the 1995 National Nutrition Survey ($n = 1960$) and the 2011/12 National Nutrition and Physical Activity Survey ($n = 2103$) were examined. Usual protein intakes were estimated using the National Cancer Institute method, and intakes and adequacy were compared between the two surveys.

Results Participants reported a higher total protein intake in 2011/12 than 1995 (81.0 vs. 73.4 g, $p < 0.001$). Mean protein intake per kg body weight (1995, 1.0 g/kg vs. 2011/12, 1.1 g/kg) and ability to meet the Australian (1995, 85% vs. 2011/12, 88%) and World Health Organisation (1995, 90% vs. 2011/12, 94%) protein requirements increased over time. Males >70 years or those with poor self-assessed health status were more likely to report inadequate protein intake compared with other respondents. Higher protein intake was associated with greater consumption of vegetables, fruit, dairy products, meat and alternatives and lower consumption of discretionary foods and alcohol. Participants obtained 17% of their protein intake from breakfast, 30% from lunch, 43% from dinner and 10% from snacks. Main protein sources included lean red meat, poultry and full cream milk.

Conclusion Specific dietary advice for older Australians, particularly older men and those with poor health, to promote healthy food choices with adequate protein content is needed for disease prevention and maintenance of quality of life.

Introduction

Achieving a healthy diet with ageing can be challenging. Decreased energy requirements in older age necessitates the careful selection of nutrient-dense foods to ensure that a high quality diet with adequate macro- and micro-nutrients is chosen [1–5]. In addition, dietary intake and nutritional status can be compromised by age-related physiological changes such as early satiety, hypogeusia, anosmia, and dental issues [6], as well as illness, and physical or psychosocial limitations [7].

Nutrient reference values (NRVs) for dietary protein are for healthy adults and are based on nitrogen balance studies [8] and indispensable amino acid requirements [9]. In most Western countries, protein recommendations for healthy adults do not change with age, with exceptions in Australia [10] and France [11] where protein recommendations increase with age. International NRVs are presented in Table 1 [10, 12].

Protein adequacy is also linked to protein quality, determined by the balance, digestibility, absorption and availability of essential amino acids for protein synthesis and estimated by the digestible indispensable amino acid score (DIAAS) [5]. DIAAS is based on a theoretical best protein comparison. Scores for animal-sourced proteins such as milk, eggs, and beef are highest (greater than 100), compared to the lower DIAAS of most plant proteins [5]. Soy flour protein has a DIAAS of 89 [13] and chickpeas of

These authors contributed equally: Anna Rangan, Vasant Hirani

Supplementary information The online version of this article (https://doi.org/10.1038/s41430-019-0478-x) contains supplementary material, which is available to authorized users.

✉ Fiona O'Leary
fiona.oleary@sydney.edu.au

[1] The University of Sydney, Nutrition and Dietetics Group, School of Life and Environmental Science, Faculty of Science & The Charles Perkins Centre, Camperdown, NSW, Australia

Table 1 International nutrient reference values for protein for older adults

g/kg/BW/day	Health Council of the Netherlands (2001)	Institute of Medicine USA (2005)	NHMRC Australia (2006)	WHO/ FAO/ UNU (2007)	AFSSA France (2007)	D-A-CH Germany (2008)
Average Requirement	0.60	0.66	M:51–70 y:0.68 >70 y:0.86 F:51–70 y:0.60 >70 y:0.75[b]	0.66	0.80	0.60
Population Reference Intake	0.80	0.80[a]	M:51–70 y:0.84 >70 y:1.07 F:51–70 y:0.75 >70 y:0.94[d]	0.83[c]	1.00	0.80

[a]Recommended Dietary Allowance

[b]Estimated Average Requirement

[c]Safe level of intake

[d]Recommended Dietary Intake

NHMRC: National Health and Medical Research Council [10]; WHO/FAO/UNU: World Health Organisation/ Food and Agriculture Organisation [12]; Agence Francaise pour la Sante et la Securite [12]; D-A-CH: Deutschland-Austria-Confoederatio Helvetica [12]

83 [14]. It has been proposed that a DIAAS of >75 is required for a minimum protein nutrition claim on packaged foods, although high quality DIAAS scores are generally >90 [5, 14].

In addition to amount and quality of protein, the meal distribution of protein influences the concentration of circulating amino acids, which subsequently may affect amino acid uptake into muscle. There is evidence from short term feeding studies that an age-related resistance of muscles to protein synthesis exists, and that greater quantities of amino acids and protein are required to initiate muscle protein synthesis in older compared to younger adults [15, 16]. Studies have shown that ingestion of different protein sources exerts different effects [17] and that 25–30 g protein per meal may be necessary to promote post-prandial muscle protein synthesis [15–17].

As diet quality may impact healthy ageing, knowledge of food consumption patterns is important to guide health policy and promotion. Although several studies have assessed older Australian's food intakes and diet quality [18, 19], none have assessed intakes of large cohorts aged over 65 years. With increasing evidence of the importance of adequate protein intakes and diet quality, our study aims were to examine the changes in protein consumption patterns in Australians aged ≥65 years in 1995 and 2011/2012; and specifically to 1. Determine protein intake and the proportion of the population with inadequate protein intakes; 2. Determine changes in protein quality and diet quality 3. Describe meal occasions and diet quality associated with protein intake. This analysis is necessary to guide the development of nutrition policy for future aging populations in Australia and elsewhere.

