Dietary Quality Is Related to Frailty in Community-Dwelling Older Adults

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Background. The etiology of the geriatric syndrome frailty is multifactorial. Besides hormonal and inflammatory processes, nutritional influences may be of major relevance. In this cross-sectional study, the association between dietary quality and frailty was investigated.

Methods. In 192 community-dwelling older volunteers (>75 years), an interview-based food frequency questionnaire was used to assess nutritional data. A Mediterranean diet (MED) score (maximum 9 points) was used to evaluate dietary quality. Frailty was defined as the presence of at least three and prefrailty as the presence of one or two of the following criteria: weight loss, exhaustion, low physical activity, low handgrip strength, and slow walking speed. Older adults without any of these attributes were defined as “nonfrail” Binomial logistic regression analysis was used to assess the risk of being frail (vs prefrail and nonfrail) in each quartile (vs lowest quartile) of the MED score.

Results. The mean (SD) age of the participants was 83 (4) years; 41.1% were prefrail and 15.1% were frail. The risk of being frail was significantly reduced in the highest quartile of the MED score (OR 0.26; 95% CI 0.07–0.98).

Conclusions. A healthy dietary pattern is associated with a lower risk of being frail. Larger, prospective and interventional studies are needed to clarify the association between dietary quality and frailty.

Key Words: Dietary quality—Frailty—Community-dwelling adults—Mediterranean score—Antioxidants.

Received November 18, 2011; Accepted September 5, 2012

Decision Editor: Luigi Ferrucci, MD, PhD

Frailty is a clinically relevant geriatric syndrome which is characterized by an increased vulnerability toward internal and external stressors. Frailty is associated with an increased risk of negative health outcomes (1,2) and therefore a decline in quality of life.

Besides hormonal changes and inflammatory processes, nutrition plays a decisive role in the development of frailty. Weight loss is one of the defining characteristics of frailty (2). It has not only been shown that frail older adults have a low intake of energy, protein and several micronutrients (3), but also lower plasma concentrations of various nutrients compared with nonfrail individuals (4,5). Furthermore, in the study of Semba et al. (6), low plasma levels of beta-carotene, alpha-tocopherol, and vitamin D as well as the number of nutrients with low plasma levels were associated with a higher incidence of frailty over a period of 3 years.

Data on nutrient supply, however, do not necessarily reflect the quality of the whole diet. To assess the overall quality of a diet, generally two kinds of food-based indices have been developed, either based on dietary guidelines or based on a Mediterranean dietary pattern (7). To date, several Mediterranean food scores have been developed and modified (8–11). There is increasing evidence that a greater adherence to a Mediterranean diet is related to a lower risk of chronic diseases like cardiovascular diseases and several forms of cancer (12,13). Thus, a healthy dietary pattern like the Mediterranean diet showed a remarkable potential to prevent various illnesses. On the other hand, according to Fried et al. (2), comorbidity is an important etiologic risk factor for frailty in older people. Therefore, we hypothesized that there may be a direct association between the dietary quality and frailty.

Methods

Study Design

In this cross-sectional study in the region of Nürnberg (Germany), 206 volunteers were recruited from August 2009 to September 2010. The participants were found via an advertisement that appeared in the local newspaper and
through personal contact in a cooperating day clinic and a cooperating rehabilitation center. The inclusion criteria were an age of 75 years and older, living independently at home, having no acute illness and no cognitive impairment (Mini Mental State Examination ≥ 24 out of 30 points) (14). The study was approved by the ethics committee of the Friedrich-Alexander University Erlangen-Nürnberg. Written informed consent was obtained by all participants. The men and women visited the study site once or, if they were not able or willing to come there, were visited at home. All data were assessed by specifically trained personnel.

