**Adult lifetime diet quality and physical performance in older age:**

**findings from a British birth cohort**

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**ABSTRACT**

**Background**: Current evidence that links ‘healthier’ dietary patterns to better measured physical performance is mainly from older populations; little is known about the role of earlier diet. We examined adult diet quality in relation to physical performance at age 60-64 years.

**Methods**: Diet quality was defined using principal component analysis of dietary data collected at 36, 43, 53 and 60-64 years. Throughout adulthood, diets of higher quality were characterised by higher consumption of fruit, vegetables and wholegrain bread. Diet quality scores calculated at each age indicated compliance with this pattern. Physical performance was assessed using chair rise, timed-up-and-go and standing balance tests at age 60-64. The analysis sample included 969 men and women.

**Results**: In gender-adjusted analyses, higher diet quality at each age was associated with better measured physical performance (all p<0.01 for each test), although some associations were attenuated after adjustment for covariates. Diet quality scores were highly correlated in adulthood (0.44 ≤ r ≤ 0.67). However, conditional models showed that higher diet quality at age 60-64 (than expected from scores at younger ages), was associated with faster chair rise speed and with longer standing balance time (adjusted: 0.08 [95% CI: 0.02,0.15] and 0.07 [0.01,0.14] SD increase in chair rise speed and balance time respectively per SD increase in conditional diet quality) (both P<0.05).

**Conclusions**: Higher diet quality across adulthood is associated with better physical performance in older age. Current diet quality may be particularly important for physical performance, suggesting potential for improvements in diet in early older age.

**Keywords**: diet, life course, ageing, physical function

**INTRODUCTION**

Simple measures of muscle mass and function, such as handgrip strength and walking speed, act as biomarkers of ageing, and are important predictors of future health and mortality [1]. The variability in these measurements seen across the population [2] is therefore a concern. Although some of the observed inter-individual differences are explained by known determinants, such as gender, age and body build, much of the variability is unexplained [3]. This has focused interest on modifiable behavioural factors, linked to lifestyle, and their influence on physical performance in older age [4]. The recent description of age-related changes in physiology and function in mid-life, occurring many years before losses in function are observed [5], highlights the need to understand the effects of these factors acting across the life course; recognising that muscle mass and strength in later life reflect both the peak achieved in early adulthood as well as the rate of decline in later years [3,5,6,7].

An important lifestyle influence is nutrition, and a number of candidate nutrients (protein, vitamin D, antioxidants and n-3 fatty acids) have been linked to differences in muscle mass, strength and physical performance in older age [8]. But much of the evidence is observational, and collinearity between dietary constituents limits causal inferences. This has led to a growing interest in the role of diet quality in maintaining good physical and cognitive function during ageing [9]. ‘Healthier’ patterns, that are linked to higher intakes of a range of protective nutrients, as well as non-nutrients (such as polyphenols), have been shown to be associated with higher muscle mass, strength and better measured physical performance [8]. For example, lower rates of decline in physical performance have been described in individuals whose diets comply with a Mediterranean pattern [10-13]. However, most of these studies have been carried out in older populations, and little is known about the contribution of differences in diet quality earlier in adult life, or in childhood. A recent analysis of data from an 18-year follow up of the Nurses’ Health Study has therefore provided valuable new evidence; participants with healthier diets (averaged scores for Alternative Healthy Eating Index-2010, AHEI-2010), had a lower risk of self-reported incident physical impairment (Short Form-36 physical function scale, SF36) during the study period, suggesting that lifetime diet quality may have a protective role in preventing or delaying losses of physical function [14]. But to understand the importance of diet quality, and to evaluate potential cumulative effects across the life course, longitudinal dietary data collected at different ages are needed. Using data from a British birth cohort study, in which prospective diet records were collected in childhood and adult life [15], we examined adult diet quality and its links to physical performance at age 60-64 years, using three standardised tests of physical performance (chair rising, timed up-and-go (TUG) and standing balance).

**SUBJECTS AND METHODS**

**Study sample**

The MRC National Survey of Health and Development (NSHD) is a longitudinal study based on a socially stratified sample of 5362 births occurring in one week in March 1946 across England, Wales and Scotland [15]. By the time of follow-up in 2006-2010, 718 participants had died, 594 had withdrawn from the study, 567 had emigrated and 320 were lost to the study. Of the remaining participants, 2229 (78% of those invited) were assessed: 1690 (76%) at clinic and 539 (24%) at home [15,16]. The study was conducted according to the guidelines set out in the Declaration of Helsinki; ethical approval for the data collection was obtained from the Greater Manchester Local Research Ethics Committee and the Scotland A Research Ethics Committee.

