Dietary habits and their association with blood pressure among elderly Icelandic people

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ABSTRACT

Objective: Prevalence of hypertension, the most common risk factor for cardiovascular disease in elderly people, increases with age. The aim of the study was to investigate the association between diet and blood pressure in elderly Icelanders, with focus on cod liver oil, and to compare their diet to dietary guidelines.

Material and methods: Diet was assessed using three-day weighed food records and blood pressure was measured after a 12-hour-fast in 236, 65-91 years old, Icelanders living in the capital area of Iceland. 99 men (42%) and 137 women (58%) participated in the study.

Results: According to Nordic nutrition recommendations, intake of nutrients was above lower intake levels among the majority of participants. However, 19% were under this level for vitamin-D, 13% for iodine, 17% of men for vitamin-B6, and 26% and 12% of men and women, respectively, for iron. Systolic blood pressure was inversely associated with cod liver oil intake, even when adjusted for age, body mass index, gender, and antihypertensive medication (P=0.01). Intake of long-chain omega-3 fatty acids correlated with blood pressure in a similar way. Other dietary factors were not associated with blood pressure.

Conclusion: The results indicate that intake of cod liver oil is associated with lower blood pressure among elderly people and may therefore have beneficial effects on health. A notable proportion of participants were at risk of vitamin D, vitamin B6, iodine, and iron deficiency.

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Introduction

The risk of chronic disease is strongly associated with age but improved dietary habits and other lifestyle factors, such as physical activity, can reduce its prevalence among elderly people.[1]

Hypertension is the most prevalent risk factor for cardiovascular disease in elderly people,[2] and an investigation of the association between diet and blood pressure is therefore an important area of research.

Evidence suggests that certain dietary factors, such as long-chain omega-3 fatty acids (EPA and DHA) from fish oil, can in some cases lower blood pressure in individuals with hypertension if they are ingested regularly over a period of time.[3] Fish oil intake is relatively high in Iceland, especially from cod liver oil, which is a characteristic feature of the Icelandic diet.

Dietary assessment is necessary to be able to investigate the association between health and diet and to find out if dietary recommendations are being followed. The aim of the study was to assess the dietary intake of elderly people in the Reykjavik area in Iceland and to investigate the association between certain dietary factors and blood pressure, with an emphasis on cod liver oil intake. We hypothesized that cod liver oil intake would be associated with lower blood pressure. To our knowledge, this is the first study to examine the influence of dietary factors on blood pressure in elderly Icelanders.

Materials and methods

The current study is a part of a randomized dietary intervention study designed to investigate the effect of different milk-based supplement drinks on the efficacy of resistance training among elderly Icelanders. This descriptive observational study is based on dietary assessment and blood pressure measurements that took place prior to the start of the intervention study. In an observational study, factors of interest are observed without being affected in any way by the investigators.

Participants

Participants (N = 236) ranged in age from 65 to 91 years and consisted of 99 men (42%) and 137 women (58%). Volunteers were recruited by advertisement posters in Hrafnista,a residential and nursing home, in Hafnarfjörður, a town within the capital area of Iceland. Exclusion criteria were age under 65 years, low cognitive function (Mini-Mental State Examination (MMSE) <19 points), evidence of coronary heart disease, major orthopaedic disease, and pharmacological interventions with exogenous testosterone or other drugs known to influence muscle mass (e.g. anabolic steroids, growth hormone, insulin-like growth factor 1). Furthermore, all participants had to be free of any musculoskeletal disorders or other disorders that could have affected their ability to complete training and testing.

