



UNIVERSITÀ DEL PIEMONTE ORIENTALE

Master of Science in Food Health and Environment

Department for sustainable development and ecological transition

**Association between Mediterranean Diet Score and Frailty
Score among Older Adults in England: A Cross-Sectional
Study Using Wave 9 of the English Longitudinal Study of
Ageing**

Candidate: Amanda Panbehei

Supervisor: Prof. Lorenza Scotti



Firmato digitalmente da Lorenza Scotti
Data: 07.10.2026 17:57:04 CEST
Organizzazione: UNIVERSITA' DEGLI
STUDI DEL PIEMONTE
ORIENTALE/01943490027

Index

Summary	4
Introduction.....	6
1.1 Background.....	6
1.2 Frailty assessment	8
1.3 Clinical and public health importance of frailty	9
1.4 Nutrition, dietary patterns, and frailty.....	10
1.5 Mediterranean diet and frailty.....	11
1.6 Rationale for the present study	12
Aim of the research.....	13
Material and methods.....	14
2.1 Data source	14
2.2 Study design and study population.....	15
2.3 Frailty score	15
2.4 Mediterranean diet score	17
2.5 Confounders.....	18
2.6 Statistical analysis.....	19
Results	21
3.1 Study sample	21
3.2 Characteristics of the study sample	22
3.3 Frailty score components.....	24
3.4 Frailty score by sex	29
3.5 Mediterranean diet score	29

3.6 Univariable regression analysis	32
3.7 Multivariable regression analysis	34
Discussion.....	36
4.1 Main findings.....	36
4.2 Comparison with previous studies	36
4.3 Possible explanations for the non-significant finding	37
4.4 Other findings.....	38
4.5 Strengths and limitations	40
Future development.....	42
Conclusions.....	43
References.....	44

Summary

Frailty is an important condition in older adults and is associated with increased vulnerability, functional decline, hospitalization and mortality. Diet is a modifiable lifestyle factor that may be related to frailty. The Mediterranean diet has been associated with better health outcomes but evidence from non-Mediterranean populations remains limited. This study aimed to assess the association between Mediterranean diet score and frailty score among older adults aged 50 years or older using data from Wave 9 of English Longitudinal Study of Ageing.

This study used a cross-sectional design. The final analytical sample included 4,244 participants aged 50 years and over with sufficient 24-hour dietary recall data. Frailty score was measured as a continuous outcome using a deficit accumulation approach based on the ELSA frailty index described in previous ELSA research. Mediterranean diet score was calculated from nine dietary components using 24-hour dietary recall data and higher scores indicated greater adherence to the Mediterranean diet. Univariable and multivariable linear regression analyses were used. The adjustment included age, weight, education, net wealth, alcohol use in the last year, physical activity, and smoking status. Analyses were also repeated separately for men and women.

The mean frailty score in the total sample was 11.40, and women had higher frailty scores than men. The median Mediterranean diet score was 4. Mediterranean diet adherence was not significantly associated with frailty in either the univariable or adjusted analysis. Similar results were found in the separate analyses for men and women. Low physical activity and smoking were positively associated with frailty, while net wealth and alcohol use in the last year were negatively associated with frailty.

This study found no evidence of a significant association between Mediterranean diet adherence and frailty in ELSA Wave 9. The findings should be interpreted carefully because of the cross-sectional design and the use of 24-hour dietary recalls. Future longitudinal studies using repeated dietary measurements are needed to better understand whether long-term dietary patterns are related to frailty development in older adults.

Introduction

1.1 Background

Population ageing is one of the major public health changes of the twenty-first century. Between 2015 and 2050, the proportion of the world's population aged 60 years and over is expected to nearly double, from 12% to 22% (World Health Organization, 2024). This demographic change means that more people are living older age, and it increases the importance of understanding health conditions that affect older adults, their independence, and their need for health and social care. Ageing should not be understood only as living longer. The World Health Organization defines healthy ageing as the process of developing and maintaining functional ability that enables wellbeing in older age (World Health Organization, 2015). Functional ability refers to what older people are able to do and value in their daily lives, and it is influenced by their physical and mental capacities, their environment, and the interaction between them (World Health Organization, 2015). Therefore, ageing research should consider not only diseases, but also physical function, independence, intrinsic capacity, and the ability to remain active and participate in daily life. These aspects are also relevant to frailty, because frailty reflects reduced physiological reserve, reduced resilience, and greater vulnerability to health-related stressors in later life (Kim and Rockwood, 2024). Older adults do not all age in the same way. Some people remain active, independent, and resilient in later life, while others become more vulnerable to illness, functional decline, and adverse health outcomes. This variation shows that chronological age alone is not enough to describe health status in older adults.

Frailty is one way to describe this increased vulnerability in later life. It is generally understood as a state of reduced physiological reserve and reduced resilience across different body systems.

Frailty is not the same as having one specific disease. Instead, it reflects a broader condition in which an older person may be less able to respond to stressors such as acute illness, hospitalization, surgery, or other health-related events (Kim and Rockwood, 2024). Moreover, it is different from multimorbidity and disability, although these conditions may overlap: multimorbidity means having several chronic diseases at the same time while disability is usually related to difficulties in doing daily activities. Differently, frailty is more related to reduce physiological reserve and increased vulnerability. This difference is important because older adults with similar age or similar diseases may still have different levels of function, independence, and health risk (Kim and Rockwood, 2024; Dominguez et al., 2023).

This condition is common among older adults, but reported prevalence varies between studies. This variation is partly explained by differences in age groups, populations, countries, and frailty measurement tools. In population-level studies from 62 countries, pooled frailty prevalence was estimated at about 12% when physical frailty measures were used and about 24% when the deficit accumulation model was used. Pre-frailty was also common, with estimates around 46% using physical frailty measures and 49% using the frailty index. These findings show that the way frailty is measured can strongly influence prevalence estimates (O’Caoimh et al., 2021).

Early assessment of frailty in older adults is important because frailty increases vulnerability to adverse outcomes and can substantially reduce quality of life. Indeed, this condition usually

leads to a reduced physiological reserve and reduced ability to resist and recover from health-related stress problems and it is also associated with negative outcomes, such as falls, hospitalization, functional decline, lower quality of life, and mortality (Kim and Rockwood, 2024; Ofori-Asenso et al., 2019). This means that older adults with frailty may have more difficulty responding to stressful events, such as disease, surgery, hospitalization, or other health-related problems (Kim and Rockwood, 2024; Ofori-Asenso et al., 2019).

Frailty is influenced by different demographic, social, lifestyle, nutritional, and health-related factors. Some factors, such as age and sex, cannot be changed. However, other factors, such as physical activity, smoking, nutrition, diet quality, and social conditions, may be modifiable. For this reason, it is important to study lifestyle-related factors that may be associated with frailty in older adults (Boucham et al., 2024).

1.2 Frailty assessment

Frailty can be measured in different ways, and there is no single tool that is used in all studies and settings. The choice of measurement tool is important because it can affect both frailty prevalence estimates and associations with risk factors. Two common approaches in frailty research are the physical frailty phenotype and the frailty index.

The physical frailty phenotype defines frailty mainly as a physical syndrome. It includes five components: unintentional weight loss, exhaustion, weakness, slowness, and low physical activity. Based on this model, older adults can be classified as robust, pre-frail, or frail depending on how many components are present. This approach is useful because it focuses

on physical signs of decline, but it may not fully include cognitive, psychological, social, and medical aspects of frailty (Fried et al., 2001; Kim and Rockwood, 2024; VO Et Al., 2024).

The frailty index is based on the accumulation of health deficits. In this approach, different health problems are counted across several domains, such as chronic diseases, symptoms, physical limitations, cognitive problems, disability, mood symptoms, sensory problems, and other health-related conditions. A higher score indicates that more deficits have accumulated and that the person has a higher level of frailty. This approach is useful in population-based studies because it can be created from available health variables and can represent frailty as a continuous and multidimensional condition (Rockwood and Mitnitski, 2007; Searle et al., 2008; Kim and Rockwood, 2024).

