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ZINC AND PROTEIN STATUS IN THE ELDERLY

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Protein and zinc status were assessed in 24 community based and 66 institutionalised elderly Australians, aged 60 to 99 years. Serum albumin concentrations were significantly related to both protein intake ($r = 0.36, P < 0.001$) and zinc intake ($r = 0.33, P < 0.001$). Plasma zinc concentrations were not related to zinc intake ($r = 0.12, P > 0.05$) or to protein intake ($r = 0.007, P > 0.05$). Thus in aged persons with low serum albumin, it would appear useful to consider both protein and zinc intake.

Introduction

Advances in health care have increased lifespan. In 1978, 9.2 per cent of the Australian population was over 65 years of age (Cameron, 1980) more than double that in 1947 (Australian Population and Immigration Council, 1979). The health of these aged persons must be optimised.

Recent evidence suggests that a Western diet may place certain groups at risk of zinc deficiency (Sandstead, 1973; Freeland-Graves, Bodzy & Eppright, 1980; Holt *et al.*, 1980; Dreosti, 1980) and one may be the elderly (Greger & Sciscoe, 1977; Vir & Love, 1979; Flint *et al.*, 1979). Changes associated with aging such as decreased taste acuity (Greger & Geissler, 1978; Henkin, Graziadel & Bradley, 1969) and delayed wound healing (Henkin, 1974; Sandstead *et al.*, 1970) may be, in part, the result of dietary deficiency of zinc (Solomons *et al.*, 1979; Sandström & Cederblad, 1980*a*; Prasad, 1979). Zinc plays an important role in several human metabolic pathways (Hsu, 1979; Vallee, 1976). DNA and RNA polymerase are zinc metallo-enzymes so that zinc nutriture may influence protein synthesis (Hsu, 1979; Vallee, 1976). Daily zinc supplementation has also been found to increase serum albumin concentrations in a group of hypoalbuminaemic and hypozincaemic aged persons (Wahlqvist *et al.*, 1981).

One of the major determinants of plasma zinc concentration appears to be serum albumin concentration, as albumin is one of the zinc binding plasma proteins (Boyett & Sullivan, 1970; Giroux, 1975; Prasad & Oberleas, 1970) and total plasma zinc and serum albumin have been correlated (Solomons, 1979; Vir & Love, 1979; Giroux, Durieux & Schechter, 1976; Walker *et al.*, 1973).

Sixty to 70 per cent of circulating zinc is loosely bound to albumin, and 30-40 per cent is bound tightly to an α_2-macroglobulin (Boyett & Sullivan, 1970; Giroux, 1975; Parisi & Vallee, 1970; Schechter *et al.*, 1976; Walker *et al.*, 1973). A minor fraction is chelated to amino acids (Prasad & Oberleas, 1970; Giroux & Henkin, 1972).

As part of a larger nutritional study, zinc and protein status and their interrelationship were assessed in both community and institutionalised aged persons.

Subjects and methods

Elderly subjects, 60 years of age and over, who were free from acute illness were selected from the community and from a geriatric institution. The community based elderly subjects (10 m, 14 f) were selected by a two stage cluster sampling technique (Flint *et al.*, 1979). The institutionalised subjects (13 m, 53 f) were randomly selected from those who had been institutionalised for three months or more. From the Australian Bureau of Census and Statistical Data of the 1976 census, a random selection of people over 70 years of age was obtained from the randomly selected collectors' districts. This method was devised to obtain a representative sample of elderly people in the community.

Zinc and protein intake

Dietary intake data on the community elderly were assessed by the method of Burke (1947). The intake of institutionalised subjects was assessed by three days of weighed food intake. A dietitian visited the house of each subject and all interviews were performed by the same dietitian. Household measures, serving utensils and food models were used to estimate portion size. The intake of institutionalised subjects was assessed by three days, one of which included a weekend day, of weighed food intake. The food served to each subject was weighed, and also that not eaten. The amount of food consumed was obtained by difference. All food weighings were conducted by the same dietitian. Recipes from the institution were consulted to estimate the component parts of the food consumed by each subject. McCance and Widdowson's Food Composition Tables (1979) were used to estimate the nutrient intake. The adequacy of energy, protein and zinc intakes was evaluated according to the recommendations of the National Health and Medical Research Council of Australia (1979) and the Food and Nutrition Board, National Academy of Sciences, Washington (1980).

Plasma zinc and serum albumin concentrations

All glassware used in the analyses were acid washed and rinsed in deionised distilled water to minimise zinc contamination. Samples of each batch of disposable needles and plastic syringes were checked for zinc contamination.

