Risk of malnutrition and zinc deficiency in community-living elderly men and women. The Tromsø Study

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Abstract

Objective: Elderly people may be at particular risk of zinc deficiency due to an increased prevalence of malnutrition. The aim of this study was to evaluate the zinc status in community-living elderly people at risk of malnutrition.

Design: Cross-sectional population-based survey. Individuals at risk of malnutrition were identified by the Malnutrition Universal Screening Tool. Zinc status was assessed by measuring serum zinc. Logistic regression was performed to evaluate the association between the risk of malnutrition and zinc deficiency.

Setting: Municipality of Tromsø, Norway

Subjects: Random sample of 743 men and 778 women aged 65-87 years old.

Results: Zinc deficiency was found in 10.1% of the participants, including 13.1% of the men and 7.3% of the women. Among the men and women at risk of malnutrition, 31% and 12.7%, respectively, had zinc deficiency. In a model adjusted for age, gender, serum albumin and smoking status, zinc deficiency was positively associated with the risk of malnutrition (odds ratio 2.2 [95% confidence interval 1.3-3.6]).

Conclusion: Overall, zinc deficiency was found in one out of ten community-living elderly people and was associated with the risk of malnutrition. Our results encourage the assessment of zinc status in elderly people at risk of malnutrition, with a special emphasis on elderly men.

Introduction

Zinc is an essential micronutrient present in all body tissues and fluids. It is contained in a large number of enzymes. Second only to iron, zinc is the most abundant trace element in humans (1). Mild zinc deficiency may be associated with impaired taste and smell, reduced immunity and increased risk of pneumonia (2, 3). In cases of severe zinc deficiency, skin lesions, anaemia, diarrhoea, anorexia, decreased lymphocyte function, impaired visual function and mental retardation may be observed (4). An increased risk of depression in individuals with zinc deficiency has been previously reported (5). At present, community-based research on the impact of zinc deficiency on mental health is scarce.

Important causes of reduced body zinc include a low intake of zinc-containing foods and a decreased absorption of zinc due to intestinal malabsorption (2). Meat is a good source of zinc. Additionally, plant-based foods contain zinc. However, phytate in many plants reduces the bioavailability of zinc from those plants. Worldwide, zinc deficiency is regarded as a significant contributor to the disease burden, especially among children in developing countries (6). In the developed part of the world, elderly people may be at particular risk for zinc deficiency due to an increased prevalence of malnutrition (7). However, previous studies from Belgium and the United Kingdom exploring the relationship between malnutrition and zinc deficiency in elderly individuals have yielded conflicting results (8, 9).

Moreover, previous studies addressing zinc status in the general population of elderly men and women have mostly included a limited number of participants; only a few larger population-based studies of zinc status in elderly people have been conducted. The prevalence of zinc deficiency has been found to be between 6 and 15% (10).

Therefore, in the present study, we aimed to evaluate both the zinc status and the association between zinc deficiency and risk of malnutrition in a large sample of community-living elderly individuals.

Methods

Study population

The Tromsø Study is a population-based health study of the population of Tromsø, a town with 70,000 inhabitants in Northern Norway (11). The 6th Tromsø Survey was conducted between October 2007 and December 2008 (12). We restricted our analysis to participants

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between 65 and 87 years of age, and all inhabitants in this age group (n=6098) were invited. A total of 4017 men and women participated by going to a study center for data collection, yielding an overall participation rate of 66% (4017/6098). Serum from all participating individuals was frozen, and the serum zinc and albumin were later analysed in a random selection of 1765 individuals. The blood collection tubes were free of trace elements and the needles were of standard type. Information on weight loss, height or weight was missing for 200 subjects. Due to laboratory technical problems, 44 samples were discarded. Consequently, a population of 1521 men and women were included in the analysis.

Zinc and albumin analysis

Non-fasting venous blood samples were collected for the measurement of zinc and albumin using trace metal-free tubes to avoid contamination. The samples were frozen and stored at -70°C, and the serum zinc was analysed later using flame atomic absorption at a wavelength of 213.9 nm (Perkin Elmer AAnalyst 800 Atomic Absorption Spectrophotometer). Serum zinc concentrations have diurnal variations, with the highest values present in the morning and slightly reduced values present after food intake later in the day (13). The International Zinc Nutrition Consultative Group (IZiNCG) recommended different serum zinc cut-off values according to gender (men or women), fasting state (non-fasting or fasting) and time of measurement (AM or PM) (13). In the present study, the participants visited the research centre between 8 AM and 5:30 PM. According to the IZiNCG guidelines, we applied the non-fasting AM or PM cut-off values for men and women depending on attendance time, i.e., cut-offs of 10.7 μmol/L (AM) and 9.3 μmol/L (PM) for men and 10.1 μmol/L (AM) and 9.0 μmol/L (PM) for women. Zinc deficiency was defined as a serum zinc level below these cut-off values.

