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Does diet influence physical performance in community-dwelling older people? Findings from the Hertfordshire Cohort Study

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Abstract

Background: recent studies suggest that diet may affect the physical performance of older adults, but the impact of variations in the UK diet on physical performance has not been assessed.
Objective: to examine relationships between diet and physical performance in community-dwelling older men and women.
Setting and participants: a total of 628 men and women aged 63–73 years who were taking part in the Hertfordshire Cohort Study.
Methods: diet was assessed using an administered food frequency questionnaire; physical performance was assessed by the time taken to complete a 3-m walk, chair-rise test and one-legged balance test.
Results: in women, higher intakes of the antioxidant nutrients, β-carotene and selenium, were associated with shorter 3-m walk times; higher β-carotene and vitamin C intakes were associated with shorter chair-rise times (all $P < 0.05$). Higher vitamin D intakes and percentage energy from protein were also associated with faster 3-m walk times (both $P < 0.05$), but they were not related to chair-rise time. There were no associations between any measure of dietary intake and balance in the women studied. After adjustment for the effects of confounding influences, we found no associations between diet and physical performance among men.
Conclusions: these data indicate that variations in the diets of community-dwelling older women may be linked to differences in physical performance, but further work is needed to determine the role of variations in diet on physical performance and its decline with age among older adults in the UK.

Keywords: *diet, physical performance, older people, elderly*

Introduction

The maintenance of muscle strength and physical performance in older age are key components of healthy ageing. Loss of muscle strength and reduced performance in later life have serious health consequences for individuals in terms of disability, loss of independence, morbidity and mortality [1–5], and are associated with significant healthcare costs [6]. However, despite their importance, our understanding of the determinants of variations in muscle strength and physical performance are poorly understood.

Recent studies have shown that influences acting in early life can have lifelong effects on muscle mass and strength [7]. Poor growth, both in foetal life and in infancy, is associated with lower muscle mass and strength in adulthood [8,9], and the value of a lifecourse approach to understanding muscle function in adult life is now increasingly recognised [10]. Although muscle strength is closely related to physical performance, the role of developmental influences on physical performance is less clear, and these may be less important than lifestyle factors acting later in life [11]. While a number of adult influences have been described, including age, gender and physical activity [12,13], these factors do not fully explain observed variation in physical performance.

One lifestyle influence that has been less well-studied is diet, and relatively little is known about the contribution of variations in diet to physical performance across the life

course. A number of nutrients have been identified as potential determinants of muscle function, including protein [14,15], vitamin D [15,16] and the antioxidant nutrients β-carotene, and vitamins E and C [15,17]. The nutrient for which there is the most robust evidence is vitamin D, and a meta-analysis of controlled trials has shown beneficial effects of supplementation on the prevention of falls [18]. However, there is some inconsistent evidence of benefit, and the association between vitamin D and physical performance remains controversial [19]. More recently a series of observational studies have pointed to the importance of oxidative stress in the aetiology of sarcopenia and poor muscle function [20]. Positive effects of higher plasma vitamin E concentrations on physical performance have been reported [17], and importantly, poor vitamin E and carotenoid status has been shown to be predictive of decline in physical function [21,22].

To the best of our knowledge, the effects of variations in the UK diet on physical performance have not been assessed. There are enormous differences in diet across the UK population [23], that could have implications for muscle strength and function. We have previously shown that 'healthier' diets, and particularly a higher consumption of oily fish is associated with greater grip strength in older men and women in the Hertfordshire Cohort Study (HCS) [24,25]. In this paper, we examine the relationships between diet and physical performance, measured using a short physical performance battery, in a group of HCS men and women who were living in West Hertfordshire. Our analyses considered intakes of protein, vitamin D and antioxidant nutrients, the foods that are major dietary sources of these nutrients, and a total diet score that defines quality or 'healthiness' of the diet [23].

