Published in final edited form as:
J Am Geriatr Soc. 2008 January ; 56(1): 84–90. doi:10.1111/j.1532-5415.2007.01478.x.

Diet and its relationship with grip strength in community-dwelling older men and women: the Hertfordshire Cohort Study

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Abstract

OBJECTIVES—To examine relationships between diet and grip strength in older men and women, and to determine whether these relationships are modified by prenatal growth.

DESIGN—Cross-sectional and retrospective cohort study

SETTING—Hertfordshire, UK

PARTICIPANTS—Two thousand, nine hundred and eighty three men and women aged 59 to 73 years who were born and still live in Hertfordshire, UK

MEASUREMENTS—Weight at birth recorded in Health Visitor ledgers. Current food and nutrient intake assessed using an administered food frequency questionnaire, grip strength was measured with a hand-held dynamometer.

RESULTS—Grip strength was positively associated with height and weight at birth, and inversely related to age (all $P<0.001$). Of the dietary factors considered in relation to grip strength, the most important was fatty fish consumption. An increase in grip strength of 0.43kg (95% CI 0.13 to 0.74) in men ($P=0.005$), and 0.48kg (95% CI 0.24 to 0.72) in women ($P<0.001$), was observed for each additional portion of fatty fish consumed per week. These relationships were independent of adult height, age and birth weight, each of which had additive effects on grip strength. There was no evidence of interactive effects of weight at birth and adult diet on grip strength.

CONCLUSION—These data suggest that fatty fish consumption can have an important influence on muscle function in older men and women. This raises the possibility that the anti-inflammatory actions of n-3 fatty acids may play a role in the prevention of sarcopenia.

Keywords

diet; sarcopenia; grip strength

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INTRODUCTION

Sarcopenia, the progressive loss of muscle mass and strength with ageing, is an important determinant of morbidity in older life[1,2]. It is a major risk factor for falls[3] and an important influence on frailty and disability in the elderly[1,2,4]. Recent estimates of the annual health care costs attributable to sarcopenia are around $18.5 billion in the United States[5] .

Despite the obvious importance of sarcopenia in terms of public health, relatively little is known of the role of diet and nutritional status in its aetiology[2]. Whilst effects of early growth on adult muscle function have been described, such that poor growth is associated with lower muscle mass and strength in adult life[6-8], the contribution of diet across the life course remains little studied. Since diet is a potentially modifiable influence on muscle function we need to know more about its role in the development of sarcopenia.

Existing studies on sarcopenia and diet have focused on a limited number of nutrients. Dietary protein has been considered as a potential determinant of muscle function as ageing is often associated with a reduction in food intake, and protein intake may be insufficient[9]. Although there is concern that the dietary reference intake for protein may be set too low to ensure optimal intakes in healthy elderly adults, protein supplementation studies are not always successful in influencing muscle function[10]. More consistent links have been demonstrated between vitamin D status and intake and markers of muscle function, and beneficial effects of improved status have been described in both observational[11] and supplementation[12] studies. There is also increasing interest in the role of antioxidant status in the development of sarcopenia because of the involvement of oxidative stress in its pathogenesis[13], and recent observational studies show associations between frailty and low circulating levels of both vitamin E and carotenoids[14,15].

Using grip strength as a clinical marker of muscle function, we examine its relationships with diet in a community-dwelling cohort of 2983 men and women aged 59-73 years. Our analyses consider protein, vitamin D and antioxidant nutrients, the foods that are the major dietary contributors to intakes of these nutrients, and a total diet score that defines the quality of the diet. Because we have previously observed interactive effects between birth weight and adult diet on serum cholesterol concentrations[16], and birth weight is associated with sarcopenia[6-8], we also consider how relationships between diet and grip strength are modified by birth weight.