Because a large proportion of zinc in the serum is bound to albumin (13), an additional assessment of the serum albumin was necessary using the bromocresol green method (Hitachi Modular P, Roche). The lower reference for serum albumin was 34.0 g/L.

Nutritional assessment

Height and weight were measured without shoes and in light clothing. Body mass index (BMI) was calculated as weight divided by the square of height (kg/m^2). The participants were asked if they had involuntarily lost weight during the last six months and, if so, how

many kilograms (kg) they had lost. The weight loss was grouped as either below 5%, between 5% and 10% or above 10% of body weight prior to weight loss. Based on both the BMI and degree of weight loss, we categorised each subject as being at low, medium or high risk of malnutrition, according to the Malnutrition Universal Screening Tool (MUST) (Figure 1). This tool also has an acute disease component (associated with a lack of nutritional intake for >5 days) that, in our analyses, was set to zero because all of the participants presented at the research centre and were thus regarded as not acutely ill. The weight loss question in the present study was slightly modified to address weight loss over a time span of the "last 6 months", but this encompass the time span of the "last 3-6 months" in the original 'MUST' tool. The British Society of Parenteral and Enteral nutrition (www.bapen.org.uk) developed the 'MUST' tool (14) and is one of the nutritional screening instruments recommended by the European Society for Parenteral and Enteral nutrition for use in non-institutionalised elderly (15).

Mental health, sociodemographic characteristics and life style factors

We also aimed to study the association between zinc deficiency and mental health. The Hopkins Symptoms Check List-10 (SCL-10) was utilised to assess mental health distress. The SCL-10 is a self-administered instrument that primarily explores symptoms of anxiety and depression (16). The ten items of the SCL-10 were part of the self-administered questionnaire that was included in the invitation to participate in the survey. The questionnaire was collected at the research centre. A higher SCL-10 score indicates a greater number of symptoms (score ranging between 1.0 and 4.0).

An important source of zinc in the Western diet is meat (17). Frequency of meat intake during the preceeding week, smoking habits and sociodemographic variables were also obtained from the self-administered questionnaires.

Statistical analysis

Differences between both men and women and participants according to zinc status were analysed using the t-test, chi-square test or Mann-Whitney U test (Tables 1 and 3). The associations between risk of malnutrition (medium and high risk combined) and zinc deficiency were analysed using logistic regression, yielding odds ratio (OR) estimates with 95% confidence intervals (CIs) (Figure 2). The OR estimates were adjusted for age, smoking status and serum albumin. The SCL-10 score was positively skewed, and the median SCL-10

values with 25-75% interquartile (IQ) ranges are reported. Two-sided p-values <0.05 were considered statistically significant. The analyses were performed using SPSS statistical software version 19.0 (SPSS Inc., Chicago, Illinois, USA).

Each participant provided written informed consent. The study was conducted according to the guidelines of the Declaration of Helsinki.

Results

A total of 743 men and 778 women were included in the analysis. A risk of malnutrition (medium and high risk combined) was found in 8.0% of the participants, more often in women (10.4%) than in men (5.5%). BMI did not differ between men and women; however, former smoking was more common in men than in women (Table 1).

The mean serum zinc value was 11.9 μmol/L in both men and women (range 4.8-20 μmol/L) (Table 1). The prevalence of zinc deficiency was 10.1% among all participants, with rates of 13.1% in men and 7.3% in women. Among participants at risk of malnutrition, zinc deficiency was found in 31.7% of the men and 12.3% of the women (Figure 2). With increasing age, zinc deficiency was more prevalent in both men and women (Table 2). The mean albumin level was 45.1 g/L (range 35.7-51.9 g/L), and the albumin level was slightly lower in zinc-deficient individuals (Table 3).

The association between zinc deficiency and risk of malnutrition was further analysed using logistic regression. Zinc deficiency was positively associated with the risk of malnutrition both in a model adjusted for gender only (OR 2.6 [1.6-4.2]) and in a model adjusted for gender, age, smoking status and serum albumin (OR 2.2 [95% CI 1.3-3.6]).