Methods

The Hertfordshire cohort study

From 1911 to 1948, midwives collected detailed records on infants born in Hertfordshire, UK. In 1998, the NHS central registry traced men and women born in Hertfordshire between 1931 and 1939, still living in the county and registered with a general practitioner. This study is based on 955 men and 835 women in West Hertfordshire. We received permission to contact 792 men and 647 women. A total of 396 (50%) men and 321 (50%) women agreed to have a home interview where trained research nurses collected information on medical, diet and social history. A total of 349 (88%) men and 280 (87%) women subsequently attended a clinic for a number of investigations including anthropometry and completion of a short physical performance battery [26]. Inter- and intra- variability studies were carried out at regular intervals during the fieldwork to ensure comparability of measurements within and between observers. The study had ethical approval from the Hertfordshire and Bedfordshire Local Research Ethics Committee and all participants gave written informed consent.

Dietary assessment

Diet was assessed using an administered food frequency questionnaire (FFQ) [23]. The FFQ includes 129 foods and food groups and was used to assess an average frequency of consumption of the listed foods over a 3-month period preceding the home interview. 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 database or manufacturers' composition data [23]. Use of dietary supplements over the preceding 3 months was also recorded. Nutrient intakes from dietary supplements were calculated using the frequency and dose reported by the participant and manufacturers' composition data. Complete dietary data were available for 348 men and 280 women.

The quality or 'healthiness' of the diet was defined using scores from a principal component analysis-defined pattern of foods that is consistent with healthy eating recommendations, as it was characterised by high consumption of fruit, vegetables, whole-grain cereals and oily fish, but low consumption of white bread, chips, sugar and full fat dairy products [23]. This was termed a 'prudent' diet pattern. An individual's prudent diet score indicates their compliance with the pattern; thus high prudent diet scores indicate diets characterised by high consumption of fruit, vegetables, whole-grain cereals and oily fish, and low scores indicate diets characterised by high consumption of white bread, chips, sugar and full fat dairy products.

Physical performance

At clinic, each participant completed a short physical performance battery [26]. This included measures of time taken to complete a 3-m customary pace walk and 5 sit–stand chair rises; balance performance was assessed by measurement of one-legged timed standing balance [11,27].

Statistical analysis

Data were analysed using STATA version 10 (STATA Corp, College Station, TX, USA). Normality of variables was assessed and transformed as appropriate. One-legged balance data were bimodal and thus analysed as the proportion of people who lost their balance within the first 5 s (i.e. having 'poor balance') vs. the rest of the group. Multiple linear regression and multiple logistic regression were used to explore the relationships between diet and the three physical performance measures, in men and women separately. A univariate assessment of the correlates of diet and physical performance (current age, anthropometry, social class, smoking status, alcohol consumption, age left education) [23] was assessed using linear regression and adjustments for these were made in analyses as appropriate. Height and weight were highly correlated ($r = 0.46$, $P < 0.001$ for men; $r = 0.29$, $P < 0.001$ for women). To avoid multi-collinearity problems when including height and weight in the same models, we calculated a sex-specific

standardised residual of weight-adjusted-for-height. The dietary variables considered were prudent diet score; protein as percentage of energy (a measure of protein density of the diet); vitamins C,D,E, selenium and β-carotene; and food groups that are main sources of these nutrients (fruit, nuts, vegetables, meat and fish).

Results

Participant characteristics

The characteristics of the men and women studied and their intakes of selected foods and nutrients are shown in Table 1. The men and women were similar in age and social background, but among the women, there were fewer smokers and a smaller proportion of women were drinking in excess of the recommended units of alcohol (both $P < 0.001$). The women's performance in all three physical performance tests was poorer when compared with that of the men; the time taken for a 3-m walk and chair rises was longer (both $P < 0.001$) and the % with poorer balance was greater ($P < 0.035$).