Other frailty screening tools have also been developed, including the FRAIL scale, Groningen Frailty Indicator, Tilburg Frailty Indicator, and PRISMA-7. These tools are often shorter and easier to use in community or clinical settings. However, differences between frailty tools remain an important issue in research because some tools focus mainly on physical function, while others include psychological, cognitive, social, or medical domains. For this reason, studies should clearly report how frailty was measured, especially when comparing findings across different populations or studies (O’Caoimh et al., 2021; Vo et al., 2024).

1.3 Clinical and public health importance of frailty

Frailty assessment is also relevant from a public health perspective since identifying frailty can help clinicians to understand risk, plan care, and provide additional support when needed,

moreover, it can help make care more person-centred and appropriate for the patient's overall condition (Kim and Rockwood, 2024).

Moreover, it has to be noticed that frailty is important because several related factors are potentially modifiable including physical inactivity, smoking, poor nutrition, social isolation, and some unmanaged health conditions. The identification of these factors may help in planning prevention strategies and interventions to delay or reduce frailty in older adults (Boucham et al., 2024).

1.4 Nutrition, dietary patterns, and frailty

Nutrition is closely related to frailty because it can influence several processes involved in healthy ageing. Specifically, poor nutritional status may contribute to reduced muscle mass, weakness, fatigue, lower physical performance, inflammation, reduced immune function, and lower physiological reserve. These problems are closely connected to frailty, especially because weight loss, weakness, exhaustion, slowness, and low physical activity are important features of physical frailty (Lorenzo-López et al., 2017; Lengelé et al., 2025). Frailty has been associated with lower protein intake, poorer diet quality, lower intake of some micronutrients, reduced dietary antioxidant capacity, and malnutrition or risk of malnutrition. Both the quantity and quality of diet are therefore relevant. Energy and protein intake may affect body weight and muscle maintenance, while micronutrients and antioxidant-rich foods may influence inflammation, oxidative stress, and general health in older adults (Lorenzo-López et al., 2017; Lengelé et al., 2025). Diet may also be related to frailty through inflammation. Chronic low-grade inflammation is one biological process associated with ageing and physical decline. Western-style dietary patterns, which are often high in saturated

fats, refined sugars, processed foods, and salt, have been linked with higher inflammation. In contrast, diets rich in fruit, vegetables, whole grains, and unsaturated fats have been associated with lower inflammatory markers. This provides a reason to study overall dietary patterns rather than only single nutrients (Ecarnot and Maggi, 2024). Dietary patterns are useful in frailty research because people eat combinations of foods and nutrients rather than isolated nutrients. A dietary pattern can reflect the overall quality of the diet and the combined effects of different foods. Healthy dietary patterns usually include higher intake of fruit, vegetables, whole grains, fish, legumes, and nuts, while Western dietary patterns are often characterised by higher intake of red meat, processed meat, refined grains, and foods high in sugar or saturated fat. Higher adherence to healthy dietary patterns has been associated with lower odds of frailty in older adults (Rashidi Pour Fard et al., 2019).

1.5 Mediterranean diet and frailty

The Mediterranean diet is one of the most studied healthy dietary patterns. It is usually characterised by high intake of fruits, vegetables, whole grains, legumes, nuts, and olive oil, moderate intake of fish, poultry, and dairy products and low intake of red meat, processed meat, sweets, and saturated fat. This dietary pattern has fiber, unsaturated fatty acids, vitamins, minerals, and antioxidant compounds. These components may be important to frailty because they can support muscle function, reduce inflammation, and help maintain general health in older adults (Trichopoulou et al., 2003; Dominguez et al., 2023, Ecarnot and Maggi, 2024).

Previous studies have generally suggested that higher adherence to the Mediterranean diet is associated with lower frailty risk in older adults. Systematic reviews and meta-analyses have

reported that older adults with higher Mediterranean diet scores were less likely to be frail or pre-frail. However, the findings are not exactly the same in all studies. Differences in study design, dietary assessment, frailty measurement, population characteristics, and confounder adjustment may affect the results (Wang et al., 2018; Dominguez et al., 2023; Poursalehi et al., 2023)

1.6 Rationale for the present study

Although previous studies have assessed the association between the Mediterranean diet and frailty, some gaps still exist. Most of these studies have been done in Mediterranean or southern European populations, where the Mediterranean diet is more commonly part of the usual food culture. There is less evidence from England, which is not a Mediterranean country. Also, many studies have assessed frailty as a categorical outcome, while fewer studies have assessed frailty as a continuous score based on deficit accumulation. Therefore, it is useful to study the association between Mediterranean diet score and frailty score based on the data of the English Longitudinal Study of Ageing (ELSA), a longitudinal population-based study on a sample of the English population.

Aim of the research

The aim of this study was to assess the association between Mediterranean diet score and frailty score among adults aged 50 years and over, using data from Wave 9 of ELSA.

The specific objectives were:

1. To describe Mediterranean diet score and frailty score in the study sample, overall and by sex.
2. To examine the associations between potential confounders and frailty score using univariable regression analysis.
3. To assess the association between Mediterranean diet score and frailty score after adjustment for relevant confounders using multivariable regression analysis.
4. To examine whether the association between Mediterranean diet score and frailty score differed between men and women.

Material and methods

2.1 Data source

The ELSA study is a large longitudinal and population-based study of adults aged 50 years or older living in England, aimed at assessing the determinants of ageing trajectories. The study was set up in 2002, with the first wave of data collection lasting two years, and subjects were then re-interviewed every two years to collect information about health, socioeconomic status, lifestyle, cognitive function and social factors. Currently, data from 11 waves are available. In this thesis Wave 9 was used because it includes the dietary recall data and health-related variables to assess the association between Mediterranean diet score and frailty score (Banks et al., 2020).

Specifically, two databases of the wave 9 ELSA study were used:

1. Core interview dataset, which contains the main information collected through the face-to-face interview and the self-completion questionnaire at every wave of the study. It includes demographic characteristics, socioeconomic status, health and functional status, lifestyle behaviours, cognitive function and social factors
2. Nutrition dataset which collected dietary intake retrieved through the Oxford WebQ, online questionnaire. The Oxford WebQ is a web-based tool assessing food and drink consumption over the previous 24 hours, designed for repeated administration in large studies (Liu et al., 2011).

The questionnaire was completed on at least one day by the study participants although most of them completed it on two days. The dataset provides intake of the main food groups and nutrients and the portion sizes, as well as additional information helpful to determine whether the foods consumed in the previous 24 hours were part of the participant's usual diet or differed from their habitual eating pattern, as investigated by questions such as "Would you say that what you ate and drank yesterday was fairly typical for you?", "Were you ill?" and "Were you fasting?"

2.2 Study design and study population

This study had a cross-sectional design because the analysis was based on one wave of ELSA. The study population included adults aged 50 years and over who participated in Wave 9 ELSA and had sufficient dietary data to calculate the Mediterranean diet score. Individuals younger than 50 years and with fewer than two 24-hour dietary recalls were excluded.

2.3 Frailty score

Frailty score was the outcome variable in this study. Frailty was measured using a frailty index based on the deficit accumulation approach. The frailty index used in this study was based on the ELSA frailty index described by Johnson et al. (2024), which was developed from a previous ELSA study by Marshall et al. (2015). According to Marshall et al, this index includes 62 self-reported health problems related to chronic disease, general health, mobility, daily activities, psychological well-being, memory and cognition.