The reported weekly frequency of meat intake was not lower in the participants with zinc deficiency (Table 3). Mental health distress, as assessed by the SCL-10 score, was reported more frequently by women than by men (Table 1). However, no significant differences in mental health distress were found between the two categories of zinc status in men or women (Table 3).

Discussion

In this population-based study of elderly men and women, we found that, based on a low serum zinc concentration, one out of ten individuals had zinc deficiency. However, in elderly men at risk of malnutrition, one out of three had zinc deficiency. In women, the corresponding proportion was lower, but the value was still significantly increased compared with that in women not at risk of malnutrition.

Prevalence of zinc deficiency in elderly individuals

Previous studies of zinc status in elderly individuals largely explored smaller populations, and various cut-offs for zinc deficiency have been applied. A Norwegian study of home-living elderly individuals revealed that 4 out of 97 participants had serum zinc levels below 8 µmol/L (18). In a European multicentre study that included 853 elderly individuals from Italy, Greece, Germany, France and Poland, a slightly higher cut-off (11.0 µmol/L) was used, resulting in the classification of 31% of the participants as zinc-deficient (5). Applying the same cut-off value to the present study sample would have revealed a similar zinc deficiency prevalence rates (28%).

In the present study, the prevalence of zinc deficiency increases significantly with increasing age (Table 2). Some previous studies of zinc deficiency compared the old and oldest old subjects, but most studies included a small number of participants. In the Zenith study of 387 participants from France, the UK and Italy, the prevalence of zinc deficiency was similar between old and oldest old subjects (19). However, in another study from Italy, the oldest old had significantly lower levels of plasma zinc compared with the old (20). This age-associated increase in zinc deficiency may be explained by several factors, including both an age-related decline in the absorptive capacity of the small bowel and a general decline in energy and food intake in the oldest old (10).

Risk of malnutrition and zinc deficiency

The relationship between the risk of malnutrition and serum zinc was previously explored in a study of 50 hospitalised patients using the Mini Nutritional Assessment tool (8). In that study, no association was found between zinc status and the risk of malnutrition. A population-based study of elderly individuals using the 'MUST'-tool showed lower mean zinc values in individuals at risk of malnutrition (9). However, the proportion of malnourished elderly individuals with zinc deficiency was not estimated.

Several mechanisms may explain the observed associations between malnutrition and zinc deficiency. First, zinc deficiency may produce altered taste and smell, resulting in reduced appetite and consequent weight loss and malnutrition (21). Second, a reduced intake of zinc-containing food in malnourished elderly individuals may result in reduced body zinc. In Western diets, meat (beef and pork) is the most important source of zinc, contributing approximately 50% of the total zinc intake (17).

The recommendations for the intake of zinc are similar for elderly and other adult individuals. In the present study, no association was found between the reported intake of meat per day and zinc deficiency. However, more detailed information regarding the intake of zinc-containing foods was not available; in general, it may be difficult to obtain valid data concerning food habits from self-administered questionnaires (22).

One strength of the present study is the strictly population-based design and the relatively large study population. The Tromsø study includes populations from both urban and rural areas and may be regarded as relatively homogeneous with respect to both ethnicity and living conditions. The external validity (to other countries) of our results regarding the association between risk of malnutrition and zinc deficiency in community-living elderly individuals may, of course, be questioned, but it is likely that the positive relationship between the two variables that we demonstrate is generalizable. There is, however, a need for more studies in diverse populations which may confirm or refute our conclusions.

A potential problem is the assessment of zinc status by serum zinc as only a small proportion of the body zinc is present in the serum pool.The assessment of zinc status is challenging and several biomarkers and methods have been suggested, such as the measurement of zinc in hair, erythrocytes and serum or plasma. However, serum (or plasma) zinc is the recommended method for the assessment of zinc status in larger populations (23, 24). The optimal indicator of individual zinc status has not been identified, and caution should be used when applying serum (or plasma) zinc in an individual setting.

Furthermore, we did not collect information about sources of zinc such as micronutrient supplementation containing zinc and the consumption of zinc-fortified foods. Participation in the study required the ability to fill out a self-administered questioionnaire and to visit a

research centre. These requirements may have led to a bias in the sampling because elderly people with cognitive decline or mental illness may have been less willing to participate in the study. The blood collection tubes were free of trace elements, but the needles were of standard type. Thus, the needles may have introduced contamination with zinc and increased the plasma zinc concentration.