*Dietary assessment*

Diet was assessed using prospective 5-day food diaries completed by the participants at ages 36 (1982), 43 (1989), 53 (1999) and 60-64 (2006-2010) years [17,18]. All food and drink items consumed were recorded using household measures; images and notes at the start of the diaries were provided to guide estimation of portion size. At age 60-64, 880 men and 989 women completed at least 3 days of the food diary. Of these participants, 988 (53%) had completed food diaries (for at least 3 days) at every adult assessment. All foods and drinks consumed at each age were allocated to one of 45 mutually exclusive food groups on the basis of similarity of type of food and nutrient composition [Supplementary Table 1]. The average consumption of each food family (g/day) was calculated for all participants at each age. A principal component analysis (PCA) of the daily consumption of the 45 food groups at each age was used to examine dietary patterns [19]. The first component described a ‘healthier’ profile of foods at each age in adulthood (details are given in Supplementary methods; PCA coefficients are shown in supplementary Table 2). Pattern scores, defining individual participant’s compliance with the ‘healthier’ dietary pattern, are referred to as ‘diet quality scores’ throughout the paper; a higher score indicated a diet of higher quality.

*Physical performance outcomes*

Physical performance was assessed by trained nurses following standard protocols using three tests at age 60-64: chair rises, timed up-and-go (TUG) and standing balance. [21,22]. The time taken to perform 10 chair rises (rise from a sitting to a standing position and sit back down again) was recorded and used to derive chair rise speed as the number of repetitions per minute. The TUG test required the participant to rise from a chair, walk 3m at a normal pace, turn around, return to the chair and sit down; TUG speed was calculated by dividing 6 (distance in metres) by the time taken in seconds. Standing balance time was measured as the length of time a participant could stand on one leg with their eyes closed, up to a maximum of 30 seconds. The present analysis included 969 participants, for whom complete dietary data were available (at each age) and at least one measure of physical performance at age 60-64.

*Participant characteristics*

Height and weight were measured by nurses at age 60-64. Self-reported smoking status (never/ex/current) at age 60-64 was categorized into ever smokers and never smokers. Leisure time physical activity at age 60-64 was assessed by questionnaire; participants were asked how often in the previous month they had participated in any sports, vigorous leisure activities or exercises, and categorized into the following groups: inactive (no participation); moderately active (participated in relevant activities 1-4 times per month); and active (participated in relevant activities 5 or more times per month). Occupational social class was categorised using the Registrar General's classification: I; II; III non-manual; III manual; IV; and V. Self-reports of diabetes and doctor diagnosed angina and myocardial infarction from assessments undertaken up to and including age 60–64 were used to distinguish between participants with and without reports of diabetes and cardiovascular disease [7].

*Statistical Analysis*

Participant characteristics were described using summary statistics. Pearson correlation coefficients were used to assess stability of diet quality. In addition to diet quality scores assessed at each age, an overall adult diet quality score (ADQ) was calculated for every participant. Using the quartiles of the diet quality score defined at age 60-64, points were allocated to the quarter of the distribution each participant’s diet quality score was in (1 = lowest quarter, 2 = second, 3 = third and 4 = highest quarter) at each age. These points were summed across the four ages in adulthood; scores ranged from 4 (poor diet quality across all ages) to 16 (high diet quality across all ages).

Diet quality scores at each age and physical performance measures were standardized (sex-specific) in models to ensure effect sizes were comparable. The variable for standing balance time was positively skewed and was therefore log-transformed after adding one. Height and weight were highly correlated; to avoid multi-collinearity problems, a sex-specific standardised residual of weight-adjusted-for-height was calculated as a measure of adiposity. Separate linear regression models were used to examine the association between diet quality scores at different ages and ADQ, in relation to each physical performance measure at 60-64 years. We considered a number of covariates, informed by previous analyses and published literature [14,22]; models were adjusted for: gender, age at follow-up, height, weight-for-height residual, smoking history, leisure time physical activity, presence of diabetes and cardiovascular disease. As diet quality has been shown to differ between men and women [23], we examined potential gender-diet interactions; in gender-adjusted models, the statistical significance (p<0.05) of interaction effects between gender and diet quality scores were assessed. We evaluated the impact of adjustment for social class in separate models, and we examined whether associations in the analysis sample were generalizable to the wider NSHD cohort. In sensitivity analyses, diet quality scores were derived using the maximum available sample with dietary data at each age and relationships between diet quality at each age and the physical performance measures were re-examined.

Conditional models were used to examine whether higher diet quality than expected at age 60-64, given diet quality at earlier ages, was associated with differences in the physical performance measures at 60-64 years. To implement these, residuals, representing conditional diet quality scores, were obtained by regressing diet quality scores at each age in adulthood on the adult diet quality scores at all previous assessments [24]. Each physical performance measure was then regressed on all conditional diet quality scores with adjustment for diet quality at age 36 and other participant characteristics.

**RESULTS**

*Participant characteristics*

The characteristics of the 969 participants who were included in the analysis sample are presented in Table 1. Mean age at clinic visit was 63 years among men and women. Although mean TUG speed was similar among men and women, men recorded slightly longer standing balance times and had faster chair rise speed than women on average.

Compared to the participants who were assessed at the most recent follow-up of the cohort but were not included in the analysis sample due to incomplete dietary or physical performance data, men and women in the analysis sample had lower mean BMI and longer standing balance times (p<0.05 for all); chair rise and TUG speeds did not differ significantly between the two samples (p>0.05). Women in the analysis sample were more likely to have never smoked, to have engaged in physical activity at least once per month and to be of higher social class (p<0.05); there were no differences in these characteristics among men.