Sample Characteristics
Age was calculated from the date of birth. Height was measured with the participants standing upright without shoes. Weight was measured in light clothing without shoes. Body mass index (BMI) was calculated for each subject as quotient of weight [kg] and height² [m²]. Geriatric depression scale (maximum 15 points [15]) was used to determine the emotional status with scores of 6 points or higher indicating depressive mood. The number of self-reported medications used was documented as “more than three medications” or “less than three medications.” The degree of dependency in daily life was assessed by the questionnaire on instrumental activities of daily living (IADL, 8 questions, maximum 8 points) of Lawton and Brody (16) with a lower score signifying a higher level of dependency. The IADL items dealing with the dependency on help in going shopping and cooking meals were separately evaluated. The participants’ answers were documented as “goes shopping independently” and “cooks independently” versus “needs help with shopping” and “needs help with cooking.” To assess the grade of comorbidity, the Charlson Comorbidity Index was used. This Index is a sum score on 19 weighted (1, 2, 3, or 6 points) diseases associated with increased mortality—with a higher score indicating a higher mortality risk (17). The participants were asked if they were living alone or not. The educational level was defined as “low” for participants with only elementary school or no degree, “medium” for the ones who attended a secondary school, and “high” for participants with university entrance diploma or higher degrees. The men and women were asked if they had used any dietary supplements during the past 2 years. Prevalent chewing and swallowing difficulties were also documented as reported by the participants.

Frailty Assessment
Frailty was defined according to Fried et al. (2) on the basis of the five following criteria: (i) self-reported weight loss of more than 4.5 kg in the last year; (ii) exhaustion (self-reported feeling that everything was an effort or one could not get “going” > 2 times a week); (iii) low grip strength measured with a dynamometer (Jamar, Sammons Preston Rolyan, Illinois); (men ≤ 29–32 kg, women ≤ 17–21 kg, stratified by BMI quartiles of to the original study sample of Fried et al. [2]); (iv) low walking speed, defined as a walking time of more than 6–7 seconds/4.57 m depending on gender and height; (v) low physical activity (men < 383 kcal/week, women < 270 kcal/week). The latter was assessed using the short form of the Minnesota Leisure Time Activities Questionnaire which ascertains the time spent on selected physical activities in the prior 2 weeks (18). The cutoff values for grip strength, walking speed, and physical activity were derived from the lowest sex specific quintiles of the original study population of Fried et al. (2). Frailty was determined as the presence of three and prefrailty as the presence of one or two of these characteristics. Older adults without any of these attributes were defined as “nonfrail.”

Nutritional Assessment
Nutritional data were collected during a personal interview by a trained nutritionist using the food frequency questionnaire (FFQ) of the German part of the European Prospective Investigation into Cancer and Nutrition (EPIC) study (19). The EPIC-FFQ assesses the usual consumption of foods during the last 12 months using standard portion sizes (eg, 1 cup, 1 piece, and 1 teaspoon per month or per week or per day). It comprises 103 foods and food categories and additional questions on the choice of fats and the use of dietary supplements. In this study, slight modifications of the original FFQ on the allocation of foods in 12 food categories have been made to improve its sensitivity toward antioxidants and unsaturated fatty acids (eg, subdividing the category “fish” into three categories of fish with different contents of fat). Furthermore, a question on the consumption of unrefined cereals was added. To calculate the average amount of alcohol, monounsaturated and saturated fatty acids, the German nutrient database “Bundeslebensmittelschlüssel” (BLS II.3) was used which consists of about 13,000 coded foods, menus, and menu components and is mainly based on nutritional values calculated from recipes (20).

Assessment of Dietary Quality
The Mediterranean food score used here is the alternate MED score of Fung et al. (21) who adapted the original score of Trichopoulou et al. (9) for a non-Mediterranean population. To calculate the score, the FFQ foods are merged into nine nutritional characteristics that are either seen as beneficial (vegetables, legumes, fruits, unrefined cereals, nuts, high MUFA/SFA, moderate alcohol, and fish) or detrimental (red and processed meat) for health (Table 1). In contrast to the original concept of Trichopoulou et al. (9), milk and milk products do not account to the score, because Fung et al. (21) did not estimate this food group to be of importance for the development of chronic diseases. In regard to different energy intakes in men and women and in accordance with the original publication of Trichopoulou et al. (22), daily intakes of foods were extrapolated to 2500 kcal for men and...
Table 1. MED Score (21): Nutritional Characteristics and Medians of Intake