After an overnight fast, blood was obtained by venipuncture from the antecubital fossa and transferred immediately to plastic vials with and without lithium heparinisation. Within an hour of collection, tubes were centrifuged at 3000 rpm for 15 minutes.

Plasma for zinc analysis was removed from the heparinised tubes with acid washed pasteur pipettes and stored in 1 ml aliquots in polypropylene tubes at -20 °C until assay. Where haemolysis was evident samples were considered as unsuitable for zinc analysis and discarded, as erythrocytes contain zinc in association with carbonic anhydrase (Underwood, 1977). One ml aliquots of serum were also stored in polypropylene tubes at -20 °C until assay for albumin.

Zinc was analysed by flame atomic absorption spectrophotometry (Varian Technicon Model AA6) by the method of Meret & Henkin (1971). Working standards were checked against those from the National Bureau of Standards.

Serum albumin was measured on a Roche Centrifichem 300, using a Roche standard albumin assay kit, which is based on the bromocresol green method (Dow & Pinto, 1969).

Statistical analyses

Comparisons of community and institutionalised elderly were made with Student's *t*-test. Relationships were assessed by linear correlation coefficient (*r*) where applicable and by multiple regression analysis.

Results

Subjects

The institutionalised elderly were older than the community group ($P < 0.001$) (Table 1). Body weight was less in the institutionalised elderly than for the community elderly ($P < 0.001$) (Table 1).

Table 1. Age and weight of elderly subjects (mean ± s.e.m. range in parenthesis)

	Community			Institutionalised		
	Total (n = 24)	Males (n = 10)	Females (n = 14)	Total (n = 66)	Males (n = 13)	Females (n = 53)
Age (Yrs)	76.2 ± 0.8 (70.1-87.3)	79.0 ± 1.3 (72.3-87.3)	74.2 ± 0.6 (70.1-78.5)	82.2 ± 1.1** (60.7-98.9)	80.2 ± 2.1 (68.9-96.5)	82.7± 1.2** (60.7-98.9)
Weight (Kg)	67.9 ± 1.9 (51.0-86.8)	71.2 ± 2.5 (54.0-83.0)	65.4 ± 2.6 (51.0-86.8)	57.4 ± 1.9** (35.0-92.5)	60.3 ± 3.3* (40.0-82.0)	56.5 ± 1.6** (35.0-92.5)

Significance of difference from the community is indicated as *$P<0.05$; **$P<0.001$

Dietary intake

Different dietary methods were used to assess the intakes of community and institutionalised elderly, but these methods were the best available to estimate the food intake of these two elderly groups. The dietary history method is subject to observer bias (Black, 1981), but as all the interviews were conducted by a skilled dietitian, observer bias would be negligible.

The community elderly had significantly higher intakes of energy, protein and zinc than the institutionalised elderly ($P < 0.001$) (Table 2).

Eleven per cent (7 subjects) of the institutionalised elderly consumed less than two-thirds of the allowance for energy (7600 kJ for a 55 kg 65 year-old man plus 400 kJ for every 5 kg increase; 5800 kJ for a 40 kg 65 year-old woman plus 200 kJ for every 5 kg increase), whilst the energy intake by all community subjects was adequate.

Eight per cent (2 subjects) of the community elderly and 14 per cent (9 subjects) of the institutionalised group had less than 12 per cent of energy intake in the form of protein. On the basis of a recommended 0.8 g protein per kilogram body weight (Irwin & Hegsted, 1971), four per cent (1 subject) of the community and 21 per cent (14 subjects) of institutionalised elderly had low intakes. There was no significant difference between groups in the protein intake per kg body weight (Table 2).

Twenty-one per cent (5 subjects) of the community elderly and 85 per cent (56 subjects) of the institutionalised had zinc intakes of less than two-thirds of

Table 2. Daily nutrient intakes of elderly subjects (mean ± s.e.m., range in parentheses)