*Diet quality*

Mean diet quality score increased from age 36 years to age 60-64 among men and women (Figure 1). Women had higher diet quality scores than men at all ages in adulthood (p<0.001). However, while mean diet quality scores increased across adulthood, the correlations between scores at all ages in adulthood were reasonably high (0.44 ≤ r ≤ 0.67), indicating stability in ranking of participants in terms of their diet quality between 36 and 60-64 years (Supplementary Table 3). At all ages, increasing diet quality scores were associated with greater consumption of fresh fruit, leafy vegetables and wholegrain bread, but lower consumption of white bread, added sugar and processed meat (all p-values for trends <0.001). (Supplementary Table 4). The differences were large, such that three to fourfold differences in consumption were observed for many of these foods across the range of diet quality scores.

*Relationship between diet quality in adulthood and physical performance measures*

The associations between diet quality in adulthood and physical performance at age 60-64 are presented in Table 2. There was little evidence of gender-diet interactions (data not shown); men and women were therefore pooled for all analyses. In the gender-adjusted analysis, higher diet quality scores at each age were associated with better measured performance in the three tests (p<0.01). These associations were mostly robust to adjustment (gender, age at follow-up, height, weight-for-height residual, smoking history, physical activity, diabetes and cardiovascular disease) (p<0.05), with the exception of the associations regarding diet quality at age 43, and the association between diet quality at age 53 years and TUG speed. There were consistent positive associations between diet quality and physical performance in the cross-sectional associations at 60-64 years, and using the overall ADQ score. The size of effects was meaningful; for example, compared to individuals in the bottom quartile of diet quality at 60-64, those in the top quartile performed 2.37 (95% CI: 0.96, 3.79) additional chair rises per minute in gender-adjusted analysis and 1.75 (0.28, 3.23) additional chair rises in fully-adjusted analyses (data not shown). Further adjustment for social class attenuated the associations between diet quality at younger ages and physical performance at 60-64, so that the associations with diet quality at age 53 and between ADQ score and chair rise and TUG speed were no longer statistically significant (data not shown). However the cross-sectional associations between diet quality at age 60-64 and both chair rise speed and standing balance time were robust to adjustment (both, p=0.004); TUG was of borderline significance (p=0.052). Sensitivity analyses, that included all participants who provided dietary data at each age, showed comparable associations between diet quality scores at each age and the physical performance outcomes to the analysis sample (Supplementary Table 5).

Because there was tracking of diet quality across adulthood, we used conditional models to explore whether higher diet quality than predicted, based on earlier diet quality scores, was associated with better physical performance. Using these models, higher diet quality than expected at age 60-64, when taking into account earlier diet quality, was associated with faster chair rise speed and with longer standing balance time (Table 3). These relationships were robust in the fully-adjusted analysis and when additionally adjusted for social class (data not shown).

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**DISCUSSION**

We have used prospective diet records, collected at four points between the ages of 36 years and 60 to 64 years, to examine associations between diet quality across adulthood and measured physical performance in older age. Diets of higher quality, characterised by higher consumption of fruit and vegetables and wholegrain bread, and lower consumption of white bread, potato products, added sugar and processed meat, were positively associated with all measures of physical performance at 60-64 years. This was a consistent finding for diet quality defined at different ages and using an index of overall diet quality in adulthood, and was largely robust to adjustment for other participant characteristics, that included physical activity and smoking status. Comparable associations to the analysis sample were observed when dietary data was analysed for all available participants, and findings were similar in men and women. However the strongest associations were observed in the cross-sectional analyses of diet quality at 60-64 years, in relation to contemporary measures of physical performance. Furthermore, our conditional analyses showed higher diet quality than expected at age 60-64, (when taking into account earlier diet quality), was associated with faster chair rise speed and with longer standing balance time. This may suggest that changes in food choice, to improve overall diet quality in later life, could have potential to improve physical performance – and to contribute to healthier ageing.

There is some interest in the effects of long-term exposure to dietary patterns across the life course, as influences on health in later life. For example, in a large population of adults studied in the China Health and Nutrition Survey, ‘healthier’ dietary trajectories in mid-life were associated with lower HbA1C at 15-year follow-up, even if contemporary dietary pattern scores were similar [25]. This suggests that the cumulative effects of exposure linked to diabetes risk in later life may be more important than current diet. Similarly, using data from the NSHD to examine long-term effects of dietary patterns on bone health in older age, Ward and colleagues found that the trajectory of a protein-calcium-potassium rich dietary pattern between 36 and 60-64 years was associated with higher bone mineral content across all skeletal sites in women [26].

Our finding, that higher adult diet quality is related to better measured physical performance in older age, is consistent with other evidence, although there are few data from other longitudinal studies, with repeat assessments of dietary intake throughout adulthood, to compare directly with our study. The most comparable prospective cohort is the Whitehall cohort in the UK, in which fruit and vegetable consumption, an indicator of diet quality, was reported 17, 10 and 5 years before an assessment of physical performance (at mean age 65.9 ± 5.9 years) [27]. The findings were similar; low fruit and vegetable consumption (less than 2 portions per day) recorded at each wave, and a longer period of low fruit and vegetable consumption in adult life, was associated with slower walking speed at follow-up. In the Whitehall study there was evidence of an accumulation of risk for slow walking speed that was associated with low fruit and vegetable consumption. Although we found graded differences in measured physical performance in relation to overall adult diet quality (ADQ), which may be consistent with cumulative effects (Table 2), the tracking of diet quality throughout adulthood made this difficult to assess in our study. Furthermore, the observed improvements in measured physical performance, in relation to improvements in diet quality closer to the time of measurement, seen in the conditional analyses, may point more to the importance of current diet. However, further data are needed to confirm this.