<table>
<thead>
<tr>
<th>Nutritional Characteristics</th>
<th>Included Food Items of the FFQ</th>
<th>Medians (g/day) Men/Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>Vegetables</td>
<td>261.4/225.0</td>
</tr>
<tr>
<td>Legumes</td>
<td>Legumes and soy</td>
<td>13.1/1.1</td>
</tr>
<tr>
<td>Fruit</td>
<td>Fresh, canned, and dried fruit, fruit juice</td>
<td>447.0/383.9</td>
</tr>
<tr>
<td>Unrefined cereals</td>
<td>Unrefined grains, brown rice, and unrefined pasta</td>
<td>36.1/35.7</td>
</tr>
<tr>
<td>Nuts</td>
<td>Nuts and seeds</td>
<td>8.2/5.3</td>
</tr>
<tr>
<td>Red and processed meat</td>
<td>Red meat and meat products</td>
<td>51.6/34.5</td>
</tr>
<tr>
<td>MUFA/SFA</td>
<td>All food items</td>
<td>1.1/1.1</td>
</tr>
<tr>
<td>Alcohol</td>
<td>All food items</td>
<td>5–15†</td>
</tr>
<tr>
<td>Fish</td>
<td>All fish items</td>
<td>36.4/30.1</td>
</tr>
</tbody>
</table>

Note: MUFA = monounsaturated fatty acids; SFA = saturated fatty acids.
*Values are ratios and therefore nondimensional.
†Range is set a priori, representing “moderate intake.”

2000 kcal for women. The MED score is calculated as a sum-score: For an intake above the sex-specific median, one point was assigned for every characteristic except “red and processed meat” which is seen as detrimental and therefore rated with one point for consumption below the sex-specific median. The characteristic “alcohol” was rated with 1 point for a moderate consumption of 5–15 g/day. A maximum score of 9 points could be achieved, which indicates the greatest adherence to a Mediterranean diet.

Statistical Analysis

SPSS 18.0 (IBM) software was used for all statistical analyses except logistic regression analysis, which was conducted by the statistics software R (General Public License).

The distribution of the prevalence of participants’ characteristics in the three frailty groups was tested for significant differences by χ² testing. The distribution of continuous variables in nonfrail, prefrail, and frail participants was tested by the Kruskall–Wallis test. The Mann–Whitney U test was used for post hoc pairwise comparison between groups in the MED score.

For further analysis, the MED score was divided into quartiles with the lowest quartile representing the least healthy diet. By binomial logistic regression analysis, the association between frailty (with prefrailty and nonfrailty as reference outcome) and the MED score (with the lowest quartile as reference group) was quantified by odds ratios with accompanying 95% confidence intervals. Additionally, a test for linear trend was performed.

The odds ratios were not adjusted for sex, age, educational level, comorbidity, and energy intake.

To investigate the effects of diet on every single frailty criterion, we calculated the odds ratios (OR) for weight loss, low grip strength, exhaustion, low walking speed, and low physical activity in the 2nd, 3rd, and 4th quartiles compared with the 1st quartile of the MED score by logistic regression analysis as described previously.

An acceptable level of significance was established a priori as p < .05 without adjustment for multiple testing in view of the exploratory nature of analyses.

Results

Sample Characteristics

Of the 206 community-dwelling older adults in whom frailty was assessed, 192 provided complete information (less than three items missing) on the FFQ and were included in the following analyses. The participants had a mean age of 83 ± 4 years, 64.6% were female. The mean BMI was 27.5 ± 3.7 kg/m²; 41.1% of the participants were prefrail and 15.1% were frail. The most prevalent frailty criterion was “low grip strength” which was found in 75 older adults (39.1%), followed by “low walking speed” and “exhaustion” each found in 42 participants (21.9%).

A total of 39 men and women (20.3%) reported “low physical activity” and 16 participants (8.3%) reported a weight loss.

The three frailty groups differed significantly in the distribution of sex (p < .05) and age (p < .001) (Table 2). Frail older adults lived alone more often (p < .05), had a lower educational level (p < .01), higher depression (p < .001) and lower IADL scores (p < .001) than prefrail and nonfrail ones (p < .05). The use of more than three medications was more prevalent with increasing frailty status (p < .01), and frail participants scored significantly higher on the Charlson comorbidity scale than prefrail and nonfrail ones (p < .05). Frail participants were also more likely to depend on help with shopping (p < .001) and to have chewing and swallowing difficulties (p < .05) (Table 2).

MED Score

The mean intakes of the nutritional characteristics composing the MED score are presented in Table 1 in g/day. The mean MED score in points was 4.4 ± 1.9 in nonfrail, 4.3 ± 1.7 in prefrail and 3.5 ± 1.8 in frail participants. The differences between the frailty groups were significant (p < .05). Frail men and women had a significant lower MED score compared with the nonfrail and prefrail participants. The mean MED scores did not differ significantly between nonfrail and prefrail older adults (Figure 1).