Methods

Australian nutrition surveys

The 1995 National Nutrition Survey (10,851 adults) and 2011–2012 National Nutrition and Physical Activity Survey (9341 adults) collected dietary 24-hour recall information on food and beverage intake, using multi-pass methods during face-to-face interviews [20, 21]. A second recall was collected in 10% (1995) and 63% (2011/12) of respondents by telephone for statistical adjustment to estimate usual intake. The scope and collection of dietary intake data were mostly similar between the surveys with results weighted to reflect the Australian population [21, 22]. Ethical approval was granted by the Australian Government Department of Health and Ageing Departmental Ethics Committee and participants provided informed consent.

Health and demographic information

Data from adults aged ≥65 years from the 1995 ($n = 1960$) and 2011/12 ($n = 2103$) surveys were used in this secondary analysis. Height, body weight (BW), and waist circumference (WC) were objectively measured, whereas demographic and health characteristics such as age, gender, educational attainment, income, employment status, country of birth, household size, self-assessed health and smoking status were self-reported in interviews with trained staff. Socio-economic quintiles were based on the Socio-Economic Index of Disadvantage for Areas (SEIFA), where lower quintiles indicated greater disadvantage [21].

The exposures and outcomes of interest were changes between surveys of: protein intake (g, g/kg BW, % energy); the proportion of adults meeting Australian and World Health Organisation (WHO)/Food and Agriculture Organisation (FAO) Estimated Average Requirements (EAR) for protein (Table 1); food sources of protein and protein quality (i.e. the percentage contribution of higher quality animal sources of protein vs. lower quality plant sources of protein); the contribution of protein at different meal occasions; and differences in diet quality (i.e. intake of five food group, discretionary choices, alcohol) of participants with higher protein intake, and between surveys.

Protein intake, usual intake and protein adequacy

Energy and protein intake data were obtained for each participant from all foods and beverages consumed using Australian Food and Nutrition Database (AUSNUT) 1999 and 2013 food composition databases, specifically developed for the 1995 and 2011/12 surveys, respectively [23, 24]. Vitamin/mineral supplements were not included. Mean protein intakes (g/kg BW/day) and % energy, and food group intakes were derived from the first day of dietary recall.

Usual intakes of protein (g/kg BW) were estimated using the National Cancer Institute (NCI) method based on two recall days [25, 26]. The distribution of the usual intake of protein was estimated for age by gender using the NCI's 'Usual Dietary Intakes: SAS Macros for Analysis of a Single Dietary Component', MIXTRAN and DISTRIB Macros. Covariates included intake day of the week (weekend, weekday) and sequence of interview (recall 1, recall 2). To estimate the within-person variation, and estimate the usual intake of protein, a minimum sample size of 50 per sub-group is required. This was met in both surveys and thus the differences in sample sizes between surveys is not expected to alter the results [21]. The proportion of participants meeting the Australian [8] and WHO/FAO [5] protein requirements were estimated with 'usual intake', using the cut-point method [25, 26].

Food groups

Foods and beverages consumed were classified according to sub-categories of the Australian Dietary Guideline database and more broadly into five food groups (grains, vegetables, fruit, dairy and alternatives, meat and alternatives) [27] or discretionary foods and beverages [21, 22]. All mixed dishes were disaggregated into these categories, using the AUSNUT 2011–13 recipe file [28, 29]. Serves of alcohol (one serve containing 10 g alcohol) were also reported separately.

Eating occasions

The 24-hour dietary recall collected detailed information on all foods and beverages consumed on the previous day, from midnight to midnight including time of consumption, and the respondent's name of eating occasion (e.g. breakfast) [22]. In this study, main meals were analysed separately as 'breakfast' (including breakfast and brunch), 'morning tea', 'lunch', 'afternoon tea', and 'dinner' (included supper), while 'others' included meal occasions such as snacks, extended eating and other unspecified eating records.

Misreporting

Misreporting of energy intake was identified in both surveys [22] using the Goldberg cut-off method [30] with potential under-reporting categorised as reported energy intake: basal metabolic rate (EI:BMR) <0.87, plausible reporting as 0.87–2.67, and over-reporting >2.67. Respondents were categorised by misreporting status for sensitivity analysis. EI:BMR was used as a continuous variable for adjustment in statistical analysis.

Statistics

Statistical analyses were performed using IBM SPSS Statistics for Windows statistical software package version 22.0 (IBM Corp, Armonk, NY, USA) and Statistical Analysis Systems statistical software package version 9.4 (SAS Institute, Cary, NC, USA). A P-value of <0.01 was considered statistically significant. All demographic, anthropometric measures and differences in consumption between the two surveys were analysed using chi-squared, independent t-tests and ANCOVA. Protein intake (g, g/kg BW, % energy) was adjusted for misreporting status. Total protein (g/kg BW) was categorised into quartiles and adjusted by age, gender, total energy intake, and potential energy misreporting. Linear trend analysis was performed to assess the relationship between quartile of protein intake and intake of food groups. Linear regression was used to assess the change in protein (g/kg BW) for socio-demographic factors for the 2011/12 survey population including age; gender; self-assessed health status; country of birth; education; smoking status; household size; employment status; income; and SEIFA. Personal weighting factors were applied to ensure the sample was representative of population estimates [31]. Most analyses required a BW measure (i.e. adjustments for energy misreporting or calculating protein g/kg BW) and participants with missing BW were excluded from analysis that required BW. Sensitivity analysis were undertaken to determine the impact of energy misreporting (excluding implausible reporters) and missing data (inclusion of participants without BW) on protein intake.