The level of serum zinc may be related to that of serum albumin. The majority of zinc in the serum is bound to albumin, and it has been proposed that a reduction of zinc-binding sites in hypoalbuminaemia may influence the serum zinc level. However, a reduced zinc status may also inhibit albumin synthesis (25). Although albumin is not a reliable marker of nutritional status, a reduction in serum albumin can be observed in some patients with malnutrition. This reduction may be explained by coexisting comorbidity and inflammation (26). We therefore compared serum albumin levels between the low and normal zinc groups. The albumin levels were lower in both men and women with zinc deficiency. However, no individuals exhibited an albumin level below 35 g/L, which is regarded as the cut-off value defining a significant effect of albumin level on serum zinc concentration (13). Moreover, the inclusion of albumin in the model of the relationship between zinc deficiency and malnutrition only slightly changed the odds ratio estimate.

No significantly high levels of zinc were detected in this study sample. High levels of serum zinc occur only during supplementation with zinc (13), and in Norway, supplements containing significant amounts of zinc are primarily obtained by prescription. No data on supplementation consumption was available in the present study.

Zinc is not often analysed in clinical practice, as other micronutrients are more closely associated with specific functions. As an example, iron and folate are required for haemoglobin production, the deficiency of which can be manifested by anaemia and is thus more easily detected. In contrast, zinc is necessary for general metabolism, and manifestations of any deficiency may therefore be more elusive than those associated with other micronutrients (25).

Impact of zinc deficiency
The impact of mild to moderate zinc deficiency has not been fully explored. Previous research has provided evidence for the impairment of the T-lymphocyte balance due to such

deficiency, resulting in an impaired immune system and moderate zinc deficiencies in elderly men and women (27). Studies of nursing home residents suggested an increased level of pneumonia in zinc-deficient individuals and a reduction in the risk of pneumonia following zinc supplementation (28).

Furthermore, some studies have linked zinc deficiency to depression and other psychiatric disorders, mostly based on studies of psychiatric in- and out-patients (29, 30). We used the SCL-10 instrument for the assessment of psychiatric symptoms. This instrument has been widely used in epidemiological studies including elderly people. The SCL-10 captures symptoms of both anxiety and depression, which often appear together as comorbid disorders (16). However, in the present study, we found no association between zinc deficiency and symptoms of anxiety or depression in community-living elderly individuals.

Conclusion

In this population-based study, we found zinc deficiency to be associated with the risk of malnutrition. Overall, zinc deficiency was found in one out of ten community-living elderly people. Although caution should be taken when applying serum (or plasma) zinc as an indicator of individual zinc status, our results support a special attention on zinc deficiency in elderly people at risk of malnutrition, particularly elderly men.

Table 1 Characteristics of participating elderly men and women, The Tromsø study*

	All (n=1521)	**Men** (n=743)	**Women** (n=778)	p-value[†]
Age, mean (SD)	71.9 (5.6)	71.3 (5.3)	72.4 (5.8)	<0.01[‡]
Smoking status				
Never smoked % (n)	35.5 (528)	22.8 (167)	47.8 (361)	
Previous smokers % (n)	49.4 (736)	62.2 (456)	37.0 (280)	<0.01[§]
Current smokers % (n)	15.1 (225)	15.0 (110)	15.2 (115)	
Nutritional status				
BMI (kg/m^2), mean (SD)	26.9 (4.1)	27.0 (3.5)	26.9 (4.6)	0.89[‡]
Medium/high risk of malnutrition, % (n)	8.0 (122)	5.5 (41)	10.4 (81)	<0.01[§]
Laboratory values				
Serum zinc (μmol/L), mean (SD)	11.9 (1.8)	11.9 (1.8)	11.9 (1.7)	0.94[‡]
Serum zinc (μmol/L), range	4.8-20.0	4.8-18.3	7.6-20.0	
Serum zinc deficiency, % (n)	10.1 (154)	13.1(97)	7.3 (57)	<0.01[§]
Albumin (g/L), mean (SD)	45.1 (2.3)	45.3 (2.2)	44.8 (2.3)	<0.01[‡]
Mental health score				
SCL-10 score, median (interquartile range)	1.1 (1.0-1.3)	1.1 (1.0-1.3)	1.2 (1.1-1.5)	<0.01[|]

*There are minor differences in the number of evaluated individuals due to variations in missing values on the self-administered questionnaire regarding smoking

[†] p-value for differences between men and women according to the [‡]t test, [§]chi-square test or [|]Mann-Whitney U test

Table 2 Prevalence (%) of zinc deficiency in different age categories of elderly men and women, The Tromsø study.