Assessment of dietary intake

Diet was assessed using a 3-day weighed food record. Participants weighed and recorded their food intake for three consecutive days, two weekdays and one weekend day. Instructions on how to record the diet were given orally and in writing. The participants were provided with electronic scales (PHILIPS HR

Table I. *Mean values (± standard deviation) of age (years), body weight (kg), height (cm), body mass index (BMI, kg/m²), energy intake (kcal/day), basal metabolic rate (kcal/day), and systolic and diastolic blood pressure (mmHg) for all participants (n = 236). The table also presents the number of participants using antihypertensive drugs.*

	Men	Women
Age, years	74.6 (± 5.9)	72.8 (± 5.9)
Weight, kg	93.9 (± 16.7)	74.6 (± 13.1)
Height, cm	177.5 (± 7.6)	162.9 (± 5.6)
BMI, kg/m2	29.7 (± 4.6)	28.1 (± 4.9)
Basal metabolic rate, kcal/day	1741.3(± 264.5)	1329.6 (± 137.0)
Systolic blood pressure, mmHg	150.6 (± 20.6)	139.8 (± 18.2)
Diastolic blood pressure, mmHg	77.9 (± 10.1)	74.8 (± 9.5)
Use of antihypertensive drugs, n	60	64

2393) and were asked to record all food items and drinks. The results of the food records were typed into an online food calculation program based on the ISGEM databank (2011), which contains data on the composition of foods on the Icelandic market.

Dietary nutrient and food intake was evaluated by comparison with Icelandic and Nordic Nutrition Recommendations[4], recommended daily intakes, average requirements, lower intake levels, upper intake levels, and acceptable macronutrient distribution range, expressed as percentage of total energy intake.

Blood pressure measurements

Baseline fasting blood pressure was measured with a Medisana upper arm blood pressure monitor (Medisana AG, Neuss, Germany). All blood pressure measurements were performed by one of two nurses with the participant still and relaxed in a sitting position with the upper right arm exposed. . During the measurements the subject did not engage in conversation and his/her arm was allowed to rest on a desk so that the antecubital fossa was at approximately the same level as the heart. Two readings were taken at intervals of two minutes and the average of those readings represented the subject's blood pressure. The average of three measurements was used when the difference between the first two readings was greater than 10 mmHg. Stage one hypertension was defined as systolic blood pressure (SBP) ≥140 mmHg and/or diastolic blood pressure (DBP) ≥90 mmHg, isolated systolic hypertension as SBP ≥140 mmHg and DBP <90 mmHg, and isolated diastolic hypertension as SBP ≥140 and DBP ≥90.[5,6] Participants were asked not to take any antihypertensive medications for 12 hours prior to the measurements. Antihypertensive medications were defined as drugs with ATC (anatomical therapeutic chemical) codes C02-C04 and C07-C09.

Underreporting

Underreporting was evaluated by using the ratio of energy intake and calculated basal metabolic rate (EI:BMR). This ratio was compared with the Goldberg cut-off 2. The cut-off limit was calculated specifically for the current study using the methodology described by Goldberg and colleagues,[7] with later modifications.[8] To calculate the Goldberg cut-off on an individual level, a conservative sample size of n = 1 was used, rather than the current study's actual sample size. This approach has been used in other studies.[9]

Table II. *Mean intake (± standard deviation) of selected nutrients, vitamins, minerals, and food groups (n = 160). Intake of macronutrients, expressed as percent of total energy percentage (E%), is also presented.*

	Men	Women
Nutrients		
Vitamin D, µg/day	11,3 (± 11,3)	15,2 (± 18,6)
Vitamin C, mg/day	87,6 (± 51,0)	89,2 (± 56,2)
Vitamin B6, mg/day	1,9 (± 0,8)	1,5 (± 0,6)
Folic acid, µg/day	269,2 (± 125,5)	233,6 (± 95,5)
Calcium, mg/day	946,0 (± 375,2)	814,8 (± 220,7)
Magnesium, mg/day	290,5 (± 73,0)	252,2 (± 56,4)
Iodine, µg/day	211,7 (± 135,0)	170,5 (± 123,9)
Iron, mg/day	11,0 (± 5,9)	8,7 (± 4,2)
Salt, g/day	6,9 (± 2,0)	5,7 (± 1,6)
Alcohol, g/day	6,9 (± 12,0)	3,2 (± 5,4)
Protein, g/kg/day	1,0 (± 0,2)	1,0 (± 0,2)
Protein, E%	18,8 (± 3,8)	18,0 (± 3,1)
Fat, E%	37,0 (± 7,0)	37,3 (± 5,8)
Carbohydrates, E%	40,1 (± 6,2)	41,5 (± 5,3)
Processed sugar, E%	6,9 (± 3,6)	7,1 (± 3,8)
Fiber, E%	1,8 (± 0,5)	2,0 (± 0,6)
Long-chain omega-3 fatty acids, g/day	1.3 (± 1.2)	1.5 (± 1.8)
Food groups		
Milk products, g/day	308,7 (± 219,7)	270,0 (± 150,5)
Cheese, g/day	31,9 (± 25,7)	31,3 (± 24,7)
Fish, g/day	98,0 (± 71,0)	71,9 (± 47,5)
Cod liver oil, g/day	3,77 (± 4,62)	4,82 (± 5,45)
Fruit and vegetables, g/day	207,8 (± 168,6)	230,0 (± 145,2)
Fruit, g/day	107,0 (± 115,0)	127,3 (± 115,2)
Vegetables, g/day	100,8 (± 83,6)	102,7 (± 71,7)