The compilation of dietary data over long time periods is affected by background changes in food habits and food availability. Using the longitudinal dietary data collected in this survey, we were able to describe improvements in diet quality between 1982 and the most recent data collection in 2006-10; although women had higher diet quality scores at each age in adulthood, the changes over time were evident in both genders. These changes are explained by trends in food consumption that have been described previously [17]; consumption of less healthy foods (including white bread, added sugar, processed meat) fell, while healthy foods (including vegetables, wholemeal bread, reduced-fat milk) increased. This may reflect participants’ increasing adherence to healthy eating guidance (promoted consistently in the UK since the 1980s), together with changes to the food supply (such as the availability of reduced fat milk) [28]. To ensure comparability of patterns over time we used fixed coefficients from the PCA of the dietary data collected at 60-64 years [20]; using this approach we were able to show stability in ranking of participants in terms of diet quality through adulthood, alongside the background changes in diet that were taking place.

A strength of this study is the availability of prospective dietary data, assessed and analysed using consistent methods across adulthood. It is also important that we examined objective measures of physical performance. But it is a limitation of the study that a sub-sample of the original cohort, who provided dietary data at each stage of the survey, were included in this analysis, and that they differed in some characteristics from the remainder of the cohort. For example, when compared other participants who were studied at 60-64 who did not have complete dietary data, average body mass index was lower among the participants in the analysis sample. Although this may have implications for the external validity of the findings presented, we make internal comparisons in our analyses, and it is unlikely that these differences would explain the data we present. Furthermore, sensitivity analyses, using diet quality scores, derived using the maximum available sample with dietary data at each age, showed similar associations to the analysis sample. A second limitation is that we used self-reported dietary data, for which there are concerns regarding measurement error [29]. However, this may be less important for the description of overall dietary patterns; importantly, comparable patterns have been reported using different dietary assessment methods [30,31]. Thirdly, although we observed links between lower diet quality at younger ages in adulthood and poorer measured physical performance when the NSHD participants were aged 60-64, we cannot exclude the possibility that reverse causation could explain or contribute to these associations. Finally, although in observational data there is potential for residual confounding, and additionally, we cannot account for measurement error in the covariates considered, there are sound mechanistic reasons to link higher diet quality to better physical performance in older age; this pattern would be expected to provide higher intakes of a range of nutrients (protein, vitamin D, antioxidants) [23], that in turn are linked to positive effects on muscle mass and strength and physical performance in older age [8].

Our findings link quality of diet to better physical performance in older age, suggesting that improvement in diet quality has the potential to yield gains in function. If these observational findings are confirmed in other studies, they have important public health implications: positive changes in dietary patterns in early older age could have benefits for physical performance and healthier ageing.

**ACKNOWLEDGMENTS AND CONFLICTS OF INTEREST**

The authors thank the study participants for their continuing participation in the MRC NSHD. They also thank members of the NSHD scientific and data collection teams who have been involved in the NSHD data collections. Data used in this publication are available to bona fide researchers upon request to the NSHD Data Sharing Committee via a standard application procedure. Further details can be found at <http://www.nshd.mrc.ac.uk/data> (doi: [10.5522/NSHD/Q101](http://dx.doi.org/10.5522/NSHD/Q101); doi: [10.5522/NSHD/Q102](http://dx.doi.org/10.5522/NSHD/Q102)). The authors’ responsibilities were as follows: DK, RC were responsible for the design and conduct of the NSHD. SMR, AAS, HES and LW planned the analyses. LW conducted the statistical analyses with support from HES and RC. SMR and LW wrote the first draft of the manuscript. All authors read and approved the final version of the manuscript.

*Funding:*

The NSHD is funded by the UK Medical Research Council (MRC). The MRC also supports RC and DK (programme code MC\_UU\_12019/4), KW (U105960371). SMR, LW, HES, AAS and CC are supported by the MRC (MC\_UP\_A620\_1015, MC\_UU\_12011/2) and the University of Southampton UK. No author had any potential conflicts of interest.