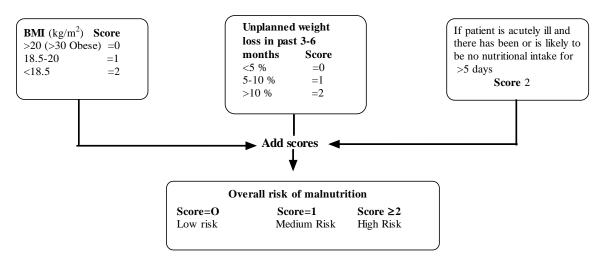| Age range (years)	All	Men	Women
64-71	8.9 (75/843)	12.0 (53/441) [†]	5.5 (22/402)
72-78	9.4 (43/456)	12.0 (26/217)	7.1 (17/239)
79-87	16.2 (36/222)	21.2 (18/85)	13.1 (18/137)
p-value*	0.005	0.07	0.005

*p-value for linear by linear association between age categories
[†] % (number of subjects with zinc deficiency/number of subjects in the age group)

Table 3 Characteristics of the participating elderly men and women* according to zinc status, The Tromsø study.

	Men (n=743)			Women (n=778)		
	Zinc status			Zinc status		
	Zn-deficient (n=97)	Zn-normal (n=646)	*p*-value[†]	Zinc-deficient (n=57)	Zn-normal (n=721)	*p*-value[†]
Age, mean (SD)	72.2 (5.9)	71.2 (5.2)	0.02[‡]	74.7 (6.5)	72.2 (5.7)	0.07[‡]
Single marital status, % (n)	26.8 (26)	22.4 (145)	0.41[§]	63.2 (36)	49.8 (359)	0.07[§]
Smoking status						
Never, % (n)	27.7 (26)	22.1 (141)		56.4 (31)	47.1(330)	
Previous, % (n)	58.5 (55)	62.8 (401)	0.48[§]	30.9 (17)	37.5 (263)	0.41[§]
Current, % (n)	13.8 (13)	15.2 (97)		12.7 (7)	15.4(108)	
Nutritional status						
Medium/high risk of malnutrition, % (n)	13.4 (13)	4.3 (28)	0.01[§]	17.5 (10)	9.8 (17)	0.07[§]
Nutritional intake						
Meat intake ≤ 3 times/week, % (n)	20.2 (18)	18.8 (114)	0.85[§]	34.7 (17)	28.1 (181)	0.41[§]
Mental health						
SCL-10 score, median (interquartile range)	1.1 (1.0-1.3)	1.1 (1.0-1.2)	0.93[ǀ]	1.2 (1.1-1.5)	1.2 (1.1-1.4)	0.77[ǀ]
Supplementary laboratory values						
Albumin (g/L), mean (SD)	44.3 (2.4)	45.5 (2.2)	<0.05[‡]	43.6 (2.7)	44.9 (2.2)	<0.05[‡]

*There are minor differences in the number of evaluated individuals due to variations in missing values on the self-administered questionnaire regarding smoking.

[†] *p*-value for differences between groups according to the [‡]t test, [§]chi-square test or [ǀ]Mann-Whitney U test

BMI (kg/m^2) Score	Unplanned weight loss in past 3-6 months Score	If patient is acutely ill and there has been or is likely to be no nutritional intake for >5 days
>20 (>30 Obese) =0	<5 % =0	Score 2
18.5-20 =1	5-10 % =1	
<18.5 =2	>10 % =2	

Add scores

Overall risk of malnutrition

Score=O	Score=1	Score ≥2
Low risk	Medium Risk	High Risk

The "Malnutrition Universal Screening Tool" is reproduced here with the kind permission of BAPEN (British Association for Parenteral and Enteral Nutrition). For further information on 'MUST and management guidelines, see www.bapen.org.uk.

Figure 1 The Malnutrition Universal Screening Tool (MUST) is composed of a BMI score, a weight-loss score and an acute illness component. The risk of malnutrition can be assessed based on the sum of these scores.
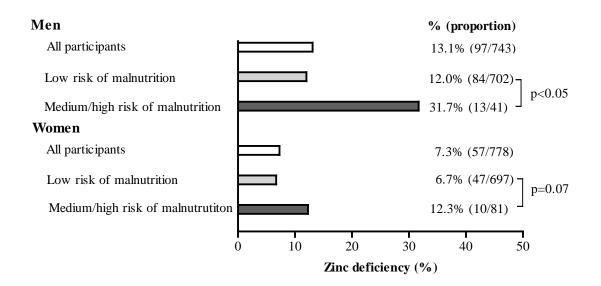
Figure 2 Zinc deficiency given as % (proportions) for all men and women, as well as for low and medium/high risk categories of malnutrition, The Tromsø study.

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