METHODS

The Hertfordshire Cohort Study

From 1911 to 1948, midwives made detailed records, which included birth weight, on all infants born in the county of Hertfordshire, UK. These records have been described previously[17]. In 1998, 7106 men and women born between 1931 and 1939 who were still alive and living in Hertfordshire were traced using the National Health Service central registry. General Practitioners gave permission for us to write to 3126 (82%) men and 2973 (91%) women. 1684 (54%) men and 1541 (52%) women agreed to be interviewed at home. The mean birth weights of people who were interviewed were similar to those who were not interviewed, in men 3.46kg (SD 0.55) compared with 3.50kg (SD 0.54), and in women 3.36kg (SD 0.54) compared with 3.35kg (SD 0.50). During the interview diet was assessed by a trained research nurse, and information was obtained on the participant's medical and social history. 1579 of these men (94%) and 1418 of the women (92%) subsequently attended a clinic for further investigations. Complete age, height and grip strength data were available for 1569 men (93%) and 1414 women (92%).

The study had ethical approval from the Bedfordshire & Hertfordshire Local Research Ethics Committee and the West Hertfordshire Local Research Ethics Committee. All participants gave written informed consent.

Dietary assessment

Diet was assessed using a food frequency questionnaire (FFQ) that was based on the EPIC questionnaire18. The FFQ includes 129 foods and food groups, and was used to assess an average frequency of consumption of the listed foods over the 3-month period preceding the home interview. Each FFQ was administered by a trained research nurse. Prompt cards were used to show the foods included in each food group, to ensure standardised responses to the FFQ. Frequencies of other foods that were not listed on the FFQ were also recorded if consumed once per week or more. Standard portion sizes19 were allocated to each food apart from milk and sugar for which daily quantities consumed were recorded. Nutrient intakes were calculated by multiplying the frequency of consumption of a portion of each food by its nutrient content according to the UK national food composition database20 or manufacturers' composition data. Dietary interviews took place between 1998 and 2004.

At the end of the FFQ each participant was asked about dietary supplements they had taken in the preceding 3 months. Nutrient intakes from dietary supplements were calculated using the frequency and dose reported by the participant, and manufacturers' supplement composition data.

Prudent dietary pattern score

The 129 foods listed in the food frequency questionnaire were put into 54 food groups on the basis of similarity of type of food and nutrient composition. Principal components analysis of the reported weekly frequencies of consumption of these food groups was used to define patterns of diet. This statistical technique produces new variables (components) that are independent linear combinations of the dietary variables with maximum variance21. The first component, that explains the most variance in the dietary data, described a pattern of foods that was characterised by high consumption of fruit, vegetables, wholemeal cereals and fatty fish but by low consumption of white bread and chips, sugar and full-fat dairy products. This pattern of diet reflects recommendations for a healthy diet, and we called it a ‘prudent’ diet in common with other published studies22. A prudent diet score was calculated for each participant using the coefficients from the analysis. The coefficient for each of the 54 food groups was multiplied by the reported frequency of consumption of the group, and these values were summed to provide a prudent diet score for each individual, that indicates compliance with the pattern. A high prudent diet score (in the upper part of distribution of scores) indicates a diet characterised by high consumption of fruit, vegetables, wholemeal cereals and fatty fish; whilst a low score (in the lower part of the distribution of scores) indicates a diet characterised by high consumption of white bread and chips, sugar and full-fat dairy products. Nutrient supplements were not included in the principal components analysis.

Grip strength

As a marker of muscle function, maximum grip strength was measured using a handgrip Jamar dynamometer at the clinic visit. Grip strength was measured three times on each side and the best of these measurements was used for the analyses.

Statistical analysis

Normality of variables was assessed and variables transformed as required. Data were analysed using Stata version 9.2. T-tests and Wilcoxon-Mann-Whitney tests were used to test for differences in the characteristics between men and women and between their food and nutrient intakes. Univariate and multiple linear regressions were used to explore the relationships between diet and grip strength.