	Community			Institutionalised		
	Total (n = 24)	Males (n = 10)	Females (n = 14)	Total (n = 66)	Males (n = 13)	Females (n = 53)
Energy (kJ)	8325 ± 451 (5408-13277)	9917 ± 786 (5408-13277)	7188 ± 270 (6101-9415)	6952± 348* (3254-12838)	7503 ± 392** (4815-10428)	6817 ± 289 (3254-12838)
Protein (g)	69.9 ± 3.4 (49.9-114.7)	80.4 ± 6.3 (55.2-114.7)	62.5 ± 2.2 (49.9-73.2)	55.7 ± 2.1** (29.7-100.1)	60.0 ± 5.0* (37.1-93.7)	54.6 ± 2.2* 29.7-100.1)
Protein (g/kg)	1.06 ± 0.05 (0.7-1.5)	1.14 ± 0.08 (0.7-1.5)	1.01 ± 0.05 (0.8-1.4)	1.00 ± 0.1 (0.6-1.9)	0.99 ± 0.06 (0.6-1.5)	1.00 ± 0.04 (0.6-1.9)
% energy from protein	14.4 ± 0.6 (7.0-19.6)	13.9 ± 1.3 (7.0-19.6)	14.3 ± 0.5 (10.0-17.0)	13.8 ± 0.3 (7.8-20.2)	13.7 ± 0.8 (8.7-18.7)	13.8 ± 0.9 (7.8-20.2)
Zinc (mg)	11.0 ± 0.5 (7.3-17.2)	11.8 ± 0.9 (7.3-17.2)	10.4 ± 0.5 (7.6-14.4)	7.6 ± 1.1** (3.5-26.9)	8.1 ± 1.0* (4.4-18.6)	7.4 ± 0.5** (3.5-26.9)
Zinc (mg/kg)	0.164 ± 0.008 (0.10-0.26)	0.167 ± 0.013 (0.10-0.26)	0.163 ± 0.011 (0.11-0.23)	0.135±0.008* (0.06-0.52)	0.135 ± 0.016 (0.06-0.30)	0.135 ± 0.010 (0.06-0.52)

Significance of difference from the community is indicated as $^*P<0.05$; $^{**}P<0.001$.

the recommended dietary allowance for zinc (15 mg per day). When zinc intake was expressed in terms of body weight, the difference between the elderly groups was still significant (Table 2).

There was a significant correlation between protein and zinc intake for the total population (n = 90; r = 0.81; P < 0.001) (Fig. 1).

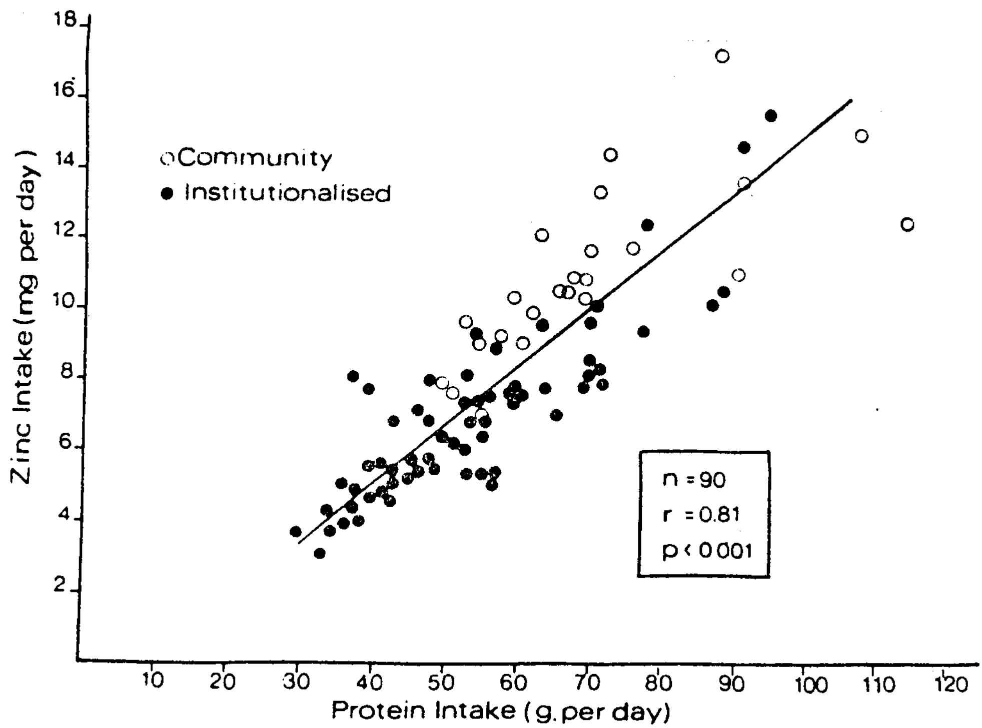

Fig. 1. Relationship between zinc intake and protein intake in elderly Australians

Plasma zinc and serum albumin concentrations
The mean plasma zinc concentrations for the institutionalised was not significantly different from that for community elderly (Table 3). However, 20 per cent (5 subjects) of the community and 29 per cent (19 subjects) of institutionalised elderly had plasma zinc concentrations of less than 12.2 μmol/l (Prasad *et al.*, 1978). The mean serum albumin concentration for the institutionalised elderly