Results

Characteristics of participants

Characteristics of the study population in 1995 and 2011/12 are described in Table 2. In 2011/12, a higher percentage of participants were older, female, better educated, employed, born overseas, lived alone, non-smokers, reported higher perceived health status, compared to the 1995 survey. Under-reporting of energy intake, BMI (27.1 vs 28.3 kg/m^2, p < 0.001) and WC (92.6 vs 97.4 cm, p < 0.001) of participants ≥65 years increased between/from 1995 to 2011/12.

Protein intakes and changes from 1995 to 2011–12

Protein intakes are shown in Table 3. Compared to 1995, 2011/2012 participants reported higher absolute protein intakes (73.4 vs 81.0 g, $p < 0.0001$), protein intake per kilogram BW (1.0 vs 1.1 g/kg BW, $p < 0.0001$), percentage energy from protein (16.8% vs 18.6%, $p < 0.0001$) and energy intake (7569 vs 7665 kJ, $p = 0.0078$). Concurrent with increased protein consumption, the proportion of participants with inadequate protein intake, indicated by inability to meet the Australian EAR, decreased from 1995 to 2011/12 (15.1% to 12.0%), with >70 year old males showing higher rates of inadequate intakes (24.0% to 22.3%). A similar pattern was seen when using the WHO/FAO EAR (1995, 9.6% and 2011/12, 6.4%).

Protein quality and changes from 1995 to 2011/12

Food sources of protein by gender are described in Fig. 1. Lean red meat (<10% fat) was the main protein source at both times. Lean poultry displaced full-fat milk consumption as the second largest protein source in 2011/12. Percentage energy from protein contribution by individual food groups can be found in Supplementary Table 1. Overall, there were minor changes noted in the food sources of protein consumed from 1995 to 2011/12 (Table 4), with small increases in the contribution from animal sources (1995, 56.8% and 2011/12, 58.5%) and a corresponding decrease from plant sources (1995, 41.7% and 2011/12, 39.9%). In 2011–12, highest sources of animal protein was red meat (21.8%), followed by dairy foods (16.6%), poultry (10.4%), fish (7.3%) and eggs (2.5%). Largest sources of plant protein was from grains and cereals (22.5%), followed by vegetables (11.2%), fruits (3.1%), nuts and seeds (1.4%) and legumes (0.9%).

Protein intake and diet quality

At both times, protein intake (g/kg BW) was positively associated with consumption of most foods from the five food groups (vegetables, fruits, dairy products, and meat and alternatives) and negatively associated with discretionary foods and alcohol (Table 5).

Overall, vegetable consumption decreased, while meat and alternatives and alcohol increased from 1995 to 2011/12.

Protein intake at meals

The composition of meals for protein and food groups is shown in Supplementary Table 2. Breakfast and lunch were more protein-dense (%E protein) in 2011/12 compared with the previous survey. Overall, breakfast provided the least protein (1995, 14.0 g and 2011/12, 14.3 g), followed by

Table 2 Characteristics of Australian National Nutrition Survey participants, 1995 and 2011

		1995	2011-12	Difference 1995 vs. 2011–12
		$n = 1960$	$n = 2103$	
		Total	Total	p-value*
Demographics				
Age	(year)	72.6	73.5	<0.001
	SD	5.7	6.4	
Gender	Male	46	43.3	<0.001
Country of birth	Australia	72.2	67.4	<0.001
	English-speaking countries	13.9	15.1	
	Others	13.9	17.5	
Completed high school	Yes	15.9	25.2	<0.001
Self-assessed health	Excellent/very good	35.8	39.6	<0.001
	Good	31.6	33	
	Fair/poor	32.6	27.3	
Current smoking status	Yes	10.8	8.4	<0.001
People in household	1 person	31.1	42.9	<0.001
	2 people	59	50.1	
	3 or more	9.9	7	
Employment status	Employed	0.3	14.4	<0.001
National SEIFA quintiles	Lowest	22.7	22.6	ns
	2nd	22.8	23	
	3rd	18.4	19	
	4th	18.1	16	
	Highest	17.7	19.4	
Anthropometrics				
BMI[a]	(kg/m^2)	27.1	28.3	<0.001
	SD	4.4	5.4	
Body weight[b]	(kg)	72.2	76.6	<0.0001
	SD	14.1	16.7	
Waist circumference[c]	(cm)	92.6	97.4	<0.001
	SD	13.1	14.1	
Dietary reporting				
Potential mis-reporting	Under-reporting	17.5	18.5	<0.001
	Plausible reporting	81.4	80.1	
	Over-reporting	1.1	1.4	
Missing body weight	(%)	1.1	17	

Categorical variables are reported as a proportion of the population (%) continuous variables are reported as mean and standard deviation.

ns: not significant; SEIFA: Socio-Economic Index of Disadvantage for Areas

[a]1995 $n = 1863$; 2012 $n = 1712$; b 1995 $n = 1910$; 2012 $n = 1738$

[c]1995 $n = 1904$; 2012 $n = 1712$

*Categorical variables: p-value from chi-squared analysis; continuous variables: p-value from linear trend analysis

Table 3 Protein intakes from 1995 to 2011 by age and gender, adjusted by energy-reporting status