RESULTS

Participant characteristics

The characteristics and intakes of selected foods and nutrients are shown in Table 1. 58% of men and women were in manual social classes; 15% of men and 10% of women were current smokers. 53% of men and 63% of women achieved the recommended intake of 5 portions of fruit and vegetables per day. Energy intakes were close to the estimated average requirements for older men and women; 98% of men and 99% of women had protein intakes above the reference nutrient intake23. Although women had lower total food and energy intakes than men, their consumption of fruit, nuts, white and fatty fish, and breakfast cereals was greater, and % energy from protein, and their intakes of vitamin C, β-carotene were higher. Following adjustment for total energy intake, the women also had greater intakes of selenium vitamin E and D than the men (all P<0.001, data not shown).

Influences on grip strength

As expected, gender, height and age were important influences on grip strength. Grip strength was higher in men than in women (Table 1, $P<0.001$). It was positively associated with height (0.47, 95% CI 0.42 to 0.52 kg per cm in men; 0.27, 95% CI 0.22 to 0.32 kg per cm in women, both $P<0.001$), but fell with increasing age (−0.49, 95% CI −0.62 to −0.37 kg per year in men; −0.26, 95% CI −0.37 to −0.15 kg per year in women, both $P<0.001$). Grip strength was therefore adjusted for the effects of age and height before subsequent analyses, and men and women were considered separately.

Dietary patterns, food consumption and grip strength

Grip strength was positively related to prudent diet score in both men and women (Table 2), such that men and women with high scores, whose diets were characterised by high consumption of fruit, vegetables, wholemeal bread and fatty fish, had higher grip strength. Table 2 also shows the univariate associations between selected foods and grip strength. In men, higher consumption of fruit, fatty fish and breakfast cereals but lower meat consumption (including red and white carcass meats) was associated with higher grip strength. In women, higher grip strength was also associated with higher consumption of fruit and fatty fish, but there was no association with breakfast cereals or meat consumption. Additionally, grip strength in women was positively associated with vegetable consumption. In both men and women the most important food in terms of its association with grip strength was fatty fish, and the effect size on grip was comparable in the two genders. Adjustment for energy intake made little difference to these univariate relationships between food consumption and grip strength in either gender (data not shown).

To take account of the collinearity between foods we examined the relationships between foods and grip strength in multivariate analyses. In men, fatty fish consumption was the only independent predictor of grip strength (0.33, 95% CI 0.02 to 0.64 kg per portion consumed per week, $P=0.036$). In women, both fatty fish and vegetable consumption were independently related to grip strength (0.35, 95% CI 0.10 to 0.60 kg per portion fatty fish consumed per week, $P=0.006$; 0.03, 95% CI 0.00 to 0.06 kg per portion vegetables consumed per week, $P=0.028$). In separate multivariate analyses we considered the relationships in men and women between prudent diet score and grip strength, after taking account of fatty fish consumption. In men, the association between prudent diet score and grip strength was no longer evident when fatty fish consumption was accounted for,

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suggesting that the association with prudent diet score was explained by differences in fatty fish consumption. In women, independent associations between grip strength and prudent diet score and fatty fish consumption remained in this analysis, although the size of the effect of prudent diet score on grip strength was markedly reduced (0.17, 95% CI 0.00 to 0.34 kg per unit change in score, P=0.044).

Nutrient intake and grip strength

Table 3 shows the univariate associations between intakes of selected nutrients and grip strength in men and women. Apart from % energy from protein, which showed a borderline association with grip strength, none of these nutrients was related to grip strength in men, and this did not change when nutrients from dietary supplements were also included (data not shown). Adjustment for energy intake revealed modest positive associations between β-carotene and selenium intakes with grip strength. In contrast, among the women all of the selected nutrients except vitamin E were related to grip strength in univariate analyses, and this did not change when nutrients from dietary supplements were included (data not shown) or after adjustment for energy intake.