Table 1. Participant characteristics

Characteristic	Men ($n = 348$)	Women ($n = 280$)
Mean (SD) unless stated otherwise		
Age (years)	67.8 (2.5)	68.1 (2.5)
Height (cm)[a]	174.1 (6.6)	160.9 (6.0)
Weight (kg)[b]	81.2 (1.2)	70.5 (1.2)
Social class I–IIINM, *n* (%)[a]	145 (41.8)	111 (39.6)
Social class IIIM–V, *n* (%)[a]	202 (58.2)	169 (60.4)
Smoking status: never, *n* (%)	123 (35.3)	185 (66.3)
Smoking status: ex, *n* (%)	185 (53.2)	69 (24.7)
Smoking status: current, *n* (%)	40 (11.5)	25 (9.0)
Alcohol consumption >recommended units, *n* (%)[a,c]	66 (19.0)	13 (4.6)
Left education ≥15years, *n* (%)	281 (80.8)	233 (83.2)
Physical performance		
3-m walk (s)[a]	3.3 (0.5)	3.5 (0.8)
Chair rises (s)[a,b]	15.2 (1.2)	16.7 (1.3)
Balance lost in < 5 s, *n* (%)[a]	58 (17.3)	66 (24.3)
Food consumption, median (IQR) portions/week		
Fruit	11.5 (6.5, 17.5)	15.4 (9.5, 21.6)
Nuts	0.20 (0.0, 0.5)	0.20 (0.0, 0.5)
Vegetables	23.7 (17.0, 31.0)	25.8 (19.5, 33.3)
Meat and meat dishes	9.7 (7.2, 12.5)	8.5 (6.3, 11.0)
White fish and shellfish	1.5 (1.0, 2.2)	2.0 (1.2, 2.6)
Oily fish	0.7 (0.5, 1.5)	1.0 (0.5, 1.5)
Nutrient intake, median (IQR) per day		
Energy from protein, %	16.6 (2.5)	17.5 (2.7)
Vitamin C, mg	132 (97, 171)	150 (111, 196)
β-Carotene, μg	3115 (2261, 3853)	3471 (2601, 4281)
Selenium, μg	52.5 (45.5, 62.8)	52.1 (43.7, 64.2)
Vitamin E, mg	10.2 (8.4, 12.6)	10.0 (8.1, 12.3)
Vitamin D, μg	3.20 (2.44, 4.33)	3.17 (2.53, 4.72)

[a]Data on height were missing for one man and one woman; data on 3-m walk were missing for two men; data on chair rises were missing for 14 men and 10 women; data on balance were missing for 13 men and 8 women, data on social class and alcohol were missing for one man.
[b]Geometric mean (SD).
[c]Recommended units of alcohol: 21 units per week for men; 14 units per week for women.

As we have previously described in the HCS cohort [23], the diets of men and women differed, such that women had 'healthier' diets characterised by greater consumption of fruit, vegetables and white and oily fish (all $P < 0.01$), and higher prudent diet scores (mean 1.01 (SD 1.74) in women, compared with −0.26 (1.97) in men, $P < 0.001$). After adjustment for energy intake (data not shown), women had higher intakes of all nutrients presented in Table 1, and a higher percentage protein energy when compared with the men.

Diet and physical performance

Table 2 shows the relationships between the dietary variables and the time taken to complete a 3-m walk in the men and women studied. Among the men, there were few univariate associations between diet and 3-m time (data not shown) and, after adjustment for the effects of confounding influences (age, social class, smoking, alcohol, age left education, height, and weight-adjusted-for-height), no independent associations were found with any measure of diet. In the women, a higher prudent diet score was associated with shorter 3-m walk time ($P = 0.016$), and there were inverse associations with consumption of vegetables ($P = 0.022$), white and shellfish ($P = 0.041$) and oily fish ($P = 0.007$), although none of these associations was robust to adjustment for confounding factors. However, there were associations between nutrient intake and 3-m walk time among the women studied, such that greater intakes of β-carotene, selenium, vitamin D and a higher percentage protein energy were all associated with a shorter 3-m walk time, both before (data not shown) and after adjustment (Table 2).

The associations between chair-rise time and diet are shown in Table 3. In men, as seen for 3-m walk time, there were no associations between diet and chair-rise time, both before (data not shown) and after adjustment for the effects of confounding factors (Table 3). Among the women, univariate comparisons showed that shorter chair-rise times were associated with higher prudent diet scores ($P = 0.011$), and greater consumption of nuts ($P = 0.014$) and vegetables ($P = 0.002$). However, with the exception of vegetable consumption, these associations were not robust to adjustment. There were associations between chair-rise time and nutrient intakes in the women; greater intakes of β-carotene and vitamin C were associated with shorter chair-rise times ($P = 0.003$ and $P = 0.039$, respectively, in univariate comparisons) and these associations were robust to adjustment.

Few associations were found between the measure of balance and the dietary variables in both the men and women studied (data not shown). Higher prudent diet scores in the women were associated with better balance ($P = 0.033$) but this was not robust to adjustment for confounders.