	1995 n =1910			2011-12 n =1738			Difference 1995 vs. 2011–12*		
	Total	M	F	Total	M	F	Total	M	F
Protein intake (g/day)									
Total	73.4	83.2	65.5	81	90.1	72.9	<0.0001	<0.0001	<0.0001
SD	23.4	25.3	20.1	23.5	23.6	21.4			
65–70 yrs	76.4	85.5	67.7	86.9	96.9	76.6	<0.0001	<0.0001	<0.0001
SD	23.9	25.2	20.5	23.2	22.8	21.3			
71–80 yrs	71.9	82.3	64.2	78.9	87.9	71.3	<0.0001	<0.01	<0.0001
SD	22.8	25.2	19.4	23.2	24.2	20.7			
≥ 81 yrs	69.1	78.3	63.3	73.3	77.5	70.3	ns	ns	<0.01
SD	21.8	23.3	19.7	23.2	22.3	22.5			
Protein intake (g/kg BW/day)									
Total	1	1.1	1	1.1	1.1	1.1	<0.0001	ns	<0.0001
SD	0.3	0.3	0.3	0.3	0.3	0.3			
65–70 yrs	1.1	1.1	1	1.1	1.2	1.1	<0.0001	<0.01	<0.01
SD	0.3	0.3	0.3	0.3	0.3	0.3			
71–80 yrs	1	1.1	1	1.1	1.1	1.1	ns	ns	ns
SD	0.3	0.3	0.3	0.3	0.3	0.3			
≥ 81 yrs	1.1	1.1	1	1.1	1.1	1.1	ns	ns	ns
SD	0.3	0.3	0.3	0.3	0.3	0.4			
Energy from protein (%)									
Total	16.8	16.6	17	18.6	18.1	19	<0.0001	<0.0001	<0.0001
SD	4.9	5.1	4.9	5	4.7	5.2			
65–70 yrs	16.7	16.5	16.9	18.9	18.8	19.1	<0.0001	<0.0001	<0.0001
SD	4.9	5	4.8	4.7	4.5	4.9			
71–80 yrs	17	16.7	17.3	18.5	17.9	19.1	<0.0001	<0.01	<0.0001
SD	5.1	5.2	5	5.2	5	5.3			
≥ 81 yrs	16.4	16.6	16.2	17.9	17	18.5	<0.001	ns	<0.0001
SD	4.6	4.4	4.6	4.8	4.2	5.2			
Not meeting WHO AR (%)[b]									
Total	9.6	8.2	10.8	6.4	5.1	7.5	0.0005	0.0102	0.012
65–70 yrs	9.5	8.2	10.8	5.8	3.8	7.6	0.0087	0.0123	0.1240
>70 yrs	9.7	8.2	10.8	6.9	6.0	7.5	0.0198	0.2147	0.6279
Not meeting Australian protein EAR (%)[a]									
Total	15.1	16.5	14	12	14.8	10.2	0.018	0.356	0.0188
65–70 yrs	7.6	8.2	7.1	4.6	4.6	4.7	0.037	0.08	0.238
>70 yrs	21.1	24	19	17.4	22.3	13.7	0.024	0.447	0.0237

Note. Continuous variables are adjusted for energy-reporting status

BW body weight

[a]EAR: Estimated Average Requirements (g/kg/day) for Australians:

Males 65–70 years: 0.68; > 70 years: 0.86; Females 65–70 years: 0.60; > 70 years: 0.75 ns: not statistically significant

[b]*WHO AR:*World Health Organisation: Average requirement 0.66 g protein/kg BW/day

*Proportions: p-values from chi-squared test; continuous variables: p-values from linear trend analysis

lunch (1995, 22.6 g and 2011/12, 25.2 g, $p < 0.01$), with the highest protein intake at dinner (1995, 35.8 g and 2011/12, 35.7 g). Protein intake at midmeals was low ranging from 3.3 to 6.3 grams per occasion in 1995 and 4.1 to 8.1 g in 2011/12.

Linear regression analysis

Lower income, living alone, poorer health status, lower educational attainment and lower SEIFA were all associated with lower protein intakes (g/kg BW), with and without adjustment