Adult diet, birth weight and grip strength

Birth weight was positively related to grip strength in both men and women (2.06, 95% CI 1.38 to 2.74 kg per kg birth weight in men; 1.50, 95% CI 0.91 to 2.10 kg per kg birth weight in women, both P<0.001). To examine the combined influences of birth weight and adult diet on grip strength we included fatty fish consumption in the model. In both men and women there were independent additive effects of adult diet and birth weight on grip strength but there was no evidence of any interactive effects between adult diet and birth weight (data not shown). Table 4 shows the independent contributions of height, age, birth weight and fatty fish consumption to grip strength in the men and women we studied. After taking account of height, age and birth weight, an increase in grip strength of 0.43kg (95% CI 0.13 to 0.74, P=0.005) in men, and 0.48kg (95% CI 0.24 to 0.72, P<0.001) in women, was observed for each additional portion of fatty fish consumed per week.

DISCUSSION

We have described associations between the dietary intakes of community-dwelling older men and women and grip strength. In both men and women, the most important association was with fatty fish consumption. Each additional portion of fatty fish consumed per week was associated with a gain in grip strength of 0.43kg (95% CI 0.13 to 0.74) in men, and 0.48kg (95% CI 0.24 to 0.72) in women. Whilst a healthier (‘prudent’) pattern of eating was also associated with higher grip strength, this effect was at least partly explained by more prudent diets also being characterised by greater consumption of fatty fish. Consumption of white fish and shellfish was not related to grip strength.

We studied a large population of older men and women. Although membership of this cohort was defined by area of birth, and there has been considerable loss to follow-up, the participants' characteristics are comparable with those of the wider community17. The associations we describe are from internal comparisons, and there is no reason to expect these findings to differ outside the cohort. We assessed diet using an administered food frequency questionnaire. Whilst there is concern that food frequency questionnaires can be prone to measurement error24, the assessment of fatty fish consumption using this food frequency questionnaire has been shown to be comparable with other dietary methods25 and, since random misclassification of individual intakes would result in an attenuation of associations, it is very unlikely that measurement error could explain the associations between fatty fish consumption and grip strength that we observed. A significant limitation of the current study is that the data are cross-sectional. We were therefore unable to address whether participants had made any changes to their diets in response to development or diagnosis of disease. Future studies will be needed to address how greater consumption of fatty fish impacts on longitudinal decline in muscle function.

When we examined the relationships between nutrient intake and grip strength we focused on nutrients that have been shown to have beneficial effects on muscle function in supplementation studies (protein, vitamin D), and nutrients with antioxidant function (β-carotene, selenium, vitamin E, vitamin C). Grip strength was positively related to protein intakes in women, and to the protein density of the diet in men and women (although of borderline significance in men). Although muscle function can be improved by increased availability of amino acids26, it was surprising to see a relationship between protein intake and grip strength in individuals whose protein intakes were above recommended intakes23 and whose diets were of relatively high protein density. When we looked at vitamin D intake, despite the positive association between fatty fish consumption and grip strength, we only observed an association between vitamin D intake and grip strength in women. Whilst this may reflect a real difference between genders, it could also be due to greater measurement error associated with estimates of vitamin D intake in the men studied. This possibility is consistent with the change in association with grip strength observed following energy adjustment (Table 3), as this partially corrects for the effect of measurement error27. For the antioxidant nutrients we considered, we found positive associations between β-carotene and selenium intakes with grip strength in both men and women, and with vitamin C intake in women, suggesting that antioxidant status may have an important influence on muscle function. Although vitamin E status has been shown to relate to frailty15, we did not observe an association between vitamin E intake and grip strength in our study. It is not clear why the nutrient effects on grip strength were more marked in the women we studied when compared with the men, although this may reflect the combined influences of diets of higher micronutrient density in individuals whose grip strength is also lower (Table 1).