Our physical activity questionnaire was limited to questions about leisure-time physical activity and did not provide information about total physical activity. Therefore, a physical activity level (PAL) of 1.58 was calculated from reference values for the same age group,[8] based on double-labelled water studies.

Basal metabolic rate was calculated using the Harris-Benedict equation[10]. The basal metabolic rate was corrected for fat mass using a 50% correction factor for obese subjects (BMI >30 kg/m²) by using the following formula to calculate weight for substitution into the Harris-Benedict equation: (Actual body weight – ideal body weight) x 0.5 + Ideal body weight.[11] Ideal body weight was calculated using the Robinson formula.[12]

Statistical analysis

The data were entered into the SPSS statistical package, version 20.0 (SPSS, Chicago, IL, USA). Data are described as mean ± standard deviation (SD). Statistical significance was set at P-value <0.05. Spearman's rank correlation coefficient and Pearson's correlation were used to calculate simple correlations. Analysis of covariance (ANCOVA) was used to check the relationship between dietary in-

Table III. *Recommended daily intakes and reference values for vitamins and minerals according to the Nordic Nutrition Recommendations4 (n =160). The table also presents the proportion of participants under and over lower intake level (LI), average requirement (AR), recommended daily intake (RDI), and upper intake level (UI).*

		Reference values				< LI	< AR	> RDI	> UI
		LI	AR	RDI	UI	%	%	%	%
Vitamin D, µg/day	Men	2.5	-	15	50	18	-	29	3
	Women	2.5	-	15	50	20	-	40	5
Vitamin C, mg/day	Men	10	60	75	1000	2	36	58	0
	Women	10	50	75	1000	1	40	55	0
Vitamin B6, mg/day	Men	1	1.3	1.6	25	17	23	62	0
	Women	0.8	1.0	1.2	25	4	19	67	0
Folic acid, µg/day	Men	100	200	300	1000	3	29	32	0
	Women	100	200	300	1000	0	45	16	0
Calcium, mg/day	Men	400	-	800	2500	3	-	58	0
	Women	400	-	800	2500	2	-	46	0
Magnesium, mg/day	Men	-	-	350	-	-	-	21	-
	Women	-	-	280	-	-	-	31	-
Iodine, µg/day	Men	70	100	150	600	12	20	65	2
	Women	70	100	150	600	13	31	44	1
Iron, mg/day	Men	7	7	9	25	26	26	52	6
	Women	5	6	9	25	12	23	34	2

take and blood pressure. In the ANCOVA, adjustment factors were age and body mass index (covariates), and gender and intake of antihypertensive medications (fixed factors). All data fulfilled the assumptions of the statistical methods used.

Ethical considerations

The Icelandic National Bioethics Committe (VSNb2008060007/03-15) and the Icelandic Data Protection Authority (S4018 / 2008) approved the study, which followed the Helsinki declaration guidelines. Informed written consent was obtained from all participants.