Mobility and physical function items included difficulty walking 100 yards, sitting for about two hours, getting up from a chair, climbing one or several flights of stairs without resting,

stooping, kneeling or crouching, extending arms above shoulder level, pulling or pushing large objects, lifting or carrying weights over 10 pounds, and picking up a 5p coin. Difficulties in basic activities of daily living included dressing, walking across a room, bathing, eating, getting in or out of bed and using the toilet, while difficulties in instrumental activities of daily living included using a map, preparing a hot meal, shopping for groceries, making telephone calls, taking medications, managing money and doing work around the house or garden. Chronic conditions included high blood pressure, angina, heart attack, congestive heart failure, abnormal heart rhythm, diabetes, stroke, chronic lung disease, asthma, arthritis, osteoporosis, cancer, Parkinson's disease, emotional, nervous or psychiatric problems, Alzheimer's disease and dementia. Psychological well-being was assessed through eight items referring to the past week (feeling depressed, feeling that everything was an effort, restless sleep, not feeling happy, loneliness, not enjoying life, sadness and being unable to get going). These deficits were coded as binary (0 = deficit absent, 1 = deficit present) and the presence of the condition contributed to a higher level of frailty. Additional information added to the index included self-reported general health, eyesight and hearing, falls, hip fracture, joint replacement and pain whilst walking. Cognition was assessed through orientation in time (day of the month, month, year and day of the week), a prospective memory test, immediate and delayed word recall and verbal fluency (animal naming).

Self-reported general health, eyesight and hearing were collected using Likert scale and to each item a score was assigned as follows: Poor=1, Fair=0.75, Good=0.5, Very good=0.25 and Excellent=0. For eyesight the scores were: Blind=1, Poor=0.8, Fair=0.6, Good=0.4, Very good=0.2 and Excellent=0.

Finally, the word recall, delayed word and verbal fluency tests were scored according to the quartile or quintile distribution of the scores in the sample, assigning the score of 1 to the lowest percentile (worst result) and 0 to the highest percentile (best result of the test).

The overall score was calculated by summing the scores obtained for each component. In this thesis, frailty score was used as a continuous variable. Higher scores indicated more accumulated health problems and a higher frailty level.

2.4 Mediterranean diet score

The Mediterranean diet score, the main exposure variable in this study, was calculated following the method proposed by Trichopoulou et al. (2003), adapted to the data available in the nutrition dataset by replacing the food quantity measure in grams/day with portions/day. Consistent with the original score, each component was assigned a value of 0 or 1 using the sex-specific medians of intake in the study sample as cut-offs.

The score included nine dietary components: vegetables, legumes, fruits and nuts (combined), cereals, fish, dairy products, red meat, the ratio of monounsaturated to saturated fatty acids (fat ratio), and alcohol. Each component was scored 0 or 1 using sex-specific median cut-offs as follows.

Diet components	Scoring
Vegetables	≥ Sex-specific median: 1 < Sex-specific median: 0
Legumes	≥ Sex-specific median: 1 < Sex-specific median: 0
Fruits and Nuts	≥ Sex-specific median: 1 < Sex-specific median: 0
Cereals	≥ Sex-specific median: 1 < Sex-specific median: 0
Fish	≥ Sex-specific median: 1 < Sex-specific median: 0
Dairy products	≥ Sex-specific median: 0 < Sex-specific median: 1
Red meat	≥ Sex-specific median: 0 < Sex-specific median: 1
Fat ratio	≥ Sex-specific median: 1 < Sex-specific median: 0
Alcohol	≥ Sex-specific median: 0 < Sex-specific median: 1

For components considered beneficial in the Mediterranean diet, including vegetables, legumes, fruits and nuts, cereals, fish, and fat ratio, higher intake received one point. For components considered less beneficial, including dairy products, red meat and alcohol intake, lower intake received one point. The total Mediterranean diet score ranged from 0 to 9, with higher scores indicating greater adherence to the Mediterranean diet.

2.5 Confounders

Several variables were included as potential confounders because they may be related to both dietary behavior and frailty. These variables were age, weight, education level, socioeconomic status, alcohol consumption, physical activity and smoking. Age and weight were measured in years and kilograms. Educational level was assessed through the highest educational

qualification attained, classified into seven categories: NVQ4/NVQ5 or degree equivalent, higher education below degree, NVQ3 or A-level equivalent, NVQ2 or O-level equivalent, NVQ1 or CSE equivalent, foreign or other qualification, and no qualification. Economic status was measured through the net wealth that is defined at the benefit unit level (a single person or a couple, plus any dependent children) and is calculated as the sum of savings, investments, physical wealth and housing wealth, minus financial and mortgage debt. Smoking was included as a dichotomous variable as current smoker and not current smoker. Alcohol consumption was coded according to whether participants reported drinking alcohol in the last year (yes vs no). Physical activity was assessed in ELSA through three self-reported items asking participants how often they engage in vigorous, moderate, and mild physical activity. Response options were "more than once a week", "once a week", "one to three times a month", and "hardly ever, or never". Negative codes (refusal, don't know, not applicable) were recoded as missing. Participants were classified as having moderate-to-high physical activity if they reported engaging in moderate or vigorous activity at least once a week (i.e., "more than once a week" or "once a week" for either item). Participants were classified as having low physical activity if they reported engaging in both moderate and vigorous activity less than once a week (i.e., "one to three times a month" or "hardly ever, or never"), irrespective of their level of mild activity.

2.6 Statistical analysis

Descriptive statistics were used to describe the characteristics of the study population. Continuous variables were presented as mean and standard deviation when normally distributed, or as median and interquartile range when the distribution was non-normal.

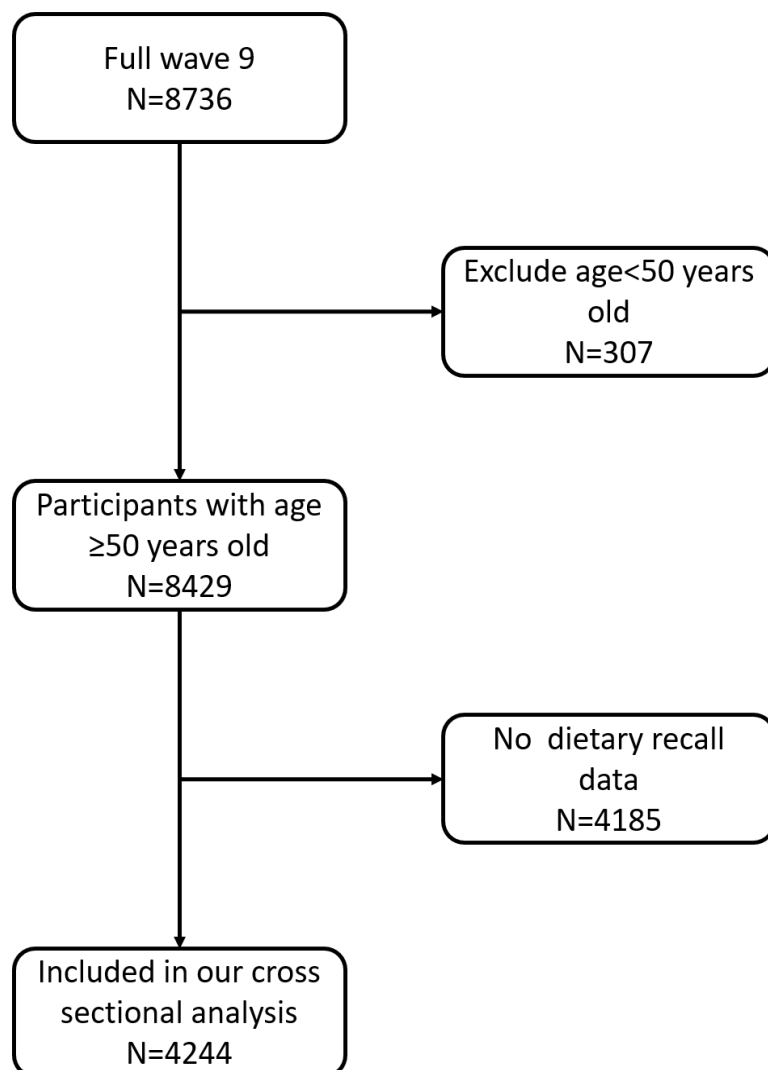
Categorical variables were presented as frequencies and percentages. Characteristics were described for the overall sample and separately by sex. Differences between men and women were examined using appropriate statistical tests. Chi-square tests were used to assess differences in categorical variables. Independent-samples t-tests were used for normally distributed continuous variables, and Mann-Whitney tests were used for continuous variables that did not follow a normal distribution. The assumption of normality was assessed using the Shapiro-Wilk test. Frailty score was analyzed as a continuous outcome variable. Linear regression was used as the main analytical approach. First, univariable linear regression analyses were performed to examine the unadjusted association between each independent variable and frailty score. Independent variables included Mediterranean diet score, age, weight, education, net wealth, alcohol use in the last year, physical activity, and smoking status. A multivariable linear regression model was then used to examine the association between Mediterranean diet score and frailty score after adjustment for all potential confounders simultaneously. The adjusted model included Mediterranean diet score, age, weight, education, net wealth, alcohol use in the last year, low physical activity, and smoking status. The multivariable model was also repeated separately for men and women to examine whether the association differed by sex. Regression results were reported using beta coefficients, standard errors, and p-values. A p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using Stata version 19.