A total of 165 (59%) of the women and 163 (47%) of the men studied were taking dietary supplements. We also

Table 2. Relationships between prudent diet score, consumption of selected foods and nutrient intake, and time taken to complete 3 m walk (s)[a]

	Men		Women	
	Regression coefficient (95% CI)[a,b]	*P*-value	Regression coefficient (95% CI)[a,b]	*P*-value
Prudent diet score	−0.012 (−0.040, 0.016)	0.386	−0.256 (−0.070, 0.019)	0.263
Fruit	−0.000 (−0.005, 0.005)	0.950	0.000 (−0.007, 0.007)	0.937
Nuts	−0.004 (−0.043, 0.034)	0.830	−0.003 (−0.063, 0.057)	0.926
Vegetables	−0.001 (−0.006, 0.003)	0.584	−0.006 (−0.012, 0.001)	0.094
Meat and meat dishes	0.002 (−0.011, 0.014)	0.812	−0.014 (−0.035, 0.006)	0.166
White and shellfish	−0.037 (−0.077, 0.002)	0.062	−0.047 (−0.106, 0.012)	0.117
Oily fish	−0.001 (−0.043, 0.040)	0.954	−0.046 (−0.104, 0.013)	0.124
% energy from protein	−0.012 (−0.033, 0.009)	0.249	−0.037 (−0.066, −0.009)	0.010
Vitamin C	0.025 (−0.030, 0.079)	0.371	−0.004 (−0.077, 0.069)	0.910
β-Carotene	−0.009 (−0.062, 0.043)	0.731	−0.079 (−0.153, −0.004)	0.038
Selenium	−0.012 (−0.065, 0.041)	0.657	−0.091 (−0.165, −0.018)	0.015
Vitamin E	0.030 (−0.021, 0.081)	0.254	−0.019 (−0.096, 0.059)	0.635
Vitamin D	0.016 (−0.033, 0.066)	0.515	−0.083 (−0.159, −0.006)	0.035

[a]Adjusted for age, social class, smoking, alcohol, age left education, height and weight-adjusted-for-height.
[b]Regression coefficients represent the change in 3-m walk time per unit increase in prudent diet score, portions of food groups consumed or % energy from protein. For the nutrients (β-carotene, selenium and vitamins C, E and D), they represent the change in 3-m walk time per unit increase in nutrient SD score.

Table 3. Relationships between prudent diet score, consumption of selected foods and nutrient intake, and time taken for chair rises[a]

	Men		Women	
	Regression coefficient (95% CI)[a,b]	*P*-value	Regression coefficient (95% CI)[a,b]	*P*-value
Prudent diet score	0.995 (0.983, 1.007)	0.383	0.985 (0.968, 1.002)	0.091
Fruit	0.999 (0.996, 1.001)	0.298	0.999 (0.996, 1.001)	0.313
Nuts	0.990 (0.974, 1.006)	0.230	0.981 (0.958, 1.005)	0.114
Vegetables	0.999 (0.997, 1.002)	0.615	0.997 (0.994, 0.999)	0.019
Meat and meat dishes	1.004 (0.998, 1.010)	0.159	1.004 (0.996, 1.012)	0.335
White and shellfish	0.993 (0.976, 1.009)	0.381	0.986 (0.962, 1.010)	0.242
Oily fish	0.990 (0.972, 1.008)	0.259	0.996 (0.973, 1.019)	0.733
% energy from protein	0.997 (0.988, 1.007)	0.579	1.000 (0.989, 1.012)	0.988
Vitamin C	0.995 (0.973, 1.019)	0.704	0.972 (0.944, 1.000)	0.048
β-Carotene	1.001 (0.979, 1.024)	0.912	0.965 (0.937, 0.993)	0.017
Selenium	0.983 (0.961, 1.006)	0.138	0.983 (0.955, 1.012)	0.250
Vitamin E	1.005 (0.983, 1.028)	0.640	0.970 (0.940, 1.000)	0.053
Vitamin D	0.999 (0.978, 1.021)	0.954	0.986 (0.957, 1.017)	0.372

[a]Adjusted for age, social class, smoking, alcohol, age left education, height and weight-adjusted-for-height.
[b]Regression coefficients represent the proportional change in chair-rise time per unit increase in prudent diet score, portions of food groups consumed or % energy from protein. For the nutrients (β-carotene, selenium and vitamins C, E and D), they represent the proportional change in chair-rise time per unit increase in nutrient SD score.

examined the relationships between total nutrient intakes (from foods and supplements) with the three measures of physical performance. In both men and women, the inclusion of supplementary nutrients made little difference to the findings (data not shown), and the patterns of associations between total nutrient intake and physical performance were very similar to those found with nutrients from foods.