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**Table 1: Characteristics of the NSHD participants included in the analysis**

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|  | **Men**  **(n=428)** | **Women**  **(n=541)** |
| Age at clinic visit (years)1 | 63.2 (1.1) | 63.3 (1.1) |
| Height (m)1 | 1.75 (0.07) | 1.62 (0.06) |
| BMI (kg/m2)1 | 27.4 (3.9) | 27.1 (4.8) |
| Ever smoked regularly2 | 285 (69.0%) | 318 (60.8%) |
| Leisure time physical activity participation2 |  |  |
| None | 264 (63.0%) | 309 (58.2%) |
| 1-4 times/month | 55 (13.1%) | 92 (17.3%) |
| 5 or more/month | 100 (23.9%) | 130 (24.5%) |
| Occupational class2 |  |  |
| I—Professional | 67 (15.7%) | 11 (2.0%) |
| II—Intermediate | 185 (43.3%) | 204 (37.7%) |
| III—Skilled (non-manual) | 42 (9.8%) | 210 (38.8%) |
| III—Skilled (manual) | 94 (22.0%) | 36 (6.7%) |
| IV—Partly skilled | 32 (7.5%) | 58 (10.7%) |
| V—Unskilled | 7 (1.6%) | 22 (4.1%) |
| Diabetes2 | 28 (6.7%) | 24 (4.6%) |
| Angina/myocardial infarction2 | 28 (7.0%) | 15 (3.0%) |
| TUG speed (m/s)1 | 0.71 (0.15) | 0.69 (0.15) |
| Chair rise speed (stands/min)1 | 26.8 (7.2) | 25.7 (8.0) |
| Standing balance time (secs)3 | 3.8 (2.6, 5.5) | 3.5 (2.5, 5.4) |

1Mean (standard deviation); 2 n (%); 3Median (interquartile range); TUG: Timed up-and-go

**Table 2: SD difference in physical performance measures at 60-64 years per SD increase in diet score1 at each age and per unit increase in adult score**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Chair rise speed** | | **Standing balance time** | | **TUG speed** | |
| **Age (yrs)** | **M3** | **Estimate (95%CI)** | **P** | **Estimate (95%CI)** | **P** | **Estimate (95%CI)** | **P** |
| *36* | ***1*** | 0.16 (0.09,0.22) | <0.001 | 0.12 (0.06,0.19) | <0.001 | 0.11 (0.04,0.17) | 0.002 |
| ***2*** | 0.11 (0.05,0.18) | 0.001 | 0.11 (0.05,0.18) | 0.001 | 0.08 (0.01,0.15) | 0.029 |
| *43* | ***1*** | 0.09 (0.03,0.16) | 0.005 | 0.09 (0.03,0.16) | 0.004 | 0.09 (0.02,0.15) | 0.009 |
| ***2*** | 0.05 (-0.02,0.11) | 0.147 | 0.06 (0.00,0.13) | 0.066 | 0.05 (-0.02,0.12) | 0.185 |
| *53* | ***1*** | 0.13 (0.07,0.20) | <0.001 | 0.11 (0.04,0.17) | 0.001 | 0.11 (0.04,0.17) | 0.001 |
| ***2*** | 0.08 (0.01,0.15) | 0.019 | 0.08 (0.02,0.15) | 0.013 | 0.06 (-0.01,0.13) | 0.092 |
| *60-64* | ***1*** | 0.16 (0.10,0.22) | <0.001 | 0.16 (0.10,0.22) | <0.001 | 0.12 (0.06,0.19) | <0.001 |
| ***2*** | 0.12 (0.06,0.19) | <0.001 | 0.12 (0.05,0.18) | <0.001 | 0.09 (0.02,0.16) | 0.012 |
| *ADQ2* | ***1*** | 0.05 (0.03,0.07) | <0.001 | 0.05 (0.03,0.07) | <0.001 | 0.04 (0.02,0.06) | <0.001 |
| ***2*** | 0.03 (0.01,0.05) | 0.013 | 0.04 (0.02,0.07) | <0.001 | 0.03 (0.00,0.05) | 0.033 |

1Diet quality scores defined using food consumption data collected at each age and coefficients from the PCA of the dietary data collected at 60-64 years; 2Adult Diet Quality Scores (ADQ), where individuals’ scores were coded from 1 (lowest quartile) to 4 (highest quartile) between age 36 to age 60-64 and summed to yield a score from 4 to 16 (quartile boundaries based on diet score at 60-64); 3 Model 1: adjusted for gender; Model 2: adjusted for gender, age at follow-up, height, weight-for-height-residual, smoking history, physical activity, diabetes and cardiovascular disease. SD: standard deviations; P: P-value

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 3: SD difference in physical performance measures at age 60-64 per SD increase in conditional diet quality at age 60-641** | | | | | | |
| **Model** | **Chair rise speed (SDs)** | | **Standing balance time (SDs)** | | **TUG speed (SDs)** | |
| **(95% CI)** | **P-value** | **(95% CI)** | **P-value** | **(95% CI)** | **P-value** |
|  |  |  |  |  |  |  |
| **1** | 0.08 (0.02,0.15) | 0.010 | 0.10 (0.04,0.17) | 0.001 | 0.06 (0.00,0.12) | 0.067 |
|  |  |  |  |  |  |  |
| **2** | 0.08 (0.02,0.15) | 0.011 | 0.07 (0.01,0.14) | 0.027 | 0.06 (-0.01,0.12) | 0.091 |

1Diet quality defined using food consumption data collected at each age and coefficients from the principal component analysis of the dietary data collected at 60-64 years; Estimates represent the SD change in physical performance measure per sex-specific SD increase in diet quality at age 60-64, conditional on diet quality at all previous ages; Model 1: adjusted for gender; Model 2: adjusted for gender, age at follow-up, height, weight-for-height residual, smoking history, physical activity, diabetes and cardiovascular disease.