Results

3.1 Study sample

The initial ELSA Wave 9 sample included 8,736 participants. Participants younger than 50 years were excluded from the analysis (n=307). Among the remaining 8,429 participants, 4,185 were excluded because they had fewer than two 24-hour dietary recalls. The final sample included 4,244 participants.

Figure 1 shows the flow chart of the study population.



3.2 Characteristics of the study sample

Table 1 shows the characteristics of the study sample overall by sex. Men made up 46% of the sample, and the mean age was 68 years. Men and women differed in several characteristics, specifically, men tended to be slightly older than women (69 vs 68 years), had a higher mean weight (86 vs 72 Kg) and higher median net wealth compared to women. Regarding education level, men seem to have achieved higher education level compared to women (Higher education below degree level and NVQ4/NVQ5/Degree or equivalent 56% vs 41%). Moreover, males seem to have a higher frequency of alcohol consumption in the last year 82% compared with 71%. No significant differences between men and women were observed for smoking status and physical activity.

Table 1. Characteristics of the study population by sex

Variable	Males	Females	Total	p-value
	N=1940	N=2304	N=4244	
	N (%)	N (%)	N (%)	
Age (years), mean (SD)	68.95 (7.49)	67.65 (7.66)	68.24 (7.61)	<0.0001*
Weight (Kg) , mean (SD)	85.60 (0.40)	72.10 (0.30)	78.30 (0.30)	<0.0001*
Missing	128	168	296	
Smoking				
Not current smoker	1,813 (93.45%)	2,150 (93.32%)	3,963 (93.38%)	0.8570^
Current smoker	127 (6.55%)	154 (6.68%)	281 (6.62%)	
Education				
No qualification	157 (8.3%)	254 (11.2%)	411 (9.9%)	0.0010^
NVQ1/CSE or equivalent	69 (3.7%)	51 (2.3%)	120 (2.9%)	
NVQ2/GCE O level or equivalent	312 (16.5%)	575 (25.4%)	887 (21.4%)	
NVQ3/GCE A level or equivalent	207 (10.9%)	257 (11.4%)	464 (11.2%)	
Higher education below degree level	386 (20.4%)	360 (15.9%)	746 (18.0%)	
NVQ4/NVQ5/Degree or equivalent	666 (35.2%)	579 (25.6%)	1,245 (30.0%)	
Foreign/other	95 (5.0%)	185 (8.2%)	280 (6.7%)	
Missing	48	43	91	
Net wealth (pounds), median (Q1-Q3)	441,900 (234,060–751,500)	410,000 (218,000–708,000)	426,000 (225,250–725,030)	0.0120°
Missing	21	18	39	
Alcohol use in the last year				
No	319 (18.40%)	563 (28.83%)	882 (23.92%)	<0.0001^
Yes	1,415 (81.60%)	1,390 (71.17%)	2,805 (76.08%)	
Missing	206	351	557	
Physical activity				
Low	279 (14.38%)	369 (16.02%)	648 (15.27%)	0.1404
Medium/high	1661 (85.62%)	1935 (83.98%)	3596 (84.73%)	

*Independent samples t-test, ^ chi square test, ° Mann-Whitney test

3.3 Frailty score components

Table 2 shows the components of the frailty score overall and by sex, grouped by domain. Regarding the mobility and physical functioning domain, women seemed to have a worse profile since they showed a higher percentage of difficulties compared to males, except for the items on walking 100 yards and picking up a 5p coin, for which no significant differences were observed. Higher percentages of difficulties among females were also found for some items of the instrumental activities of daily living (IADL), such as using a map, shopping for groceries and doing housework, whereas males reported more difficulties in making phone calls and taking medications. No differences were observed for preparing meals and managing money. Not only the physical but also the psychological profile appeared to be worse in women, who felt more depressed, lonely and sad, and showed more lack of happiness and enjoyment, among other things. Women also experienced falls, joint replacement and pain in walking more frequently, whereas males had worse hearing. In the cognitive domain, females performed better than males in the immediate and delayed word recall and in giving the correct day of the month, while no differences were found for verbal fluency and the other orientation items. No strong differences between the sexes were observed in terms of basic activities of daily living (only getting in or out of bed was more frequent among women) and the prevalence of chronic diseases. Among the latter, only arthritis, osteoporosis and Parkinson's disease had different prevalences between the sexes: the first two were more common among women, the last one among men. These results taken together seem to suggest that females have a worse physical and psychological profile than males, whereas males perform worse in the memory tests.

Table 2. Frailty components overall and by sex

		Males N=1940	Females N=2304	Total N=4244	Chi square test
Frailty component		N (%)	N (%)	N (%)	p-value
Mobility and physical function					
Difficulty walking 100 yards	Yes	137 (7.07)	173 (7.51)	310 (7.31)	0.5805
Difficulty sitting for about two hours	Yes	159 (8.20)	253 (10.98)	412 (9.71)	0.0023
Difficulty getting up from a chair	Yes	343 (17.69)	485 (21.05)	828 (19.51)	0.0059
Difficulty climbing several flights of stairs without resting	Yes	401 (20.68)	693 (30.08)	1094 (25.78)	<0.0001
Difficulty climbing one flight of stairs without resting	Yes	137 (7.07)	229 (9.94)	366 (8.63)	0.0009
Difficulty stooping, kneeling or crouching	Yes	585 (30.17)	822 (35.68)	1407 (33.16)	0.0001
Difficulty extending arms above shoulder level	Yes	115 (5.93)	195 (8.46)	310 (7.31)	0.0016
Difficulty pulling or pushing large objects	Yes	128 (6.6)	308 (13.37)	436 (10.28)	<0.0001
Difficulty lifting or carrying weights over 10 pounds	Yes	166 (8.56)	459 (19.92)	625 (14.73)	<0.0001
Difficulty picking up a 5p coin	Yes	80 (4.13)	99 (4.30)	179 (4.22)	0.7825
Basic activities of daily living (ADL)					
Difficulty dressing	Yes	196 (10.11)	212 (9.20)	408 (9.62)	0.3182
Difficulty walking across a room	Yes	38 (1.96)	35 (1.52)	73 (1.72)	0.2715
Difficulty bathing or showering	Yes	83 (4.28)	115 (4.99)	198 (4.67)	0.2742
Difficulty eating, such as cutting up food	Yes	24 (1.24)	41 (1.78)	65 (1.53)	0.1523
Difficulty getting in or out of bed	Yes	62 (3.20)	106 (4.60)	168 (3.96)	0.0196
Difficulty using the toilet	Yes	44 (2.27)	71 (3.08)	115 (2.71)	0.1045
Instrumental activities of daily living (IADL)					
Difficulty using a map	Yes	29 (1.50)	62 (2.69)	91 (2.14)	0.0074
Difficulty preparing a hot meal	Yes	40 (2.06)	65 (2.82)	105 (2.47)	0.1132
Difficulty shopping for groceries	Yes	60 (3.09)	120 (5.21)	180 (4.24)	0.0007
Difficulty making telephone calls	Yes	33 (1.70)	18 (0.78)	51 (1.2)	0.0061
Difficulty taking medications	Yes	35 (1.81)	18 (0.78)	53 (1.25)	0.0028
Difficulty managing money	Yes	24 (1.24)	24 (1.04)	48 (1.13)	0.5474
Difficulty doing work around the house or garden	Yes	156 (8.05)	255 (11.07)	411 (9.69)	0.0009