Table 3. Serum albumin concentrations and plasma zinc in elderly subjects (mean ± s.e.m., range in parentheses)

	Community			Institutionalised		
	Total (n = 24)	Males (n = 10)	Females (n = 14)	Total (n = 66)	Males (n = 13)	Females (n = 53)
Serum albumin (g/l)	39.3 ± 1.2 (20.4-48.4)	39.1 ± 1.4 (32.2-48.3)	39.4 ± 1.9 (20.4-48.4)	34.1 ± 0.4** (27.2-42.9)	33.5 ± 0.8** (27.2-38.6)	34.2 ± 0.4** (28.4-42.9)
Plasma zinc (μmol/l)	13.6 ± 0.4 (9.8-17.6)	13.8 ± 0.6 (11.2-16.5)	13.5 ± 0.5 (9.8-17.6)	14.0 ± 0.3 (8.8-20.3)	13.1 ± 0.9 (8.8-20.3)	14.2 ± 0.3 (9.7-18.5)

Significance of difference from the community is indicated as *P<0.05; **P<0.001.

was significantly lower ($P < 0.001$) than for the community elderly (Table 3). Eight per cent (2 subjects) of the community and 25 per cent (16 subjects) of institutionalised elderly had serum albumin levels of less than 32 g/l.

There was no relationship between plasma zinc and serum albumin concentration in the population studied ($n = 90$; $r = 0.07$). No significant relationship was found between plasma zinc and age ($n = 90$; $r = -0.05$), but a significant negative correlation was obtained between serum albumin concentration and age ($n = 90$; $r = -0.27$; $P < 0.05$).

Dietary and biochemical correlates
In the total population there was a significant relationship between serum albumin and protein intake ($n = 90$; $r = 0.36$; $P < 0.001$) and between serum albumin and zinc intake ($n = 90$; $r = 0.33$; $P < 0.001$) (Figs 2,3).

Determinants of serum albumin
Multivariate analysis was applied to assess the relative predictive values of age, protein intake and zinc intake on serum albumin.

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3$$

Serum albumin; Age; Protein intake; Zinc intake

$$= 37.28 - 0.081\,X_1 + 0.062\,X_2 + 0.13\,X_3$$

Multiple correlation coefficient = 0.39
F-ratio = 5.238, $P < 0.01$.

Although the equation itself has predictive value, none of the regression coefficients has a significant F-value. No advantage is conferred over univariate analysis. The same is true of the equation which has protein intake and zinc intake, but not age, as independent variables (F-ratio = 6.803, $P < 0.01$ with non-significant regression coefficients).

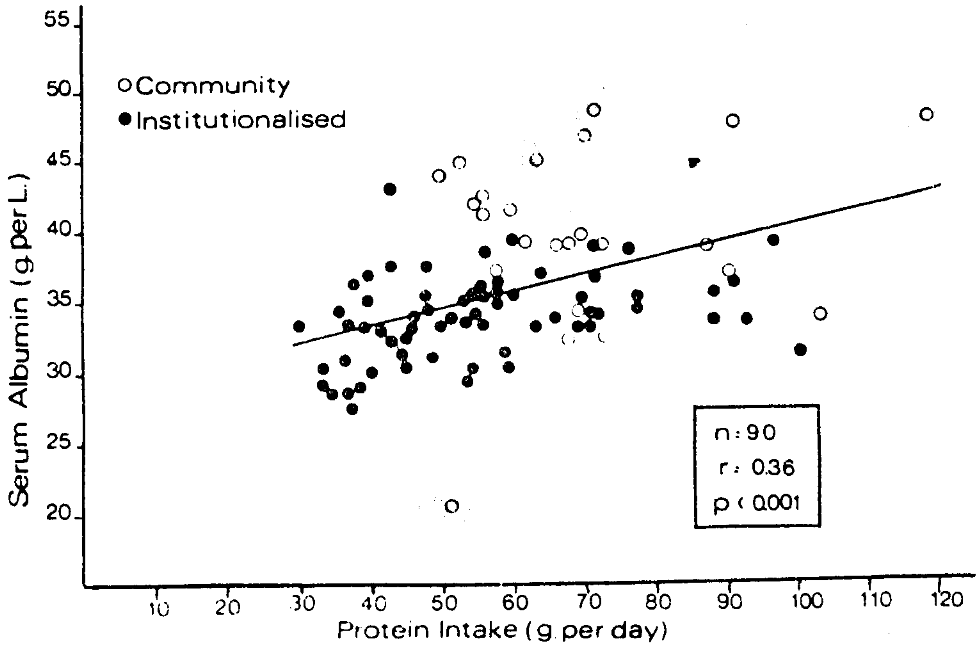

Fig. 2. Relationship between serum albumin and protein intake in elderly Australians