**Figure 1: Diet quality scores at ages 36 to 60-64 years**

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**Supplementary methods**

*Diet quality scores*

A principal component analysis (PCA) of the daily consumption of the 45 food groups at each age was used to examine dietary patterns [19]. The first component described a ‘healthier’ profile of foods at each age in adulthood (Supplementary Table 2); the pattern of foods was characterized by higher consumption of fruit, vegetables and wholegrain bread, and lower consumption of white bread, potato products, added sugar and processed meat. Pattern scores, defining individual participant’s compliance with the ‘healthier’ dietary pattern, can be calculated by multiplying their recorded consumption of each food group by its PCA coefficient (Supplementary table 2), and summed. In this study, to enable comparison of pattern scores determined at different ages on a common scale (thus reflecting the same dietary pattern), the PCA coefficients were ‘fixed’ for the pattern score calculations [20]; PCA coefficients determined at 60-64 years were used to calculate scores at every age. The pattern scores are referred to as ‘diet quality scores’ throughout the paper; a higher score indicated a diet of higher quality.

**Supplementary Table 1: Food groups used in the Principal Component Analysis**

|  |  |
| --- | --- |
| **Food group** |  |
| Brown and wholemeal bread | Brown bread, granary, wheatgerm and wholemeal |
| White bread |  |
| Breakfast cereal | Oat based, low fibre and high fibre breakfast cereal |
| Crispbreads | Crispbreads such as Rivetas, Grissini and Toast Melba |
| Rice and pasta | Rice, pasta and dishes |
| Pizza |  |
| Cakes and biscuits | Biscuits, cereal bars, sweet cereal products (pastries, buns) |
| Puddings | Cereal and milk based puddings, ice cream and dairy desserts |
| Full fat milk |  |
| Reduced fat milk | 1% fat, semi-skimmed, skimmed animal and plant based |
| Cream and fromage frais |  |
| Cheese and cottage cheese |  |
| Yoghurts | Full fat and reduced fat yoghurts and drinking yoghurts |
| Eggs and egg dishes |  |
| Full fat spread | Animal based fats, butter and plant based fats (full fat) |
| Reduced fat spread | Plant based fats (low fat and reduced fat) |
| Frying fats and oils |  |
| Poultry (chicken, turkey) |  |
| Red meat | Beef, lamb, pork and other red meat |
| Processed meat | Bacon, ham, sausages, burgers, meat pies |
| Offal | Liver and other offal dishes such as haggis and faggots |
| White fish and shell fish |  |
| Oily fish |  |
| Vegetables - brassicaceae |  |
| Tomatoes | Tomatoes, including puree, sun dried, raw and canned |
| Leafy vegetables | Yellow, red and dark green leafy vegetables |
| Other vegetables |  |
| Baked beans, pulses and lentils |  |
| Potatoes |  |
| Potato products, includes French fries, | Potato products including chips, wedges and instant mash |
| Savoury snacks | Savoury snacks (cereal, potato and vegetable based) |
| Fresh fruit |  |
| Pure fruit juice and smoothies |  |
| Nuts and seeds | Nuts and seeds (including peanut butter) |
| Dried fruit |  |
| Cooked and tinned fruit |  |
| Sweets and confectionery | Confectionery, chocolate based products, sorbets, lollies |
| Sweet spreads, honey, jam | Jam, marmalade and other sugars such as syrups and honey |
| Added sugar | Pure sugar |
| Carbonated soft drinks |  |
| Non-carbonated (fruit based) drinks | Fruit based drinks, fruit juice drinks, fruit cordials |
| Water | Water (still, tap, sparkling and flavoured) |
| Tea and coffee |  |
| Powdered beverages, cocoa | Powdered beverages such as cocoa, Horlicks |
| Miscellaneous | Including cooking sauces and accompaniments |