Compared with the lowest quartile (least healthy diet), the participants in the highest quartile (most healthy diet) had a significantly decreased chance of being frail (Table 3). There was also a linear trend in the odds ratios, indicative of a graded effect of diet (Table 3). Regarding single frailty criteria, there was a significant inverse association between “weight loss,” “low physical activity,” and “low walking speed”, respectively, and the MED score (Table 3). Of the men and women in the 4th quartile of the MED score none reported a weight loss (Table 3), so a calculation of the risk was not possible.
This cross-sectional study revealed an association between frailty and a healthy diet, according to an MED score, and lower dietary scores in frail than pre-frail and nonfrail older persons. To our knowledge, this is the first study to investigate the association between nutrition and frailty based on the whole diet of older adults. Our results support existing evidence relating frailty and physical performance to nutrition at the nutrient level. Low intakes as well as low serum levels of several nutrients were found to be related to an increased risk of frailty. In line with Milaneschi et al. (23), who observed that high adherence to a Mediterranean diet is associated with a slower decline of mobility in community-dwelling older persons, we detected an association between a high dietary quality and a lower risk of low walking speed and low physical activity (Table 3).

In the group with the highest adherence to a Mediterranean diet, we found no subject with a self-reported weight loss. Existing literature concerning Mediterranean diet and physical activity, which showed a significant lower MED score in frail compared with nonfrail or pre-frail participants.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Nonfrail (n = 84)</th>
<th>Prefrail (n = 79)</th>
<th>Frail (n = 29)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female sex*</td>
<td>56.0</td>
<td>65.0</td>
<td>86.2</td>
<td>.013‡</td>
</tr>
<tr>
<td>Age (years)‡</td>
<td>82 (76–91)</td>
<td>84 (76–94)</td>
<td>86 (75–96)</td>
<td>.000§</td>
</tr>
<tr>
<td>BMI [kg/m²]</td>
<td>26.7 (21.0–35.0)</td>
<td>28.1 (20.9–35.3)</td>
<td>26.4 (18.6–36.1)</td>
<td>.118</td>
</tr>
<tr>
<td>Living alone</td>
<td>50.6</td>
<td>59.5</td>
<td>79.2</td>
<td>.025</td>
</tr>
<tr>
<td>Educational level</td>
<td></td>
<td></td>
<td></td>
<td>.005</td>
</tr>
<tr>
<td>Low</td>
<td>41.7</td>
<td>39.2</td>
<td>51.7</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>23.8</td>
<td>31.6</td>
<td>48.3</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>34.5</td>
<td>29.1</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>GDS [points]</td>
<td>0 (0–4)</td>
<td>2 (0–5)</td>
<td>3 (0–9)</td>
<td>.000</td>
</tr>
<tr>
<td>IADL [points]</td>
<td>8 (5–8)</td>
<td>8 (1–8)</td>
<td>7 (2–8)</td>
<td>.000</td>
</tr>
<tr>
<td>More than three medications</td>
<td>35.7</td>
<td>51.9</td>
<td>69.0</td>
<td>.005</td>
</tr>
<tr>
<td>CCI [points]</td>
<td>0 (0–5)</td>
<td>1 (0–3)</td>
<td>2 (0–4)</td>
<td>.001</td>
</tr>
<tr>
<td>Goes shopping independently</td>
<td>96.5</td>
<td>87.3</td>
<td>51.7</td>
<td>.000</td>
</tr>
<tr>
<td>Cooks independently</td>
<td>88.2</td>
<td>82.3</td>
<td>72.4</td>
<td>.133</td>
</tr>
<tr>
<td>Use of supplements</td>
<td>76.5</td>
<td>68.4</td>
<td>86.2</td>
<td>.146</td>
</tr>
<tr>
<td>Chewing difficulties</td>
<td>10.7</td>
<td>26.6</td>
<td>41.4</td>
<td>.001</td>
</tr>
<tr>
<td>Swallowing difficulties</td>
<td>2.4</td>
<td>12.7</td>
<td>10.3</td>
<td>.043</td>
</tr>
</tbody>
</table>

Note: "low" = elementary school or no degree; "medium" = secondary school; "high" = university entrance diploma or higher degrees; MMSE = Mini Mental State Examination (19); GDS = Geriatric Depression Scale (20); IADL = Instrumental Activities of Daily Living (21); CCI = Charlson Comorbidity Index (22).