Table 2 continued

		Males N=1940	Females N=2304	Total N=4244	Chi square test
Frailty component		N (%)	N (%)	N (%)	p-value
Chronic conditions					
High blood pressure	Yes	97 (5.00)	112 (4.86)	209 (4.93)	0.8320
Angina	Yes	23 (1.19)	16 (0.69)	39 (0.92)	0.0945
Heart attack	Yes	19 (0.98)	13 (0.56)	32 (0.75)	0.1190
Congestive heart failure	Yes	6 (0.31)	8 (0.35)	14 (0.33)	0.8307
Abnormal heart rhythm	Yes	78 (4.02)	71 (3.08)	149 (3.51)	0.0971
Diabetes	Yes	51 (2.63)	48 (2.08)	99 (2.33)	0.2398
Stroke	Yes	15 (0.77)	9 (0.39)	24 (0.57)	0.0975
Chronic lung disease	Yes	25 (1.29)	21 (0.91)	46 (1.08)	0.2377
Asthma	Yes	17 (0.88)	23 (1.00)	40 (0.94)	0.6810
Arthritis	Yes	57 (2.94)	102 (4.43)	159 (3.75)	0.0109
Osteoporosis	Yes	14 (0.72)	42 (1.82)	56 (1.32)	0.0017
Cancer	Yes	56 (2.89)	47 (2.04)	103 (2.43)	0.0745
Parkinson's disease	Yes	9 (0.46)	3 (0.13)	12 (0.28)	0.0415
Emotional, nervous or psychiatric problems	Yes	34 (1.75)	41 (1.78)	75 (1.77)	0.9456
Alzheimer's disease	Yes	1 (0.05)	1 (0.04)	2 (0.05)	0.9033
Dementia	Yes	6 (0.31)	4 (0.17)	10 (0.24)	0.3642
Psychological well-being					
Felt depressed much of the time	Yes	115 (5.94)	205 (8.92)	320 (7.56)	0.0003
Felt everything was an effort	Yes	223 (11.52)	330 (14.35)	553 (13.06)	0.0064
Restless sleep	Yes	643 (33.20)	1063 (46.24)	1706 (40.27)	<0.0001
Lack of happiness	Yes	1830 (94.62)	2109 (91.98)	3939 (93.19)	0.0007
Loneliness	Yes	101 (5.22)	197 (8.57)	298 (7.04)	<0.0001
Lack of life enjoyment	Yes	1837 (95.03)	2111 (91.94)	3948 (93.36)	<0.0001
Sadness	Yes	208 (10.74)	412 (17.93)	620 (14.64)	<0.0001
Could not get going much of the time	Yes	236 (12.19)	363 (15.80)	599 (14.15)	0.0008

Table 2 continued

		Males N=1940	Females N=2304	Total N=4244	Chi square test
Frailty component		N (%)	N (%)	N (%)	p-value
General health, sensory impairment and other					
Self-reported general health	Excellent	250 (12.89)	336 (14.6)	586 (13.81)	0.2042
	Very good	639 (32.94)	794 (34.49)	1433 (33.78)	
	Good	662 (34.12)	758 (32.93)	1420 (33.47)	
	Fair	287 (14.79)	310 (13.47)	597 (14.07)	
	Poor	102 (5.26)	104 (4.52)	206 (4.86)	
Self-reported eyesight	Excellent	338 (17.42)	357 (15.49)	695 (16.38)	0.2240
	Very good	749 (38.61)	873 (37.89)	1622 (38.22)	
	Good	682 (35.15)	865 (37.54)	1547 (36.45)	
	Fair	141 (7.27)	179 (7.77)	320 (7.54)	
	Poor	26 (1.34)	29 (1.26)	55 (1.3)	
	Blind	4 (0.21)	1 (0.04)	5 (0.12)	
Self-reported hearing	Excellent	251 (12.94)	452 (19.62)	703 (16.56)	<0.0001
	Very good	492 (25.36)	718 (31.16)	1210 (28.51)	
	Good	727 (37.47)	811 (35.20)	1538 (36.24)	
	Fair	361 (18.61)	271 (11.76)	632 (14.89)	
	Poor	109 (5.62)	52 (2.26)	161 (3.79)	
Fall	Yes	383 (22.16)	509 (25.92)	892 (24.16)	0.0079
Hip fracture	Yes	9 (0.52)	8 (0.41)	17 (0.46)	0.6105
Joint replacement	Yes	54 (3.13)	89 (4.53)	143 (3.87)	0.0273
Pain whilst walking	Yes	110 (6.84)	188 (10.31)	298 (8.68)	0.0003

Table 2 continued

		Males N=1940	Females N=2304	Total N=4244	Chi square test
Frailty component		N (%)	N (%)	N (%)	p-value
Cognition					
Orientation in time: day of the month	Yes	1620 (84.2)	2060 (89.92)	3680 (87.31)	<0.0001
Orientation in time: month	Yes	1906 (98.6)	2273 (98.87)	4179 (98.75)	0.4385
Orientation in time: year	Yes	1905 (98.6)	2275 (98.96)	4180 (98.79)	0.2938
Orientation in time: day of the week	Yes	1920 (99.33)	2272 (98.83)	4192 (99.05)	0.0928
Immediate word recall	Q1	799 (41.29)	1243 (54.07)	2042 (48.23)	<0.0001
	Q2	538 (27.8)	546 (23.75)	1084 (25.6)	
	Q3	357 (18.45)	328 (14.27)	685 (16.18)	
	Q4	241 (12.45)	182 (7.92)	423 (9.99)	
Delayed word recall	Q1	329 (16.97)	653 (28.35)	982 (23.15)	<0.0001
	Q2	366 (18.88)	508 (22.06)	874 (20.6)	
	Q3	455 (23.47)	510 (22.15)	965 (22.75)	
	Q4	334 (17.23)	319 (13.85)	653 (15.39)	
	Q5	455 (23.47)	313 (13.59)	768 (18.1)	
Verbal fluency (animal naming)	Q1	435 (22.43)	547 (23.75)	982 (23.15)	0.5827
	Q2	392 (20.22)	479 (20.8)	871 (20.53)	
	Q3	382 (19.7)	418 (18.15)	800 (18.86)	
	Q4	388 (20.01)	472 (20.5)	860 (20.27)	
	Q5	342 (17.64)	387 (16.8)	729 (17.19)	

3.4 Frailty score by sex

Table 3 shows frailty score overall and by sex. In the total sample, the mean frailty score was 11.40 (SD 4.61), and the median frailty score was 9.95 (IQR 8.45–12.70). Women had a higher frailty score than men. The mean frailty score was 11.67 (SD 4.76) among women and 11.09 (SD 4.41) among men. This difference was statistically significant ($p < 0.0001$).