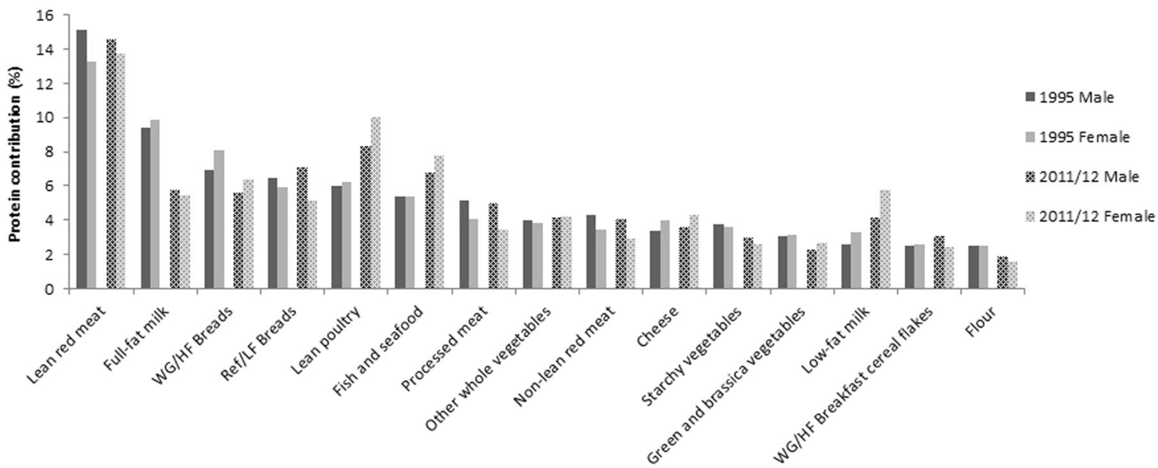

Fig. 1 Food sources of protein by gender. Lean red meat has fat content <10%; Lean poultry has fat content <10%; Non-lean red meat has fat content >10%. Other whole vegetables include whole vegetables categorised as 'Other vegetables' by the Australian Dietary Guidelines, such as tomato, celery, sprouts, zucchini, squash, avocado, capsicum, eggplant, mushrooms, cucumber, okra, and pumpkin. WG/HF: wholegrain/high fibre Ref/LF: refined grain/low fibre

Table 4 Proportion of protein contribution (%) by source

Protein source	Mean	
	1995	2011/12
Animal sourced foods		
Red meats	22.7	21.8
Poultry	6.1	10.4
Fish and seafood	5.4	7.3
Milk	13.3	10.9
Cheese	3.7	3.9
Yoghurt	0.8	1.2
Eggs	2.3	2.5
Plant sourced foods		
Grains and cereals	24.3	22.5
Vegetables	12.4	11.2
Fruit	3.5	3.1
Nuts and seeds	0.7	1.4
Legumes and tofu	0.7	0.9

Note: all categories includes processed and unprocessed and all fat types

for age and gender, but were non-significant after adjustment for energy intake and/or energy misreporting status. In the multiple regression model, only self-assessed health status was associated with mean protein intake (g/kg BW) after adjustment for age, gender, misreporting status and energy intake ($R^2 = 0.6162$, $p < 0.0001$). Mean protein g/kg BW was positively correlated with self-assessed health status ($p = 0.0016$).

Sensitivity analysis

In unadjusted analyses including all respondents (Supplementary Table 3), percentage energy from protein was similar or higher, and g/kg BW/day and g/day were lower, compared to the analysis adjusted by misreporting status. In unadjusted analysis of plausible reporters only (Supplementary Table 4), the percentages not achieving the Australian EAR were lower (1995, 3.9% and 2011/12, 5.2%), but trends were similar across surveys, ages and gender. No significant difference was found when participants with and without BW were included in the analysis for mean protein intake (g/day) (1995, $p = 0.675$ and 2011/12, $p = 0.126$) or percentage energy from protein (1995, $p = 0.587$ and 2011/2, $p = 0.8364$).

Discussion

Our findings show that protein intake as percentage of energy and g/kg BW, energy intake, and BW in adults aged ≥65 years have increased since 1995. In 2011/12, 88% of older Australians had adequate protein intake. However, a small percentage (12%) did not achieve the Australian EAR for protein, with males and those aged >70 years more likely to have inadequate intake. Comparisons with the WHO/FAO recommendations show 6% of Australians did not meet the WHO/FAO EAR for protein in 2011/12. Protein intake was positively correlated with intake of foods from the five food groups at both times, excepting grains, indicating better diet quality. Further, protein intake as g/kg BW daily was positively correlated with self-assessed health status.

Australian older adults are higher protein consumers compared with many other countries; however, comparing intakes needs to consider the similarity and likely differences due to the dietary method used. American males and females aged 60–69 years consumed 90 and 65 g/day from 2013/14 National Health and Nutrition Examination Survey data [32]

Table 5 Dietary sources of protein by quartiles of protein intake (grams/kg body weight/day), from 1995 to 2011 (Mean and SD)

Quartile protein intake (g/kg BW)[a]		1995 (n =1910)						2011–12 (n =1738)					
		Q1 ≤0.83	Q2 0.84–1.06	Q3 1.07–1.34	Q4 >1.34	Total	Trend p-value*	Q1 ≤0.86	Q2 0.87– 1.1	Q3 1.20–1.42	Q4 >1.42	Total	Trend p-value*
Food intake													
Grains	(g)	190	188	209	213	196	0.082	197	191	188	178	184	0.48
	SD	174	145	143	174	141		172	146	142	170	142	
Vegetables	(g)	225	272	291	381	283†	<0.0001	199	226	246	286	233†	<0.0001
	SD	227	189	187	228	193		233	197	192	230	194	
Fruit	(g)	213	240	256	209	226	0.006	209	218	191	237	212	0.048
	SD	280	233	230	280	224		260	221	215	257	226	
Dairy products	(g)	211	279	285	318	264	<0.0001	214	234	278	289	259	0.0002
	SD	267	222	220	267	228		271	230	224	268	229	
Meat and alternatives	(g)	48.4	92.6	134	223	115†	<0.0001	59.9	114	177	266	141†	<0.0001
	SD	103	85.6	84.6	103	106		121	103	100	120	107	
Discretionary choices	(serves)	5.6	4.6	4.0	2.6	4.4	<0.0001	5.4	4.8	3.9	2.6	4.3	<0.0001
	SD	2.6	2.1	2.2	2.4	2.2		3.0	2.5	2.4	2.9	2.5	
Alcohol	(g)	13.8	10.3	8.9	4.3	9.6†	<0.0001	21.2	14.0	13.6	5.5	13.0†	<0.0001
	SD	21.1	17.7	17.5	21.2	21.4		29.3	24.8	24.2	29.0	21.3	

Note. All values adjusted for age, gender, energy intake, energy intake and misreporting status *BW* body weight

**p*-values for trend across quartiles with ANCOVA

†*p*-value differences 1995 to 2011/12: $p < 0.0001$

which used a similar one day multi-pass 24-hour recall method, compared to 99 and 77 g/day for Australians aged 65–70 years in 2011/12; with a similar pattern noted in those aged ≥71 years. Percentage energy from protein was also higher in Australia (18.6%) compared to America (16.0%) [33]. Participants aged ≥85 years in the British Newcastle 85+ Study [34], used 2 days of multi-pass 24-h recalls, indicating that British elderly consumed less protein than Australians aged ≥81 years (mean 0.99 vs 1.1 g/kg BW/day).