Results

Results in tables II, III, IV, V, and VI are based on data from 160 participants, 65 men and 95 women. Thirty-four participants did not return food records or filled them out incorrectly (14%), and 42 were classified as underreporters according to the Goldberg cutoff 2 (18%). Participants with the ratio of energy intake to basal metabolic rate below 0.95 were classified as underreporters. Reported energy intake was significantly lower among underreporters, but with respect to other factors, underreporters and adequate reporters did not differ significantly.

Table I presents mean values (± standard deviation) of age (years), body weight (kg), height (cm), body mass index (BMI, kg/m^2), energy intake (kcal/day), basal metabolic rate (kcal/day), and systolic and diastolic blood pressure (mmHg) for all participants (n = 236).

The percentage of hypertensive men was much higher than that of women, 76% and 42%, respectively. Isolated systolic hypertension was the most common type, whereas combined systolic and diastolic hypertension was much rarer. No subjects were classified with isolated diastolic hypertension.

Cod liver oil intake (g/day) correlated with systolic blood pressure, according to Spearman correlation (ρ=-0.201, P=0.012). A significant association between blood pressure and other dietary factors was not found after gender differences had been accounted for.

Table II presents the intake of macronutrients and certain vitamins and minerals in addition to food groups.

Table III presents recommended daily intakes, lower intake levels, average requirements, and upper intake levels for nutrients and minerals. Of vitamins and minerals, intake of vitamin D was most often below lower intake levels, 18% and 20% among men and women, respectively. A positive correlation between vitamin D intake and cod liver oil intake was observed (ρ=0.731, P<0.001). 56% of participants reported cod liver oil intake in their food records.

Table IV presents the recommended intake of energy-giving nutrients, expressed as percent of total energy intake (E%), and recommendations for food intake. Percent within recommendations is also presented. Protein intake among many participants was adequate according to recommended intake for the elderly (≥65 years old), 1.0 g for each kg of body weight per day.[4] 41% of men and 47% of women reached the recommendations for protein. A large proportion of men (46%) and women (37%) was above recommendations for salt, and fiber intake was below recommendations among 65% of men and 51% of women. Consumption of fruit, vegetables, and milk products was within recommendation among a small proportion of participants, but fish consumption was adequate among most.

Table V presents the difference between diastolic and systolic blood pressure across tertiles of cod liver oil intake (g/day) and intake of long omega-3 fatty acids (g/day), for both men and women (n=160), as calculated with analysis of covariance. The relationship between cod liver oil, as tertiles of intake, and systolic blood pres-

Table IV. *The first column presents recommendations for intake of salt, macronutrients, and food groups, or the acceptable macronutrient distribution range (E%), expressed as percentage of total energy intake, for elderly people (≥ 65 years old) according to the Nordic Nutrition Recommendations4. The second column shows the percent of participants (n = 160) within recommendations (R).*

		R or E%	% Within R or E%
Salt, macronutrients and fiber			
Salt, g/day	Men / Women	< 7/< 6	55/63
Alcohol, g/day	Men / Women	< 20/< 10	89/86
Protein, g/kg/day	Men / Women	> 1.0	41/47
Protein, E%	Men / Women	10-20	61/75
Fat, E%	Men / Women	25-35	41/33
Carbohydrates, E%	Men / Women	50-60	5/3
Processed sugar, E%	Men / Women	< 10	77/78
Fiber, E%	Men / Women	> 2	35/49
Food groups			
Milk products, g/day	Men / Women	500	18/9
Fish, g/day	Men / Women	> 43	79/71
Fruit and vegetables, g/day	Men / Women	> 400	15/12
Fruit, g/day	Men / Women	> 200	14/25
Vegetables, g/day	Men / Women	> 200	15/11

Table V. *Differences in systolic and diastolic blood pressure between tertiles of cod liver oil intake (g/day) and intake of long omega-3 fatty acids (g/day), as assessed by a general linear model. Adjustment factors were age and body mass index (covariates), and gender and intake of antihypertensive medications (fixed factors). 160 participants were included in the calculations.*