Table 3. Frailty score by sex

	Males N=1940	Females N=2304	Total N=4244	p-value
Frailty score, mean (SD)	11.09 (4.41)	11.67 (4.76)	11.40 (4.61)	<0.0001
Frailty score range	2.50-39.60	4.25-36.90	2.50-39.60	
Frailty score, median (IQR)	9.80 (8.35–12.10)	10.20 (8.50–13.30)	9.95 (8.45–12.70)	<0.0001

3.5 Mediterranean diet score

Table 4 shows Mediterranean diet score and its components overall and by sex. Regarding the diet components, females had a higher median consumption of vegetables (2.25 vs 1.88 portions/day), fruits and nuts (2.00 vs 1.75 portions/day) and higher ratio of unsaturated to saturated fat compared to males. Cereal, red meat and alcohol consumption resulted higher in males compared to females while no differences between men and women were observed in the medians of legumes, fish and dairy products consumption. The Mediterranean diet score ranged from 0 to 9, with higher scores indicating greater adherence to the Mediterranean diet. In the total sample, the median Mediterranean diet score was 4 (IQR 3–5). Men had a higher median Mediterranean diet score than women, with a median score of

5 (IQR 4–6) compared with 4 (IQR 3–5) in women although no statistically significant difference was observed.

Table 4. Mediterranean diet score and components by sex

Diet components (portions/day)	Males	Females	Total	Mann-Whitney test
	N=1940	N=2304	N=4244	
	Median (Q1-Q3)	Median (Q1-Q3)	Median (Q1-Q3)	p-value
<i>Vegetables</i>	1.88 (1.00-3.25)	2.25 (1.125-4.00)	2.00 (1.00-3.62)	<0.0001
<i>Legumes</i>	0.13 (0.00-0.50)	0.13 (0.00-0.50)	0.13 (0.00-0.50)	0.0758
<i>Fruits and Nuts</i>	1.75 (0.75-3.00)	2.00 (1.00-3.50)	2.00 (1.00-3.25)	<0.0001
<i>Cereals</i>	5.00 (3.50-6.50)	4.25 (3.00-5.50)	4.50 (3.25-6.00)	<0.0001
<i>Fish</i>	0.00 (0.00-0.50)	0.00 (0.00-0.5)	0.00 (0.00-0.5)	0.0881
<i>Dairy products</i>	1.50 (0.75-2.25)	1.50 (1.00-2.25)	1.50 (0.88-2.25)	0.6243
<i>Missing</i>	3	4	7	
<i>Red meat</i>	1.00 (0.25-1.50)	0.50 (0.00-1.00)	0.50 (0.00-1.25)	<0.0001
<i>Fat ratio</i>	0.45 (0.33-0.62)	0.47 (0.33-0.65)	0.46 (0.33-0.63)	0.0297
<i>Missing</i>	1	2	3	
<i>Alcohol</i>	0.67 (0.00-2.00)	0.25 (0.00-1.00)	0.50 (0.00-1.50)	<0.0001
Mediterranean diet score	5 (4-6)	4 (3-5)	4 (3-5)	0.0615

3.6 Univariable regression analysis

Table 5 presents the results of the univariable linear regression analyses assessing the association between adherence to the Mediterranean diet and frailty score, together with the other covariates, overall and stratified by sex. In the overall sample, Mediterranean diet score was not significantly associated with frailty score: each one-point increase in the Mediterranean diet score was associated with a 0.06-point decrease in frailty score ($\beta = -0.06$, $SE = 0.05$, $p = 0.17$). The same pattern was observed in the sex-stratified analyses, both among men ($\beta = -0.06$, $SE = 0.07$, $p = 0.40$) and among women ($\beta = -0.06$, $SE = 0.07$, $p = 0.36$).

Several other variables were significantly associated with frailty score. Older age and higher weight were associated with higher frailty scores, as was current smoking compared with not currently smoking, with consistent results in men and women. Higher education was associated with lower frailty score. Compared with the reference category, participants with NVQ2/GCE O level or higher qualifications had significantly lower frailty scores, with the strongest association for NVQ4/NVQ5/Degree or equivalent. NVQ1/CSE or equivalent was not significantly associated with frailty score. The "Foreign/Others" category was not significant in the overall sample or among women, but was significant among men. Higher net wealth (per increase of £100,000), high physical activity (vs low), and alcohol consumption (yes vs no) were all negatively associated with frailty score, with consistent results in men and women. The association was particularly strong for physical activity, with high physical activity associated with markedly lower frailty scores than low physical activity.

Table 5. Univariable linear regression analysis for frailty score

Variables	Males		Females		Total	
	Beta (SE)	p-value	Beta (SE)	p-value	Beta (SE)	p-value
Mediterranean diet score	-0.06 (0.07)	0.4000	-0.06 (0.07)	0.3600	-0.06 (0.05)	0.1700
Age	0.11 (0.01)	<0.0001	0.14 (0.01)	<0.0001	0.12 (0.01)	<0.0001
Weight	0.04 (0.01)	<0.0001	0.07 (0.01)	<0.0001	0.04 (0.00)	<0.0001
Education*						
NVQ1/CSE or equivalent	0.44 (0.63)	0.4834	-1.24 (0.72)	0.0841	-0.37 (0.47)	0.4261
NVQ2/GCE O level or equivalent	-1.7 (0.42)	<0.0001	-2.19 (0.35)	<0.0001	-2.00 (0.27)	<0.0001
NVQ3/GCE A level or equivalent	-2.22 (0.46)	<0.0001	-2.01 (0.41)	<0.0001	-2.14 (0.31)	<0.0001
Higher and below degree	-1.89 (0.41)	<0.0001	-2.02 (0.38)	<0.0001	-2.02 (0.28)	<0.0001
NVQ4/NVQ5/Degree or equivalent	-2.92 (0.38)	<0.0001	-2.98 (0.35)	<0.0001	-3.02 (0.26)	<0.0001
Foreign/Others	-1.21 (0.56)	0.0317	-0.25 (0.45)	0.5719	-0.56 (0.35)	0.1120
Net wealth (increase of 100.000 pounds)	-0.11 (0.014)	<.0001	-0.127 (0.014)	<.0001	-0.12 (0.01)	<.0001
Physical activity: high vs low	-5.45 (0.26)	<0.0001	-5.94 (0.24)	<0.0001	-5.74 (0.18)	<0.0001
Alcohol: yes vs no	-1.11 (0.25)	<0.0001	-1.52 (0.22)	<0.0001	-1.41 (0.16)	<0.0001
Smoking: current vs not current	1.08 (0.40)	0.0100	0.92 (0.40)	0.0200	1.00 (0.28)	<0.0001

*reference: no qualificatio

3.7 Multivariable regression analysis

Table 6 presents the multivariable linear regression analysis of Mediterranean diet score and frailty score. After adjustment for age, weight, education, net wealth, alcohol use, physical activity, and smoking status, Mediterranean diet score was not significantly associated with frailty score in the total sample. Each one-point increase in Mediterranean diet score was associated with a 0.04-point decrease in frailty score, but this association was not statistically significant ($\beta = -0.04$, $SE = 0.04$, $p = 0.3970$).

In the sex-stratified adjusted models, Mediterranean diet score was not significantly associated with frailty score in either men or women. Among men, the association was close to zero and not statistically significant ($\beta = 0.02$, $SE = 0.06$, $p = 0.7066$). Among women, the association was negative but also not statistically significant ($\beta = -0.05$, $SE = 0.06$, $p = 0.3821$).

In the adjusted model for the total sample, high physical activity remained negatively associated with frailty score ($\beta = -3.67$, $SE = 0.20$, $p < 0.0001$). Smoking was positively associated with frailty score ($\beta = 0.87$, $SE = 0.27$, $p = 0.0015$). Net wealth and alcohol use were negatively associated with frailty score.

Overall, Mediterranean diet score was not significantly associated with frailty score in either the univariable or multivariable regression analyses, and the direction of the association was not consistent across models and sexes.