We also considered important food sources of the nutrients of interest because of the collinearity amongst nutrients - and the possibility that other nutrients in foods can contribute to observed nutrient-outcome associations. For example, in our study, although the univariate analyses showed associations between grip strength and fruits and vegetables that were consistent with the β-carotene and vitamin C findings, we do not know whether it is these particular nutrients or other constituents of fruits and vegetables that have beneficial effects on muscle function. In this case, although we cannot identify the mechanisms involved, the findings of the food and nutrient analyses are comparable as both suggest that antioxidant status may be important for muscle function. In contrast, when we considered fatty fish consumption as an important source of dietary vitamin D, we found much stronger effects of fatty fish consumption on grip strength than we found for vitamin D intake. These differing associations may provide further insight into the mechanisms linking diet and muscle function as it suggests that there are collinear constituents of fatty fish that may affect grip strength. Fatty fish is a rich source of n-3 fatty acids, which raises the possibility that the anti-inflammatory actions of these fatty acids may also have an important influence on muscle function28.

We are not aware of other studies that have shown associations between variations in food consumption and grip strength, or with other aspects of muscle function or muscle mass. In the present study a number of foods were related to grip strength (Table 2), but in comparison with the effect of fatty fish consumption, the effects were small, and not robust to adjustment in a multivariate model. In contrast, the effect of consumption of fatty fish was much larger, and independent of other influences on grip strength. In comparison with no consumption, consuming fatty fish more than once per week was associated with a gain in

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grip strength of around 3kg (Table 4). This compares with a 5 kg decrease in grip strength shown to be associated with impairment in performing activities of daily living in older women29 and is therefore likely to be of clinical significance.

Since we have previously observed interactive influences of fat intake and birth weight on serum cholesterol concentration in men16, suggesting that adult responses to diet are conditioned by early growth, we considered the combined influences of adult diet and birth weight on grip strength. Although grip strength was linked both to weight at birth and to adult diet (Table 4), they had independent additive influences and, unlike serum cholesterol responses, there was no evidence of interactive effects of early growth with diet on grip strength in adult life.

CONCLUSION

Our data suggest that diet may impact on sarcopenia in a number of different ways, including effects on oxidative stress, inflammation as well as effects on muscle protein synthesis. Adequate intakes of protein, antioxidant nutrients and vitamin D may all be important for optimal muscle function, especially among older women. Since fatty fish consumption was strongly related to grip strength, this raises the possibility that the anti-inflammatory actions of n-3 fatty acids could also be important in the prevention of sarcopenia.

Acknowledgments

We thank the men and women who took part in the study and the Hertfordshire Cohort Study research nurses.

Financial disclosure: This work was supported by the Medical Research Council, United Kingdom.

Sponsor's role: None

References

1. Morley JE, Baumgartner RN, Roubenoff R, et al. J Lab Clin Med. 2001; 137:231–243. [PubMed: 11283518]
2. Marcell TJ. Sarcopenia: causes, consequences and preventions. J Gerontol A Biol Sci Med Sci. 2003; 58:911–916. [PubMed: 14570858]
3. Aihie Sayer A, Syddall H, Martin HJ, et al. Falls, sarcopenia and growth in early life: findings from the Hertfordshire Cohort Study. Am J Epidemiol. 2006; 164:665–671. [PubMed: 16905644]
4. Syddall H, Cooper C, Martin F, et al. Is grip strength a useful single marker of frailty? Age Ageing. 2003; 32:650–656. [PubMed: 14600007]
5. Janssen I, Shepard DS, Katzmarzyk PT, et al. The healthcare costs of sarcopenia in the United States. J Am Geriatr Soc. 2004; 52:80–85. [PubMed: 14687319]
6. Kuh D, Hardy R, Butterworth S, et al. Developmental Origins of Midlife Grip Strength: Findings From a Birth Cohort Study. J Gerontol A Biol Sci Med Sci. 2006; 61:702–706. [PubMed: 16870632]
7. Yliharsila H, Kajantie E, Osmond C, et al. Birth size, adult body composition and muscle strength in later life. Int J Obesity. 2007 in press. [PubMed: 17356523]
8. Inskip HM, Godfrey KM, Martin HJ, et al. Size at birth and its relation to muscle strength in young adult women. J Int Med. 2007 in press. [PubMed: 17697158]
9. Campbell WW, Trappe TA, Wolfe RR, et al. The recommended dietary allowance for protein may not be adequate for older people to maintain skeletal muscle. J Gerontol A Biol Sci Med Sci. 2001; 56:373–380. [PubMed: 11382798]
10. Fujita S, Volpi E. Nutrition and sarcopenia of ageing. Nutrition Research Reviews. 2004; 17:69–76. [PubMed: 19079916]