Consistent with our Australian data, males in other countries also consume more protein than females, with higher daily protein intakes for American adult males than females, aged 60–69 years [32]. The European Prospective Investigation into Cancer and Nutrition study in those aged 65–74 years, used one 24-hour recall and found intakes varied across Europe, with the highest intake in Spain (140 vs 86 g/day) and lowest in Greece (79 vs 57 g/day) [35]. Older Australian men (mean 81.4 years age) in the Concord Health and Ageing in Men study, with dietary intake assessed using diet history reported a median protein intake of 99 g/day [19], similar to our findings.

The majority of older adults met their protein needs; however, even with this higher protein intake, in 2011/12, 12% of older Australian adults and 22.3% of males aged >70 years did not meet the Australian EAR, while 6% did not meet WHO/FAO AR for protein. This discrepancy in rates of those not meeting recommendations was due to the higher EAR in Australia for those >70 years compared with the Average Requirement given by the WHO/FAO. For example, the EAR for males >70 years in Australia is 0.86 g/kg BW/day compared to the WHO/FAO Average Requirement of 0.66 g/kg BW/day. The only significant factor associated with protein intake as g/kg BW was self-assessed health status, suggesting that protein intake declines with illness and difficulties managing activities of daily living, common issues in aging. There is some evidence that there may be benefits of higher protein intakes in protecting against the development of age-related syndromes including sarcopenia and frailty [15, 36–38]; however the evidence is mixed [39].

We found that 59% of protein came from high quality protein foods, mainly meat, fish, poultry and products, while 40% was provided by plant foods. This is similar to other Western countries [40] and to Dutch community-dwelling elderly [4]. The main food groups contributing to protein intake at both times were similar, but Australians increased fish, seafood and poultry consumption in 2011/12 [41], while protein intake from dairy and grain foods decreased. The percentage contribution of lean red meat was similar, and remains the main contributor to protein intake, providing ~14% of total intake daily. Lean red meat is a nutrient-dense food containing essential nutrients, such as zinc and vitamin B_{12}, but high intake is associated with increased rates of colorectal cancer [42], stroke [43, 44] and coronary heart disease [44].

Meal patterns remained similar at both times, with the smallest protein intakes at breakfast and largest at the evening meal, which is similar to other studies [4, 16]. Some researchers have suggested that 25–30 g protein per meal may be a dietary strategy to help maintain muscle mass and function in older people [16, 45] but to date there are few studies [46] and more research is needed.

Diet quality of older people overall has changed between 1995 and 2011/12, with decreased vegetable consumption [47], but increased consumption of meat and alternatives, fruit, and alcohol. In our study, those with higher protein intakes (g/kg BW) had better quality diets, including more vegetables, dairy products, and meat and alternatives, and lower consumption of discretionary foods, beverages and alcohol. We found no change in daily discretionary foods, however, at an average of 4 serves per day, this exceeds the recommended maximal two serves daily [27].

Energy intake overall increased from 1995 to 2011/12, corresponding to higher BW. Energy intake at meals was similar at both times for lunch and dinner, but energy intake at breakfast decreased while 'other' eating occasions increased. Snacking frequency has been positively associated with discretionary food and added sugar intake in men [48] and suggests more research into the snacking behaviours of older people is warranted to assist in the development of healthy snacking messages.

This study is the first to provide results on protein intakes in a large representative sample Australians aged ≥65 years. Survey differences were apparent but these reflected changes in socio-demographic characteristics from 1995 to 2011/12. The coding, retention and the use of adjustment techniques, means that all data were retained. The use of 24-hour dietary recall allowed people to report detailed food and beverage consumption and all mixed dishes were disaggregated to account for completeness of the five food groups.

Energy under-reporting was common in both surveys, with a small but significant increase from 1995 (17.5%) to 2011/12 (18.5%). Consistent with the general population, overweight or obese participants were more likely to under-report energy intake [49]. Despite this, energy and protein intake increased between the surveys. Validation studies using biomarkers have demonstrated that dietary energy intake is under-reported to a greater extent than protein intake, indicating that foods higher in fat, carbohydrate and alcohol are more likely to be under-reported and protein is more accurately represented in dietary surveillance [50], and may reflect social desirability bias. Given this, our findings clearly indicate the need to prioritise and encourage consumption of nutrient-dense foods, particularly for those that would benefit from higher protein intake or improved diet quality.

Conclusions

This study demonstrates increased protein intake, energy intake and BW in older Australians since 1995. Even with increased BW, protein intake as g/kg BW increased; however, 12% of older Australians did not achieve their recommended intake for protein. Poorer self-assessed health status was associated with lower protein intake.