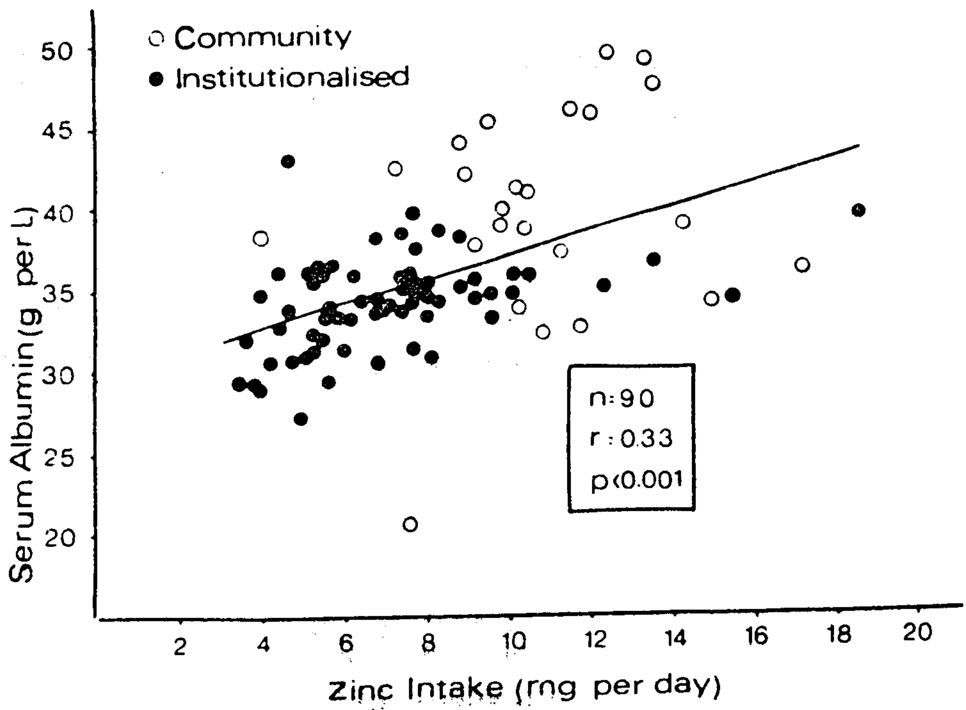

Fig. 3. Relationship between serum albumin and zinc intake in elderly Australians

Discussion

Protein

Protein intake was low in relatively more institutionalised than community elderly. An increased need for protein during stress and infection, to which this population are subject, would need to be taken into account as well (Young, 1976).

Zinc

Zinc intake by community based and institutionalised aged persons was low when compared to the US Recommended Dietary Allowance (Food and Nutrition Board, 1980). The nutritional significance of this is not clear. The composition of the diet is of importance for the ability to utilise zinc (Sandström *et al.*, 1980*a*). Institutionalised elderly consumed lower amounts of dietary fibre than those in the community (Flint & Wahlqvist, unpublished data), and this should have allowed zinc to be more bio-available in the former group (Reinhold *et al.*, 1976). Zinc absorption is also influenced by the amount of protein (Sandström *et al.*, 1980*b*).

Plasma zinc levels have been reported to decline with age (Lindeman, Clark & Colmore, 1971), but no decline was observed in this study. This may be due to the age range of the subjects studied as no comparison was made with younger subjects. However, in this study the mean plasma zinc concentration is similar to that reported in subjects with an average age less than 60 years (Lindeman *et al.*, 1971) and also to that found by others in the elderly (Wagner *et al.*, 1980).

Doubt has been expressed about the usefulness of plasma zinc in the assessment of zinc nutriture (Walker *et al.*, 1979). It is only one of the body's zinc compartments. In the present investigation plasma zinc was not related to zinc intake. However, the relationship of zinc intake to serum albumin suggests that the latter may be a functionally important measurement of zinc status.

Serum albumin level has been related to age in this study, in confirmation of previous work (Greenblatt, 1979). Serum albumin has also been related to each of protein and zinc intake. However, when these three independent variables were used together in the same multiple regression equation, none had a significant regression coefficient. It has, therefore, not been possible to determine the relative predictive power of these variables in this age group. Previous work has shown that hypoalbuminaemic elderly people respond to 50 mg zinc daily with a rise in serum albumin concentrations (Wahlqvist *et al.*, 1981). This would indicate that zinc intake itself can influence serum albumin in selected patients.

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