11. Bischoff-Ferrari HA, Dietrich T, Orav EJ, et al. Higher 25-hydroxyvitamin D concentrations are associated with better lower-extremity function in both active and inactive persons aged ≥60 y. Am J Clin Nutr. 2004; 80:752–758. [PubMed: 15321818]
12. Bischoff-Ferrari HA, Dawson-Hughes B, Willett WC, et al. Effect of vitamin D on falls. A meta analysis. JAMA. 2004; 291:1999–2006. [PubMed: 15113819]
13. Weindruch R. Interventions based on the possibility that oxidative stress contributes to sarcopenia. J Gerontol A Biol Sci Med Sci. 1995; 50:157–161. [PubMed: 7493211]
14. Semba RD, Bartali B, Zhou J, et al. Low serum micronutrient concentrations predict frailty among older women living in the community. J Gerontol A Biol Sci Med Sci. 2006; 61:594–599. [PubMed: 16799142]
15. Ble A, Cherubini A, Volpato S, et al. Lower plasma vitamin E levels are associated with the frailty syndrome:the InCHIANTI study. J Gerontol A Biol Sci Med Sci. 2006; 61:278–283. [PubMed: 16567378]
16. Robinson SM, Batelaan SF, Syddall HE, et al. Combined effects of dietary fat and birth weight on serum cholesterol concentration: the Hertfordshire Cohort Study. Am J Clin Nutr. 2006; 84:237–244. [PubMed: 16825701]
17. Syddall HE, Aihie Sayer A, Dennison EM, et al. Cohort Profile: The Hertfordshire Cohort Study. Int J Epidemiol. 2005; 34:1234–1242. [PubMed: 15964908]
18. Bingham SA, Gill C, Welch A, et al. Comparison of dietary assessment methods in nutritional epidemiology: weighed records v. 24h recalls, food-frequency questionnaires and estimated-diet records. Br J Nutr. 1994; 72:619–643. [PubMed: 7986792]
19. Ministry of Agriculture Fisheries and Food. Food portion sizes. 2nd Edition. London: The Stationery Office; 1993.
20. Holland, B.; Welch, AA.; Unwin, ID., et al. McCance and Widdowson's The Composition of Foods. 5th edition. Cambridge: Royal Society of Chemistry; 1991. and supplements to this edition
21. Joliffe IT, Morgan BJT. Principal component analysis and exploratory factor analysis. Stat Methods Med Res. 1992; 1:69–95. [PubMed: 1341653]
22. Hu FB, Rimm EB, Stampfer MJ, et al. Prospective study of major dietary patterns and risk of coronary heart disease in men. Am J Clin Nutr. 2000; 72:912–921. [PubMed: 11010931]
23. Department of Health. Dietary reference values for food energy and nutrients for the United Kingdom. London: Her Majesty's Stationery Office; 1991.
24. Bingham SA, Luben R, Welch A, et al. Are imprecise methods obscuring a relation between fat and breast cancer? Lancet. 2003; 362:212–214. [PubMed: 12885485]
25. Welch AA, Bingham SA, Ive J, et al. Dietary fish intake and plasma phospholipid n-3 polyunsaturated fatty acid concentrations in men and women in the European Prospective Investigation into Cancer-Norfolk United Kingdom cohort. Am J Clin Nutr. 2006; 84:1330–1339. [PubMed: 17158413]
26. Wolfe RR. The underappreciated role of muscle in health and disease. Am J Clin Nutr. 2006; 84:475–482. [PubMed: 16960159]
27. Willett W. Commentary: Dietary diaries versus food frequency questionnaires-a case of undigestible data. Int J Epidemiol. 2001; 30:317–9. [PubMed: 11369736]
28. Calder P. n-3 Polyunsaturated fatty acids, inflammation and inflammatory diseases. Am J Clin Nutr. 2006; 83:S1505–S1519.
29. Ensrud KE, Nevitt MC, Yunis C, et al. Correlates of impaired function in older women. J Am Geriatr Soc. 1994; 42:481–9. [PubMed: 8176141]