Table 6. Multivariable linear regression analysis for frailty score

Variables	Males		Females		Total	
	Beta (SE)	p-value	Beta (SE)	p-value	Beta (SE)	p-value
Mediterranean diet score	0.02 (0.06)	0.7066	-0.05 (0.06)	0.3821	-0.04 (0.04)	0.3970
Age	0.09 (0.01)	<0.0001	0.11 (0.01)	<0.0001	0.09 (0.01)	<0.0001
Weight	0.04 (0.01)	<0.0001	0.06 (0.01)	<0.0001	0.03 (0.00)	<0.0001
Education						
NVQ1/CSE or equivalent	-0.95 (0.39)	0.0147	-0.36 (0.37)	0.3283	-0.75 (0.27)	0.0052
NVQ2/GCE O level or equivalent	0.52 (0.56)	0.3557	-0.36 (0.7)	0.6074	0.09 (0.44)	0.8286
NVQ3/GCE A level or equivalent	-1.13 (0.4)	0.0050	-0.62 (0.34)	0.0689	-0.78 (0.26)	0.0027
Higher and below degree	-0.94 (0.43)	0.0299	-0.35 (0.39)	0.3745	-0.64 (0.29)	0.0285
NVQ4/NVQ5/Degree or equivalent	-1.06 (0.38)	0.0051	-0.71 (0.35)	0.0426	-0.98 (0.26)	0.0001
Foreign/Others	-0.51 (0.53)	0.3294	0.28 (0.44)	0.5254	0.05 (0.34)	0.8713
Net wealth (increase of 100.000 pounds)	-0.0551 (0.012)	<0.0001	-0.0563 (0.012)	<0.0001	-0.0564 (0.009)	<0.0001
Physical activity high vs low	-3.53 (0.28)	<0.0001	-3.66 (0.27)	<0.0001	-3.67 (0.2)	<0.0001
Alcohol: yes vs no	-0.39 (0.24)	0.0943	-0.71 (0.2)	0.0005	-0.75 (0.15)	<0.0001
Smoking: current vs not current	0.95 (0.38)	0.0126	1.05 (0.38)	0.0059	0.87 (0.27)	0.0015

Discussion

4.1 Main findings

This study assessed the association between Mediterranean diet score and frailty score among adults aged 50 years and older using the data from Wave 9 of ELSA. The main finding was that Mediterranean diet score was not significantly associated with frailty score in either univariable or multivariable regression analyses. This result was also seen in the separate analyses for men and women, where no significant association was found in either group. However, some other variables were associated with frailty score. Low physical activity showed a positive association with frailty score, while net wealth and alcohol use in the last year showed negative associations. Smoking was also positively associated with frailty score in the total adjusted model.

4.2 Comparison with previous studies

The finding of no significant association between Mediterranean diet score and frailty score is different from much of the previous evidence. Several systematic reviews have reported that higher adherence to the Mediterranean diet is associated with lower frailty risk in older adults. Previous reviews have suggested that older adults with higher Mediterranean diet scores are less likely to be frail or pre-frail. However, the evidence is not completely consistent, and differences in study design, dietary assessment, frailty measurement, and population characteristics may explain why findings differ between studies (Wang et al., 2018; Rashidi Pour Fard et al., 2019; Poursalehi et al., 2023; Cotroneo et al., 2026).

4.3 Possible explanations for the non-significant finding

There are several possible reasons why Mediterranean diet score was not significantly associated with frailty score in this study. First, this study used a cross-sectional design, so diet and frailty were measured at the same time. Because of this, it was not possible to know whether diet came before frailty or whether frailty influenced dietary habits. Frailer participants may have changed their diet because of illness, reduced appetite, or difficulties with daily activities. This means that reverse causation cannot be excluded.

Second, the dietary information in this study was based on 24-hour dietary recalls. This method gives useful information about recent food intake, but it may not fully represent usual long-term diet. This is important because frailty usually develops slowly over time, and long-term dietary habits may be more relevant than short-term intake. Recall error may also be present, because participants may not remember or report all foods accurately. These issues may have made the association between Mediterranean diet score and frailty score weaker.

Third, Mediterranean diet scores in this sample were mostly in the middle of the scale. Most participants had scores around 4 or 5, while very low and very high scores were less common. Because of this, there may not have been enough variation in Mediterranean diet adherence to detect a clear association with frailty score. This may be especially important if the difference in frailty is stronger between people with very low and very high adherence.

Another potential explanation concerns the way the Mediterranean diet score was constructed. Unlike the original score by Trichopoulou et al., which is based on grams per day, the intake of food groups in this study was expressed in portions per day. Since portions do

not correspond to a fixed weight across foods within the same group, this adaptation may have introduced some misclassification of adherence, possibly attenuating the association with frailty.

Finally, the Mediterranean diet may be less common in England than in Mediterranean countries. This may affect how well the Mediterranean diet score represents usual dietary behavior in this population. Also, the score used in this study was a summary score from 0 to 9. A total score is useful because it gives one simple measure of adherence, but it may hide differences between individual dietary components. For example, two people may have the same total score but different food intake patterns. These factors may help explain why no significant association was found in this study.

4.4 Other findings

Low physical activity showed a positive association with frailty score in the adjusted model. This means that participants with low physical activity had higher frailty scores compared with those who were more active. This finding is consistent with previous evidence showing that physical activity is important for maintaining muscle strength, mobility, balance, and daily function in older adults (Kim and Rockwood, 2024; Wingood et al., 2025).

Smoking was positively associated with frailty score in the total adjusted model. This means that current smokers had higher frailty scores than non-smokers after adjustment for the other variables. This finding is consistent with previous evidence, because smoking is one of the lifestyle factors associated with frailty in older adults. Smoking may also contribute to poorer respiratory and cardiovascular health, inflammation, and reduced physical function,

which can increase the accumulation of health deficits (Kim and Rockwood, 2024; Boucham et al., 2024).

Net wealth was negatively associated with frailty score in the adjusted model. This means that participants with higher net wealth tended to have lower frailty scores. This finding may reflect the role of socioeconomic conditions in health during older age. People with greater financial resources may have better access to healthy food, healthcare, safer living environments, and support services. These factors may help reduce the accumulation of health deficits over time (Gale et al., 2015; Boucham et al., 2024).

Alcohol use in the last year was negatively associated with frailty score in the adjusted model. This means that participants who reported alcohol use had lower frailty scores than those who did not report alcohol use. This finding should be interpreted carefully. It should not be understood as evidence that alcohol protects against frailty. A possible explanation is health selection bias, because healthier older adults may be more likely to drink alcohol, while frailer adults may reduce or stop drinking because of illness, medication use, or medical advice.

Women had higher frailty scores than men in this study. The selected frailty components showed that women reported more physical limitations and more mood-related symptoms than men. This finding is consistent with previous evidence showing that frailty is often more common among women, although the reasons for this difference may be complex. Differences in health conditions, physical function, social factors, and survival patterns may contribute to sex differences in frailty (Gale et al., 2015; Ofori-Asenso et al., 2019).

4.5 Strengths and limitations

This study has several strengths. First, it used data from ELSA Wave 9, which includes detailed information on health, socioeconomic factors, lifestyle, and dietary intake in adults aged 50 years and over living in England. Second, the study included a relatively large analytical sample, which made it possible to examine the association between Mediterranean diet score and frailty score in the total sample and separately among men and women. Third, frailty was measured using a deficit accumulation approach, which includes different areas of health and physical function and allows frailty to be analyzed as a continuous score.

This study also has some limitations. First, the cross-sectional design means that diet and frailty were measured at the same time. Therefore, it was not possible to determine the direction of the association or to show whether diet influenced frailty over time. Second, dietary intake was measured using 24-hour dietary recalls, which may not fully represent usual long-term diet. Third, some variables were self-reported, so recall error or reporting bias may be present.

Missing data were handled using listwise deletion in the regression models. This means that participants with missing values in any variable included in a model were excluded from that specific model. As a result, the sample size in the adjusted models was smaller than the full analytical sample. If participants with missing data were different from those included in the analysis, this may have introduced selection bias.