Discussion

The aim of our study was to examine how variation in the diets of community-dwelling older men and women living in the UK related to measures of physical performance. Dietary patterns differ hugely across the population [23], but to our knowledge, this is the first study in the UK to determine how current variations in food and nutrient intake relate to physical performance. We did not find any associations between diet and physical performance in men, but in women, higher intakes of a number of antioxidant nutrients were associated with a shorter 3-m walk and chair-rise times. Faster 3-m walk times were also associated with higher intakes of vitamin D intake and percentage protein energy in the diet. There were no associations between diet and performance in the balance test.

We restricted our analyses to nutrients that have been identified as having important influences on muscle strength and function. Our findings of better physical performance among women with greater intakes of some of these nutrients are consistent with much of this work [15], although in contrast with other studies [15,28], we did not find any differences in physical performance in relation to vitamin E intake, or fruit consumption. The most consistent picture that emerges from our analyses is the importance of antioxidant nutrients for physical performance in older women. In particular, higher intakes of

β-carotene, a principal carotenoid in the UK diet, were related to both shorter 3-m walk and chair-rise times. This accords with recent studies that have demonstrated links between low serum carotenoid concentrations and decline in walking speed [29] and frailty among older women [30].

Because many nutrients in foods are highly correlated, it is possible that other nutrients present in foods can contribute to a given nutrient-outcome association. We therefore considered foods that are key sources of the nutrients of interest, as well as the overall dietary pattern of the men and women studied. Unlike the effects of oily fish consumption that we have previously described in relation to grip strength [25], we did not find any independent associations between intakes of the foods considered or the dietary pattern with physical performance. Given the associations with the antioxidant nutrients, the lack of association with fruit and vegetable intake was surprising. It suggests that there may be specific effects of β-carotene on physical performance, as this is also found in other foods such as soft drinks and fat spreads, which were not considered in our analyses.

There is little evidence in the literature regarding gender differences in the association between diet and physical performance, although the associations we have previously described in the HCS between diet and grip strength were much more marked in women than in men [25]. This may be a result of the 'healthier' diets of women, which have higher micronutrient densities. Alternatively, as the physical performance of these women was poorer, there may be a threshold below which variations in diet are of greater importance. However, it is consistent with earlier analyses in which we have shown that physical activity is an important influence on physical performance among older women but not older men [27]. Adult lifestyle may therefore have a particularly important influence on the physical performance of older women.

A potential weakness of our study is that we only studied men and women who were taking part in the HCS, for whom we had early life information and who were still resident in West Hertfordshire. However, the HCS has been shown to be broadly representative of the wider population [24], and the associations we describe are from internal comparisons. There is no reason to expect the findings to differ outside the cohort and our findings should be generalisable. Diet was assessed using an administered FFQ by trained research nurses. Although there is concern that FFQs can be prone to measurement error, they have been shown to describe dietary patterns that are comparable with other assessment methods [31], and may be particularly suitable for the assessment of foods consumed infrequently, such as oily fish [32]. We would expect measurement error to result in misclassification of individual intakes, and to attenuate associations. It is unlikely that this would explain our findings. An important limitation is that our data are cross-sectional, and it will be important to determine how variations in diet at baseline predict decline in physical performance in the future.

Conclusion

The associations between diet and physical performance in our study suggest that diet may influence physical performance in community-dwelling older women but not men. However, further work is needed to extend and replicate these findings, and to understand how diet impacts on decline in physical performance in later life.

Key points

- Recent studies suggest that diet affects the physical performance of older adults, but the impact of current variations in the UK diet on physical performance has not been assessed.
- We found associations between nutrient intake and measures of physical performance in women but not in men, suggesting that lifestyle influences on physical performance may be more important in older women.
- Further work is needed to determine the role of variations in diet on physical performance and its decline with age among older adults in the UK.

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Conflicts of interest

The authors have no conflicts of interest.

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