Table 1

Characteristics of the Men and Women Studied

	Men (n= 1569)		Women (n=1414)		
Mean (SD)					
Birth weight (kg)	3.50	(0.54)	3.35	(0.50)	
Height (cm)	174.2	(6.5)	160.8	(5.9)	
Age	65.7	(2.9)	66.6	(2.7)	
Body mass index (kg/m^2) *†	26.9	(1.1)	27.2	(1.2)	
Maximum grip strength (kg)	44.0	(7.5)	26.5	(5.7)	
Food consumption (median (IQR) portions/week)					*P*-value
fruit	11.7	(6.5, 17.7)	14.7	(9.0, 21.5)	<0.001
nuts	0.2	(0, 0.5)	0.2	(0, 0.5)	0.001
vegetables	24	(17, 31)	25	(18, 32)	0.062
eggs & egg dishes	3.0	(1.0, 3.0)	1.0	(0.5, 3.0)	<0.001
offal	0.2	(0, 0.5)	0.2	(0, 0.5)	<0.001
other meats	9.2	(6.7, 12)	7.7	(5.5, 10.0)	<0.001
white fish & shellfish	1.5	(1.0, 2.2)	1.6	(1.0, 2.5)	0.039
fatty fish	0.7	(0.5, 1.2)	1.0	(0.5, 1.5)	<0.001
breakfast cereals	6.0	(2.0, 7.0)	6.0	(3.0, 7.0)	0.001
Nutrient intake (median (IQR) per day)					
energy: kJ	9514	(8112, 11046)	8157	(7023, 9420)	<0.001
protein (g)	89	(77, 102)	81	(71, 92)	<0.001
% energy from protein	15.8	(14.4, 17.4)	16.7	(15.2, 18.4)	<0.001
vitamin C (mg)	137	(100, 177)	141	(107, 184)	0.002
β-carotene (μg)	3177	(2334, 3932)	3251	(2441, 4062)	0.020
selenium (μg)	53	(45, 64)	50	(42, 60)	<0.001
vitamin E (mg)	10.5	(8.5, 13.1)	9.8	(8.0, 12.2)	<0.001
vitamin D (μg)	3.2	(2.4, 4.2)	3.0	(2.3, 4.2)	0.005

*Geometric mean (SD)

†Body mass index was not recorded for one man

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Table 2

Univariate Associations Between ‘Prudent’ Diet Score, Weekly Consumption of Specific Foods, and Grip Strength

	Men (n= 1569)		Women (n=1414)	
	regression coefficient (95% CI)	***P*-value**	**regression coefficient (95% CI)**	***P*-value**
‘Prudent’ diet score	0.18 (0.01, 0.35)	0.035	0.27 (0.13, 0.42)	0.000
Food consumption (portion per week)				
fruit	0.04 (0.01, 0.08)	0.014	0.04 (0.01, 0.07)	0.003
nuts	0.02 (−0.20, 0.25)	0.856	0.12 (−0.09, 0.33	0.262
vegetables	0.02 (−0.01, 0.05)	0.176	0.05 (0.02, 0.08)	0.000
eggs & egg dishes	−0.09 (−0.22, 0.05)	0.199	0.02 (−0.15, 0.20)	0.800
offal	0.07 (−0.46, 0.60)	0.797	0.36 (−0.17, 0.89)	0.185
other meats	−0.10 (−0.18, −0.01)	0.021	0.01 (−0.07, 0.09)	0.859
white fish & shellfish	0.25 (−0.02, 0.52)	0.072	0.15 (−0.06, 0.37)	0.163
fatty fish	0.40 (0.10, 0.70)	0.010	0.48 (0.24, 0.72)	0.000
breakfast cereals	0.12 (0.01, 0.23)	0.026	0.03 (−0.07, 0.13)	0.610