Residual confounding may also be present. Although the models were adjusted for several important confounders, other factors were not included, such as total energy intake,

medication use, severity of chronic diseases, social support, and access to healthcare. These factors may be related to both diet and frailty and may have influenced the results.

Future development

Future research should examine the association between Mediterranean diet and frailty using longitudinal data. Using repeated waves of ELSA would make it possible to study whether Mediterranean diet score is associated with changes in frailty score over time. This would also help to better understand the direction of the association and reduce the problem of reverse causation. Future studies could also use repeated dietary measurements to better represent usual long-term diet.

Conclusions

This study examined the association between Mediterranean diet score and frailty score among adults aged 50 years and over using data from Wave 9 of ELSA. No significant association was found between Mediterranean diet score and frailty score in the total sample or in the separate analyses for men and women. This finding may be partly explained by the cross-sectional design, the use of 24-hour dietary recall data, and the limited variation in Mediterranean diet scores in this English population.

Low physical activity showed the strongest positive association with frailty score, while smoking was also positively associated with frailty score in the adjusted model. Net wealth and alcohol use in the last year were negatively associated with frailty score. These findings show that frailty is related to several lifestyle and socioeconomic factors.

Overall, this study did not find evidence of a significant association between Mediterranean diet score and frailty score in ELSA Wave 9. Future longitudinal research using repeated waves of ELSA and repeated dietary measurements may help to better understand whether long-term adherence to the Mediterranean diet is associated with frailty development in older adults.

References

Banks, J., Nazroo, J., Steptoe, A. and Zaninotto, P. (eds.) (2020) *The dynamics of ageing: Evidence from the English Longitudinal Study of Ageing 2002–2019 (Wave 9)*. London: Institute for Fiscal Studies.

Boucham, M., et al. (2024) 'Lifestyle factors and frailty in older adults', *BMC Geriatrics*. doi: 10.1186/s12877-024-05288-4.

Cotroneo, A., et al. (2026) 'Mediterranean diet and frailty: a systematic review and meta-analysis', *Nutrition*, 149, 113218. doi: 10.1016/j.nut.2026.113218.

Dominguez, L.J., et al. (2023) 'Nutrition, physical activity and frailty in older adults', *Experimental Gerontology*, 177, 112180. doi: 10.1016/j.exger.2023.112180.

Ecarnot, F. and Maggi, S. (2024) 'Ageing, nutrition and frailty', *Aging Clinical and Experimental Research*. doi: 10.1007/s40520-024-02753-3.

Fried, L.P., Tangen, C.M., Walston, J., Newman, A.B., Hirsch, C., Gottdiener, J., Seeman, T., Tracy, R., Kop, W.J., Burke, G. and McBurnie, M.A. (2001) 'Frailty in older adults: evidence for a phenotype', *The Journals of Gerontology: Series A*, 56(3), pp. M146–M156. doi: 10.1093/gerona/56.3.M146.

Gale, C.R., Cooper, C. and Sayer, A.A. (2015) 'Prevalence of frailty and disability: findings from the English Longitudinal Study of Ageing', *Age and Ageing*, 44(1), pp. 162–165. doi: 10.1093/ageing/afu148.

Johnson, L., Guthrie, B., Kelly, P.A.T., Anand, A., Marshall, A. and Seth, S. (2024) 'Frailty or frailties: exploring frailty index subdimensions in the English Longitudinal Study of Ageing', *Journal of Epidemiology and Community Health*, 78, pp. 609–615. doi: 10.1136/jech-2023-221829.

Kim, D.H. and Rockwood, K. (2024) 'Frailty in older adults', *The New England Journal of Medicine*. doi: 10.1056/NEJMr2301292.

Lengelé, L., et al. (2025) 'Nutrition and frailty in older adults', *Current Opinion in Clinical Nutrition and Metabolic Care*. doi: 10.1097/MCO.0000000000001098.

Lorenzo-López, L., Maseda, A., de Labra, C., Regueiro-Folgueira, L., Rodríguez-Villamil, J.L. and Millán-Calenti, J.C. (2017) 'Nutritional determinants of frailty in older adults: a systematic review', *BMC Geriatrics*, 17, 108. doi: 10.1186/s12877-017-0496-2.

Liu, B., Young, H., Crowe, F. L., Benson, V. S., Spencer, E. A., Key, T. J., Appleby, P. N. and Beral, V. (2011) 'Development and evaluation of the Oxford WebQ, a low-cost, web-based method for assessment of previous 24 h dietary intakes in large-scale prospective studies', *Public Health Nutrition*, 14(11), pp. 1998–2005. doi: 10.1017/S1368980011000942.

Marshall, A., Nazroo, J. and Tampubolon, G. (2015) 'Cohort differences in the levels and trajectories of frailty among older people in England', *Journal of Epidemiology and Community Health*, 69, pp. 316–321.

O'Caoimh, R., Sezgin, D., O'Donovan, M.R., Molloy, D.W., Clegg, A., Rockwood, K. and Liew, A. (2021) 'Prevalence of frailty in 62 countries across the world: a systematic review and meta-

analysis of population-level studies', *Age and Ageing*, 50(1), pp. 96–104. doi: 10.1093/ageing/afaa219.

Ofori-Asenso, R., Chin, K.L., Mazidi, M., Zomer, E., Ilomaki, J., Zullo, A.R., Gasevic, D., Ademi, Z., Korhonen, M.J., LoGiudice, D. and Bell, J.S. (2019) 'Global incidence of frailty and prefrailty among community-dwelling older adults: a systematic review and meta-analysis', *JAMA Network Open*, 2(8), e198398. doi: 10.1001/jamanetworkopen.2019.8398.

Poursalehi, D., et al. (2023) 'Mediterranean diet and frailty: a systematic review and meta-analysis', *Ageing Research Reviews*. doi: 10.1016/j.arr.2023.101903.

Rashidi Pour Fard, N., Amirabdollahian, F. and Haghighatdoost, F. (2019) 'Dietary patterns and frailty: a systematic review and meta-analysis', *Nutrition Reviews*. doi: 10.1093/nutrit/nuz007.

Rockwood, K. and Mitnitski, A. (2007) 'Frailty in relation to the accumulation of deficits', *The Journals of Gerontology: Series A*, 62(7), pp. 722–727. doi: 10.1093/gerona/62.7.722.

Searle, S.D., Mitnitski, A., Gahbauer, E.A., Gill, T.M. and Rockwood, K. (2008) 'A standard procedure for creating a frailty index', *BMC Geriatrics*, 8, 24. doi: 10.1186/1471-2318-8-24.

Trichopoulou, A., Costacou, T., Bamia, C. and Trichopoulos, D. (2003) 'Adherence to a Mediterranean diet and survival in a Greek population', *The New England Journal of Medicine*, 348, pp. 2599–2608. doi: 10.1056/NEJMoa025039.

Vo, N.T., Liu, M.F., Wu, C.J., Lin, P.C. and Huang, M.C. (2024) 'Diagnostic accuracy of the FRAIL scale, Groningen Frailty Indicator, Tilburg Frailty Indicator, and PRISMA-7 for frailty screening

among older adults in community settings: a systematic review and network meta-analysis', *The Gerontologist*, 64(6), gnae008. doi: 10.1093/geront/gnae008.

Wang, Y., Hao, Q., Su, L., Liu, Y., Liu, S., Dong, B. and Yue, J. (2018) 'Adherence to the Mediterranean diet and the risk of frailty in old people: a systematic review and meta-analysis', *Journal of Nutrition, Health and Aging*. doi: 10.1007/s12603-018-1020-x.

Wingood, M., et al. (2025) 'Physical activity and frailty in older adults', *The Journals of Gerontology: Series A*. doi: 10.1093/gerona/glaf125.

World Health Organization (2015) *World report on ageing and health*. Geneva: World Health Organization.

World Health Organization (2024) *Ageing and health*. Geneva: World Health Organization.