Older age is a time of increasing disease risk, but adequate protein intake and good diet quality may help to alleviate some consequences of age-related disease risk. Specific nutritional advice for older Australians is needed in order to promote healthy food choices and their specific benefits for disease prevention and quality of life.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Publisher's note: Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

1. Nowson C, O'Connell S. Protein requirements and recommendations for older people: a review. Nutrients 2015;7:6874–99.
2. de Groot L, van Staveren W, Horwarth C. Nutrition and ageing. In: Mann J, Truswell SA, eds. Essentials of human nutrition. 5th edn. Oxford: Oxford University Press; 2017. p. 546–61.
3. National Health and Medical Research Council, Department of Health and Ageing, New Zealand Ministry of Health. Introduction Australia2017 (updated 22 September 2017). Available from: https://www.nrv.gov.au/introduction.
4. Tieland M, Borgonjen-Van den Berg KJ, Van Loon LJ, de Groot LC. Dietary protein intake in Dutch elderly people: a focus on protein sources. Nutrients 2015;7:9697–706.
5. Food and Agriculture Organisation. Report of an FAO Expert Consultation. Dietary protein quality evaluation in human nutrition. Report of an FAQ Expert Consultation. Rome 2013. Report No. 0254-4725.
6. O'Connor J, Milledge K, O'Leary F, Cummings R, Eberhard J, Hirani V Poor dietary intake of nutrients and food groups are associated with increased risk of periodontal disease among community-dwelling older adults: a systematic literature review. Nutrition Reviews. (2019).
7. Nowson CA, Service C, Appleton J, Grieger JA. The Impact of Dietary Factors on Indices of Chronic Disease in Older People: A Systematic Review. J Nutr Health Aging 2018;22:282–96.
8. Rand WM, Pellett PL, Young VR. Meta-analysis of nitrogen balance studies for estimating protein requirements in healthy adults. Am J Clin Nutr. 2003;77:109–27.
9. World Health Organisation. Protein and amino acid requirements in human nutrition. World Health Organization technical report series. 2007(935):1–265.
10. National Health and Medical Research Council. Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes. In: Health Mo, editor. Canberra: Commonwealth of Australia 2006.
11. Agence française de sécurité sanitaire des aliments (French Food Safety Agency). Protein intake: dietary intake, quality, requirements and recommendations. France: Republic of France 2007.
12. European Food Safety Authority. Scientific Opinion on Dietary Reference Values for protein. EFSA Panel on Dietetic Products, Nutrition and Allergies. EFSA. 2015;10:2557.
13. Mathai JK, Liu Y, Stein HH. Values for digestible indispensable amino acid scores (DIAAS) for some dairy and plant proteins may better describe protein quality than values calculated using the