Table 3

Univariate Associations Between Nutrient Intake and Grip Strength

Men (n= 1569)	unadjusted proportional effect* (95% CI)	*P*-value	energy-adjusted proportional effect* (95% CI)	*P*-value
Total protein (g)	1.06 (0.22, 4.98)	0.944	8.28 (0.61, 111.89)	0.111
% energy from protein†	1.15 (0.10, 1.33)	0.053	-	-
Vitamin C (mg)	1.44 (0.65, 3.18)	0.364	1.76 (0.76, 4.05)	0.184
Carotene (μg)	2.02 (0.96, 4.26)	0.063	2.46 (1.13, 5.35)	0.023
Selenium (μg)	2.34 (0.66, 8.26)	0.187	7.26 (1.50, 35.04)	0.014
Vitamin E	1.13 (0.39, 3.22)	0.824	1.85 (0.53, 6.44)	0.334
Vitamin D (μg)	1.57 (0.74, 3.32)	0.241	2.02 (0.90, 4.53)	0.089
Women (n=1414)				
Total protein (g)	6.61 (1.80, 24.26)	0.004	21.58 (2.53, 183.92)	0.005
% energy from protein†	1.14 (1.01, 1.28)	0.031	-	-
Vitamin C (mg)	3.56 (1.82, 6.96)	0.000	3.44 (1.70, 6.96)	0.001
Carotene (μg)	2.41 (1.28, 4.69)	0.007	2.25 (1.16, 4.36)	0.016
Selenium (μg)	8.82 (3.25, 23.89)	0.000	14.75 (4.27, 50.93)	0.000
Vitamin E (mg)	1.09 (0.45, 2.67)	0.850	0.57 (0.18, 1.82)	0.342
Vitamin D (μg)	3.82 (2.11, 6.91)	0.000	4.17 (2.15, 8.07)	0.000

* proportional change per unit increase in nutrient intake

† regression coefficient

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Table 4

Multivariate Adjusted Mean Grip Strength (SD) By Category of Age, Height, Birth Weight and Fatty Fish consumption

	Men (n= 1569)		Women (n=1414)	
Age (years)				
< 65	45.4 (7.2) n = 653		27.3 (5.8) n = 426	
< 68	43.7 (7.5) n = 554		26.7 (5.7) n = 523	
≥ 68	42.1 (7.6) n = 362	<0.001 *	25.6 (5.6) n = 465	<0.001 *
Height (cm)				
≤ 171 (men), ≤ 158 (women)	40.4 (7.2) n = 498		24.3 (5.7) n = 437	
≤ 177 (men), ≤ 163 (women)	44.4 (6.7) n = 556		27.0 (5.5) n = 476	
> 177 (men), >163 (women)	47.1 (7.2) n = 515	<0.001 *	28.0 (5.3) n = 501	<0.001 *
Birth weight (kg)				
≤ 3.2	42.7 (7.5) n = 503		25.9 (5.5) n = 614	
− 3.6	43.9 (7.2) n = 316		26.7 (5.9) n = 306	
> 3.6	45.0 (7.5) n = 750	<0.001 *	27.2 (5.9) n = 494	0.027 *
Fatty fish consumption (portions/week)				
0	42.7 (7.9) n = 205		24.3 (6.4) n = 128	
− 1	43.9 (7.4) n = 950		26.4 (5.7) n = 833	
> 1	45.1 (7.4) n = 414	0.005 *	27.4 (5.3) n = 453	<0.001 *

*P for trend from the mutually adjusted model, using continuous variables