	Difference from first tertile B	95% confidence limit		
		Lower	Higher	P
Systolic blood pressure				
Cod liver oil (g/day)				
2nd tertile	-5.81	-12.81	1.20	0.104
3rd tertile	-7.90	-13.86	-1.95	0.010
Long omega-3 fatty acids (g/day)				
2nd tertile	-9.80	-16.58	-3.02	0.005
3rd tertile	-7.53	-14.27	-0.79	0.029
Diastolic blood pressure				
Cod liver oil (g/day)				
2nd tertile	-1.11	-4.85	2.63	0.559
3rd tertile	-1.58	-4.76	1.60	0.327
Long omega-3 fatty acids (g/day)				
2nd tertile	-4.90	-8.20	-1.60	0.004
3rd tertile	-3.61	-6.89	-0.33	0.031

sure was significant between the first tertile and the third, even when gender, age, body mass index, and use of antihypertensive drugs were adjusted for (P=0.010). A similar relationship was observed for long-chain omega-3 fatty acids (P=0.029). Leisure-time physical activity in minutes per day, and current or previous smoking, did not correlate significantly with blood pressure or diet, and did not affect the association between blood pressure and intake of cod liver oil or long-chain omega-3 fatty acids when added to the linear model. Furthermore, adjustment for blood lipids (cholesterol, HDL, or triglycerides) did not eliminate this relationship (results not shown).

Table VI presents the mean intake of cod liver oil (g/day) and long-chain omega-3 fatty acids (g/day), within tertiles of consumption, according to three-day weighed food records.

Discussion

The main aim of the study was to investigate the association between diet and blood pressure among elderly Icelanders, with focus on cod liver oil, and to examine adherence to current Icelandic and Nordic nutrition recommendations. To our knowledge, this is the first study to examine the influence of dietary factors on blood pressure in elderly people in Iceland.

Table VI. *Mean intake of cod liver oil (g/day) and long-chain omega-3 fatty acids (g/day), within tertiles of consumption, according to three-day weighed food records (n = 160).*

	Cod liver oil (g/day)	Long-chain omega-3 fatty acids (g/day)
1st tertile	0 (± 0)	0.3 (± 0.2)
2nd tertile	3.6 (± 1.2)	1.0 (± 0.3)
3rd tertile	10.4 (± 3.7)	3.1 (± 1.8)

Systolic blood pressure correlated significantly and inversely with intake of cod liver oil and long-chain omega-3 fatty acids, even when gender, age, BMI, and use of antihypertensive drugs were accounted for. Diastolic blood pressure correlated significantly with intake of long-chain omega-3 fatty acids, whereas cod liver oil intake did not. Why cod liver oil intake did not correlate with diastolic blood pressure, in the same way as long-chain omega-3 fatty acids, is unclear. It is possible that other nutrients in cod liver oil may have diluted the results.

Although the results of studies are inconsistent, a growing body of evidence indicates that high doses of long-chain omega-3 fatty acids (≥ 3 g/day) decrease blood pressure slightly but significantly, especially among elderly and hypertensive people.[3,13] The results of the current study support this, but cannot prove a direct correlation. On the other hand, it is likely that cod liver oil consumption, or the ingestion of supplements that contain fish oil in sufficient amounts, decreases blood pressure among elderly people and could therefore have beneficial health effects. Caution needs to be taken when extrapolating the results to other groups. An Icelandic study from 2006 found fish oil consumption, primarily from cod liver oil, to be correlated with higher blood pressure among pregnant women.[14]

In most cases, food and nutrition intakes turned out to be similar to the results of the Icelandic National Nutrition Survey 2010-2011[15], which indicates that our participants were not unusual with regard to dietary intakes when compared to other Icelanders in the same age group.

Some gender differences were observed. Men tended to have significantly higher intakes of many vitamins and minerals than women. This difference is reflected in the higher energy intakes of men (2042 kcal/d) compared to women (1662 kcal/d).