**Supplementary Table 2. Coefficients for the first principal component from analysis of participants’ dietary data at each age diet was assessed**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Age (years)** | | | | |
|  |  | **36** | **43** | **53** | **60-64** |
| White bread |  | **-0.36** | **-0.26** | **-0.30** | **-0.24** |
| Brown and wholemeal bread |  | 0.17 | **0.22** | **0.21** | 0.12 |
| Breakfast cereal |  | 0.05 | 0.14 | 0.16 | 0.18 |
| Crispbreads |  | 0.16 | 0.17 | 0.11 | 0.11 |
| Rice and pasta |  | 0.03 | 0.08 | 0.17 | 0.10 |
| Pizza |  | 0.04 | 0.03 | 0.01 | 0.00 |
| Cakes and biscuits |  | -0.09 | 0.01 | -0.06 | -0.05 |
| Puddings |  | -0.06 | 0.04 | -0.02 | -0.02 |
| Full fat milk |  | -0.12 | -0.19 | -0.11 | -0.09 |
| Reduced fat milk |  | 0.17 | 0.19 | 0.05 | 0.13 |
| Cream and fromage frais |  | 0.02 | 0.10 | 0.07 | 0.05 |
| Cheese and cottage cheese |  | 0.10 | 0.10 | 0.06 | 0.12 |
| Yoghurts |  | 0.19 | **0.23** | **0.21** | **0.22** |
| Eggs and egg dishes |  | -0.09 | -0.03 | -0.09 | 0.01 |
| Full fat spread |  | **-0.34** | -0.14 | -0.18 | -0.07 |
| Reduced fat spread |  | 0.14 | 0.10 | 0.01 | -0.07 |
| Frying fats and oils |  | -0.17 | 0.15 | 0.09 | 0.14 |
| Poultry (chicken, turkey) |  | 0.02 | 0.07 | 0.03 | -0.03 |
| Red meat |  | -0.08 | -0.10 | -0.16 | -0.15 |
| Processed meat |  | **-0.26** | **-0.22** | **-0.27** | **-0.20** |
| Offal |  | -0.02 | 0.03 | -0.04 | -0.01 |
| White fish and shell fish |  | -0.09 | -0.07 | 0.04 | 0.02 |
| Oily fish |  | 0.08 | 0.16 | 0.16 | **0.22** |
| Vegetables - brassicaceae |  | 0.03 | 0.15 | 0.06 | 0.12 |
| Tomatoes |  | 0.06 | 0.18 | 0.17 | **0.24** |
| Leafy vegetables |  | 0.10 | **0.26** | **0.23** | **0.27** |
| Other vegetables |  | 0.12 | **0.26** | **0.28** | **0.33** |
| Baked beans, pulses and lentils |  | -0.16 | -0.01 | -0.05 | 0.08 |
| Potatoes |  | **-0.39** | -0.04 | -0.08 | 0.01 |
| Potato products, includes French fries, |  | 0.00 | **-0.26** | **-0.24** | -0.19 |
| Savoury snacks |  | -0.08 | -0.01 | -0.04 | 0.02 |
| Fresh fruit |  | **0.29** | **0.33** | **0.34** | **0.34** |
| Pure fruit juice and smoothies |  | 0.04 | 0.05 | 0.17 | 0.16 |
| Nuts and seeds |  | 0.03 | 0.11 | 0.09 | **0.20** |
| Dried fruit |  | 0.10 | 0.13 | 0.15 | **0.21** |
| Cooked and tinned fruit |  | -0.02 | 0.12 | 0.11 | 0.16 |
| Sweets and confectionery |  | -0.04 | 0.00 | -0.06 | 0.05 |
| Sweet spreads, honey, jam |  | 0.02 | 0.12 | 0.07 | 0.03 |
| Added sugar |  | **-0.30** | **-0.25** | **-0.23** | -0.17 |
| Carbonated soft drinks |  | -0.02 | -0.01 | -0.02 | -0.10 |
| Non-carbonated (fruit based) drinks |  | 0.13 | 0.09 | -0.03 | 0.01 |
| Water |  | 0.07 | 0.14 | **0.24** | **0.24** |
| Tea and coffee |  | -0.17 | -0.05 | -0.09 | 0.04 |
| Powdered beverages, cocoa |  | 0.01 | 0.04 | 0.05 | 0.05 |
| Miscellaneous |  | -0.04 | 0.09 | 0.07 | 0.05 |
|  |  |  |  |  |  |
| *Variance explained (%)* |  | 7% | 7% | 7% | 7% |
| Bold text used to highlight coefficients with greatest magnitude (≥0.2 or ≤-0.2)  Coefficients were derived using the maximum available sample with dietary data at each age | | | | | |

**Supplementary Table 3. Pearson correlation coefficients for diet quality scores at each age diet was assessed**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Age (years)** |  |
|  | **36** | **43** | **53** |
| **Men** |  |  |  |
| **43** | 0.461,2 |  |  |
| **53** | 0.48 | 0.56 |  |
| **60-64** | 0.47 | 0.54 | 0.67 |
|  |  |  |  |

**Women**

|  |  |  |  |
| --- | --- | --- | --- |
| **43** | 0.55 |  |  |
| **53** | 0.50 | 0.65 |  |
| **60-64** | 0.44 | 0.58 | 0.66 |

1Diet quality scores defined using food consumption data collected at each age and coefficients from the principal component analysis of the dietary data collected at 60-64 years; 2Pearson correlation coefficients and all such values. P<0.001 for all associations.