concept for protein digestibility-corrected amino acid scores (PDCAAS). Br J Nutr 2017;117:490–9.
14. Marinangeli CPF, House JD. Potential impact of the digestible indispensable amino acid score as a measure of protein quality on dietary regulations and health. Nutr Rev 2017;75:658–67.
15. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. J Am Med Dir Assoc 2013;14:542–59.
16. Paddon-Jones D, Campbell WW, Jacques PF, Kritchevsky SB, Moore LL, Rodriguez NR, et al. Protein and healthy aging. Am J Clin Nutr 2015;101:1339s–45s.
17. Gorissen SH, Remond D, van Loon LJ. The muscle protein synthetic response to food ingestion. Meat Sci 2015;109:96–100.
18. Thorpe MG, Milte CM, Crawford D, McNaughton SA. A comparison of the dietary patterns derived by principal component analysis and cluster analysis in older Australians. Int J Behav Nutr Phys Act 2016;13:30.
19. Waern RV, Cumming RG, Blyth F, Naganathan V, Allman-Farinelli M, Le Couteur D, et al. Adequacy of nutritional intake among older men living in Sydney, Australia: findings from the Concord Health and Ageing in Men Project (CHAMP). Br J Nutr 2015;114:812–21.
20. Australian Bureau of Statistics. National Nutrition Survey Users' Guide 1995. Canberra, Australia: ABS; 1996.
21. Australian Bureau of Statistics. Australian Health Survey: Users' Guide, 2011-13 Canberra, Australia; 2013.
22. Australian Bureau of Statistics. Australian Health Survey: Nutrition First Results - Foods and Nutrients, 2011-12 Canberra, Australia: Australian Bureau of Statistics; 2014 Available from: http://www.abs.gov.au/ausstats/abs@.nsf/lookup/4364.0.55.007main+features12011-12.
23. Australia New Zealand Food Authority. AUSNUT: Australian Food and Nutrient database 1999 for estimation of dietary intake. Canberra, Australia: Australia New Zealand Food Authority; 1999.
24. Food Standards Australia New Zealand. AUSNUT 2011-13 food nutrient database Canberra, Australia: Food Standards Australia New Zealand; 2014 [Available from: http://www.foodstandards.gov.au/science/monitoringnutrients/ausnut/foodnutrient/Pages/default.aspx.
25. Tooze JA, Kipnis V, Buckman DW, Carroll RJ, Freedman LS, Guenther PM, et al. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: the NCI method. Stat Med 2010;29:2857–68.
26. Tooze JA, Midthune D, Dodd KW, Freedman LS, Krebs-Smith SM, Subar AF, et al. A new statistical method for estimating the usual intake of episodically consumed foods with application to their distribution. J Am Diet Assoc 2006;106:1575–87.
27. National Health and Medical Research Council. Australian Dietary Guidelines. Canberra: National Health and Medical Research Council; 2013.
28. Food Standards Australia New Zealand. Australian Food, Supplement and Nutrient Database (AUSNUT) Canberra, Australia: Food Standards Australia New Zealand; 2014 (updated April 2016). Available from: http://www.foodstandards.gov.au/science/monitoringnutrients/ausnut/pages/default.aspx.
29. Food Standards Australia New Zealand. Food recipe file Canberra, Australia: Food Standards Australia New Zealand, 2014 (updated 24 April 2016). Available from: http://www.foodstandards.gov.au/science/monitoringnutrients/ausnut/ausnutdatafiles/Pages/foodrecipe.aspx.
30. Black AE. The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying diet reports of poor validity. Eur J Clin Nutr 2000;54:395–404.
31. Australian Bureau of Statistics. Australian Health Survey: Nutrition First Results- Foods andNutrients, 2011-12 Canberra2014 [updated 09/05/2014. Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0072011-12?OpenDocument.
32. U.S. Department of Agriculture, Agricultural Research Service. Nutrient Intakes from Food and Beverages: Mean Amounts Consumed per Individual by Gender and Age. NHANES2013-2014; 2016.
33. U.S. Department of Agriculture, Agricultural Research Service. Energy Intakes: Percentages of Energy from Protein, Carbohydrate, Fat, and Alcohol, by Gender and Age. NHANES2013-2014; 2016.
34. Mendonca N, Granic A, Mathers JC, Hill TR, Siervo M, Adamson AJ, et al. Prevalence and determinants of low protein intake in very old adults: insights from the Newcastle 85+ Study. Eur J Nutr. 2017;57:2713–22.
35. Halkjaer J, Olsen A, Bjerregaard LJ, Deharveng G, Tjonneland A, Welch AA, et al. Intake of total, animal and plant proteins, and their food sources in 10 countries in the European Prospective Investigation into Cancer and Nutrition. Eur J Clin Nutr 2009;63 (Suppl 4):S16–36.
36. Morley JE, Argiles JM, Evans WJ, Bhasin S, Cella D, Deutz NEP, et al. Nutritional Recommendations for the Management of Sarcopenia. J Am Med Dir Assoc 2010;11:391–6.
37. Beasley JM, Shikany JM, Thomson CA. The Role of Dietary Protein Intake in the Prevention of Sarcopenia of Aging. Nutr Clin Pract 2013;28:684–90.
38. Artaza-Artabe I, Saez-Lopez P, Sanchez-Hernandez N, Fernandez-Gutierrez N, Malafarina V. The relationship between nutrition and frailty: Effects of protein intake, nutritional supplementation, vitamin D and exercise on muscle metabolism in the elderly. A systematic review. Maturitas 2016;93:89–99.
39. Bhasin S, Apovian CM, Travison TG, Pencina K, Moore LL, Huang G, et al. Effect of Protein Intake on Lean Body Mass in Functionally Limited Older Men: A Randomized Clinical Trial. JAMA Intern Med 2018;178:530–41.
40. European Food Safety Authority. Dietary reference values for nutrients: Summary report. 2017.
41. Sui Z, Raubenheimer D, Cunningham J, Rangan A. Changes in Meat/Poultry/Fish Consumption in Australia: From 1995 to 2011-2012. Nutrients 2016;8:753–64.
42. World Cancer Research Fund, American Institute for Cancer Research. Diet, nutrition, physical activity and colorectal cancer. 2017.
43. Kim K, Hyeon J, Lee SA, Kwon SO, Lee H, Keum N, et al. Role of Total, Red, Processed, and White Meat Consumption in Stroke Incidence and Mortality: A Systematic Review and Meta-Analysis of Prospective Cohort Studies. J Am Heart Assoc 2017;6:e005983.
44. Bechthold A, Boeing H, Schwedhelm C, Hoffmann G, Knuppel S, Iqbal K, et al. Food groups and risk of coronary heart disease, stroke and heart failure: A systematic review and dose-response meta-analysis of prospective studies. Crit Rev food Sci Nutr. 2017;59:1–20.
45. Pennings B, Groen B, de Lange A, Gijsen AP, Zorenc AH, Senden JM, et al. Amino acid absorption and subsequent muscle protein accretion following graded intakes of whey protein in elderly men. Am J Physiol Endocrinol Metab 2012;302:E992–9.
46. Cheng H, Kong J, Underwood C, Petocz P, Hirani V, Dawson B, et al. Systematic review and meta-analysis of the effect of protein and amino acid supplements in older adults with acute or chronic conditions. Br J Nutr. 2018;119:527–42.
47. Australian Bureau of Statistics. Australian Health Survey: Consumption of Food Groups from the Australian Dietary Guidelines, 2011-12 Canberra, Australia; 2014.
48. Leech RM, Livingstone KM, Worsley A, Timperio A, McNaughton SA. Meal Frequency but Not Snack Frequency Is

Associated with Micronutrient Intakes and Overall Diet Quality in Australian Men and Women. J Nutr 2016;146:2027–34.
49. Tomoyasu NJ, Toth MJ, Poehlman ET. Misreporting of total energy intake in older men and women. J Am Geriatr Soc 1999;47:710–5.
50. Subar AF, Kipnis V, Troiano RP, Midthune D, Schoeller DA, Bingham S, et al. Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: the OPEN study. Am J Epidemiol 2003;158:1–13.