Intakes below lower intake values were generally rare for vitamins and minerals. Of the investigated vitamins and minerals, intake below lower intake values was most often seen for vitamin D (19.3% of participants). Vitamin D intake was also positively correlated with intake of cod liver oil, a traditional and common supplement on the Icelandic market, and most of those participants that had intakes below lower intake levels (<2.5 μg/d) did not take any cod liver oil supplements. Rich dietary sources of vitamin D are few and low intakes of vitamin D are therefore a well known issue.[16]

The mean value of vitamin D intake in the current study was 11.3 μg/d and 15.2 μg/d among men and women, respectively, and for the same age group (≥65 yrs) in the Icelandic National Nutrition Survey the mean intake was 12.9 μg/d and 8.4 μg/d among men and women, respectively.[15] In the same age group in the UK, mean levels were 4.1 μg/d among men and 2.9 μg/d among women.[16] Mean intakes of vitamin D are clearly higher in Iceland than in the UK, which is likely due to the widespread use of cod liver oil as a nutritional supplement in Iceland.

Mean intake of vitamin B6 was 1.9 mg/d among men and 1.5 mg/d among women. More men than women were below lower intake levels for vitamin B6, or approximately 17% compared to only 4% among women. This difference is reflected, at least in part, in higher recommendations for vitamin B6 among men. A considerable proportion of participants was below lower intake levels for iodine, or 12% of men and 13% of women. The same applies to iron, where 26% of men were below lower intake levels compared to only 12% of women. Higher lower intake levels of iron for men (7 mg/d) compared to women (5 mg/d) can, at least in part, explain the observed gender difference in iron intakes.

Dietary intake of protein was sufficient among 45% of participants when compared to recommendations for elderly people, 1.0 g/kg/day.[4] Mean protein intake was 1.0 g/kg/day. The average mean intake of protein seems to have been sufficient in most cases (83%) according to current recommendations for young adults, 0.8 g/kg/d.[4]

Intake of protein, expressed as energy percent (E%), was generally within recommended levels. No participants were below the recommended E% of protein, but 30% of participants were over the recommended E%. Fat intake, expressed as E%, was over recommended levels among 60% of participants. These high fat and protein intakes come at the expense of carbohydrates. Only 3.8% of participants were within the recommended intake levels for carbohydrates and none over the recommended E% of 50-60. Intake of dietary fibre was also below recommended intake value among most participants (56.9%), which is likely a reflection of the low intake of carbohydrates.

Many participants were above recommended intake levels for salt, 45.5% and 37.2% of men and women, respectively. Salt intakes are likely to be higher than estimated because salt is often added during cooking and tends not to be recorded.

Fish consumption was adequate for most participants, whereas the intake of fruit and vegetables was according to guidelines among less than 25% of participants. Low fruit and vegetable intakes are common among elderly people in Iceland[15] as well as elsewhere.[17]

Dietary data analysis did not include dietary supplements, other than cod liver oil, due to a lack of information on the nutrition contents of the various supplements in the database used. Vitamin supplements were taken by 43% of participants and 17% took other nutritional supplements. Our study was similar to the Icelandic National Nutrition Survey where no supplements, apart from cod liver oil, were included in the results.

Thirty-four participants (14%) did not return food records or filled them out incorrectly and 42 (18%) were not included in statistical analyses due to underreporting. According to food records, the energy and nutrient intake of underreporters was significantly lower compared to adequate reporters, but the dietary composition was not significantly different from that of adequate reporters. Consumption of cod liver oil was similar in both groups. Although it cannot be proven, it can be speculated that the consumption of certain food items, such as sweets was proportionately higher among underreporters. Included participants, drop-outs and underreporters were not significantly different in terms of other variables.

A few other limitations of the current study should be mentioned. The study sample was not random and might therefore not be representative of the Icelandic population. Furthermore, blood pressure was measured with an automated blood pressure monitor, which is considered less accurate than manual blood pressure measurements.[18] Three-day weighed food records can, in some cases, be an inaccurate estimation of dietary habits, especially among people that do not have regular dietary habits. In addition, weighed food records do not take seasonal fluctuations of diet into account.

In conclusion, regular intake of cod liver oil appears to be associated with lower blood pressure among elderly people and could therefore have beneficial effects on health. A notable proportion of participants were at risk of vitamin D, B6, iodine, and iron deficiency.

Acknowledgements

We thank the Technology Development Fund of the Icelandic Centre for Research (RANNIS) and the Research Fund of the University of Iceland for financial support.

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