**Supplementary Table 4: Participants’ consumption of selected foods (g/day) according to quarter of the distribution of diet quality score at each age studied**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Diet quality quarter1,2** | **Age (years)** | | | |
| **36** | **43** | **53** | **60-64** |
| **Fresh fruit** | Lowest | 38 (7, 78)3 | 41 (14, 82) | 60 (20, 115) | 57 (18, 104) |
| Second | 90 (47, 139) | 94 (51, 166) | 137 (84, 213) | 115 (67, 164) |
| Third | 183 (117, 236) | 147 (89, 204) | 187 (120, 271) | 143 (90, 212) |
| Highest | 201 (72, 305) | 229 (170, 359) | 272 (200, 367) | 219 (153, 292) |
|  |  |  |  |  |  |
| **Leafy vegetables** | Lowest | 10 (3, 19) | 12 (5, 22) | 0 (0, 0) | 0 (0, 0) |
| Second | 18 (8, 32) | 20 (12, 34) | 0 (0, 4) | 0 (0, 8) |
| Third | 25 (12, 40) | 29 (16, 43) | 1 (0, 11) | 5 (0, 16) |
| Highest | 44 (20, 76) | 43 (27, 59) | 8 (0, 28) | 16 (0, 30) |
|  |  |  |  |  |  |
| **Brown and wholemeal bread** | Lowest | 0 (0, 44) | 14 (0, 51) | 0 (0, 29) | 14 (0, 46) |
| Second | 53 (14, 105) | 53 (25, 91) | 32 (8, 65) | 29 (4, 55) |
| Third | 55 (28, 84) | 62 (29, 93) | 43 (9, 79) | 32 (4, 62) |
| Highest | 26 (8, 83) | 54 (28, 86) | 43 (14, 78) | 43 (14, 70) |
|  |  |  |  |  |  |
| **White bread** | Lowest | 78 (42, 118) | 77 (42, 114) | 87 (54, 119) | 67 (30, 99) |
| Second | 24 (5, 56) | 35 (12, 68) | 55 (26, 81) | 42 (14, 68) |
| Third | 21 (0, 46) | 22 (0, 44) | 39 (14, 71) | 30 (12, 58) |
| Highest | 21 (0, 37) | 7 (0, 26) | 22 (7, 48) | 18 (0, 38) |
|  |  |  |  |  |  |
| **Added sugar** | Lowest | 11 (1, 35) | 5 (0, 26) | 5 (0, 23) | 3 (0, 18) |
| Second | 3 (0, 11) | 0 (0, 3) | 0 (0, 5) | 1 (0, 8) |
| Third | 1 (0, 3) | 0 (0, 2) | 0 (0, 3) | 1 (0, 6) |
| Highest | 0 (0, 2) | 0 (0, 2) | 0 (0, 3) | 1 (0, 5) |
|  |  |  |  |  |  |
| **Processed meat** | Lowest | 49 (26, 73) | 52 (27, 87) | 40 (17, 66) | 43 (23, 68) |
| Second | 29 (13, 50) | 26 (11, 52) | 29 (11, 49) | 25 (10, 48) |
| Third | 20 (8, 35) | 18 (0, 36) | 18 (5, 34) | 21 (9, 39) |
| Highest | 17 (0, 64) | 11 (0, 31) | 10 (0, 22) | 12 (0, 27) |
|  |  |  |  |  |  |
| *Number of participants in each quarter of distribution* | *Lowest* | *775* | *591* | *401* | *247* |
| *Second* | *159* | *213* | *235* | *247* |
| *Third* | *43* | *124* | *183* | *247* |
| *Highest* | *11* | *60* | *169* | *247* |

1Diet quality defined using food consumption data collected at each age and coefficients from a principal component analysis (PCA) of the dietary data collected at 60-64 years; 2Diet quality groups defined using quartiles of the diet score at age 60-64; 3Median (interquartile range) and all such values; P-values for trend in consumption across diet quality groups obtained from linear regression models: all foods shown P<0.001.

**Supplementary Table 5: SD difference in physical performance measures at 60-64 years per SD increase in diet score1 at each age when based on the maximum sample size (all participants with dietary data at each age:** **1574 participants at age 36; 1562 participants at age 43; 1375 participants at age 53; 1,829 participants at age 60-64)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Chair rise speed** | | **Standing balance time** | | **TUG speed** | |
| **Age (yrs)** | **M2** | **Estimate (95%CI)** | **P** | **Estimate (95%CI)** | **P** | **Estimate (95%CI)** | **P** |
| *36* | ***1*** | 0.13 (0.08,0.18) | <0.001 | 0.10 (0.05,0.15) | <0.001 | 0.07 (0.02,0.13) | 0.006 |
| ***2*** | 0.10 (0.04,0.15) | 0.001 | 0.08 (0.03,0.14) | 0.004 | 0.06 (0.01,0.12) | 0.026 |
| *43* | ***1*** | 0.08 (0.03,0.13) | 0.001 | 0.08 (0.03,0.13) | 0.001 | 0.08 (0.03,0.13) | 0.001 |
| ***2*** | 0.05 (-0.00,0.10) | 0.057 | 0.05 (-0.00,0.10) | 0.071 | 0.04 (-0.01,0.10) | 0.140 |
| *53* | ***1*** | 0.14 (0.08,0.19) | <0.001 | 0.10 (0.05,0.16) | <0.001 | 0.09 (0.03,0.14) | 0.001 |
| ***2*** | 0.08 (0.02,0.14) | 0.007 | 0.08 (0.02,0.14) | 0.011 | 0.04 (-0.02,0.09) | 0.169 |
| *60-64* | ***1*** | 0.14 (0.09,0.19) | <0.001 | 0.13 (0.09,0.18) | <0.001 | 0.12 (0.07,0.17) | <0.001 |
| ***2*** | 0.10 (0.05,0.15) | <0.001 | 0.10 (0.05,0.15) | <0.001 | 0.07 (0.03,0.12) | 0.003 |

1Diet quality scores defined using food consumption data collected at each age and coefficients from the PCA of the dietary data collected at 60-64 years; 2 Model 1: adjusted for gender; Model 2: adjusted for gender, age at follow-up, height, weight-for-height-residual, smoking history, physical activity, diabetes and cardiovascular disease. SD: standard deviations; P: P-value