*In percent (all ordinal variables).
‡Chi-square test (for all ordinal variables).
§Median (minimum to maximum; all continuous variables).

Discussion

This cross-sectional study revealed an association between frailty and a healthy diet, according to an MED score, and lower dietary scores in frail and nonfrail older persons. To our knowledge, this is the first study to investigate the association between nutrition and frailty based on the whole diet of older adults. Our results support existing evidence relating frailty and physical performance to nutrition at the nutrient level. Low intakes as well as low serum levels of several nutrients were found to be related to an increased risk of frailty.

In line with Milaneschi et al. (23), who observed that high adherence to a Mediterranean diet is associated with a slower decline of mobility in community-dwelling older persons, we detected an association between a high dietary quality and a lower risk of low walking speed and low physical activity (Table 3).

In the group with the highest adherence to a Mediterranean diet, we found no subject with a self-reported weight loss. Existing literature concerning Mediterranean diet and physical activity, which showed a significant lower MED score in frail compared with nonfrail or pre-frail participants.

Table 3. Odds Ratio (95% Confidence Interval)* for Frailty† and for the Single Frailty Criteria in the Quartiles of the MED Score (21)

<table>
<thead>
<tr>
<th>Frailty Criteria</th>
<th>1 (n = 67)</th>
<th>2 (n = 40)</th>
<th>3 (n = 40)</th>
<th>4 (n = 46)</th>
<th>p for Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>(≤ 3 points)</td>
<td>1.04 (0.36–3.05)</td>
<td>0.37 (0.11–1.32)</td>
<td>0.19 (0.05–0.82)</td>
<td>.011</td>
<td></td>
</tr>
<tr>
<td>Weight loss</td>
<td>1.12 (0.34–4.31)</td>
<td>0.65 (0.15–2.78)</td>
<td>No calculation possible</td>
<td>.031</td>
<td></td>
</tr>
<tr>
<td>(≥ 6 points)</td>
<td>2.01 (0.76–5.33)</td>
<td>1.27 (0.45–3.55)</td>
<td>1.66 (0.62–4.42)</td>
<td>.446</td>
<td></td>
</tr>
<tr>
<td>Exhaustion</td>
<td>1.49 (0.63–3.53)</td>
<td>0.87 (0.36–2.07)</td>
<td>0.44 (0.18–1.09)</td>
<td>.068</td>
<td></td>
</tr>
<tr>
<td>Low grip strength</td>
<td>0.48 (0.15–4.52)</td>
<td>0.49 (0.17–1.44)</td>
<td>0.29 (0.09–1.00)</td>
<td>.043</td>
<td></td>
</tr>
<tr>
<td>Low walking speed</td>
<td>1.01 (0.41–2.49)</td>
<td>0.26 (0.03–0.51)</td>
<td>0.13 (0.03–0.51)</td>
<td>.000</td>
<td></td>
</tr>
</tbody>
</table>

*Binomial logistic regression adjusted for age, sex, energy intake, comorbidity, and educational level.
†Reference group: prefrail and nonfrail combined.
weight focused on individuals younger than our study and mostly aimed at preventing and reducing obesity and cardiovascular diseases (24). Further investigation into the possibility of prevention of weight loss in very old adults with a Mediterranean diet is needed.

The prevalence rates of frailty and prefrailty in this study are in accordance with a recent study in older patients recruited by general practitioners in the same geographical region, however about 10 years younger (mean age 74 years) (25). In contrast to Drey et al. (25) and in accordance with Fried et al. (2), frail participants in our sample were significantly older, more often female and less educated than prefrail and nonfrail. The dependency in daily activities increased with frailty status but in spite of that, even frail participants were still quite autonomous in their daily life, even in cooking their meals. In accordance with the frailty concept (2) and with others (25–27), frail older adults were found to be in poorer health compared with prefrail and nonfrail participants—as indicated by the higher prevalence of comorbidity, high medication use, depressive symptoms, chewing, and swallowing problems.

For the assessment of usual dietary habits, we used the FFQ of the German part of the EPIC-Study, which is well validated (28), and the concept of dietary scores is well established for describing dietary patterns and assessing dietary quality (7,29,30).

The MED score of Fung et al. (21) was adapted for a non-Mediterranean population which makes it more suitable for our sample than the original score by Trichopoulou et al. (9). One limitation of this score is the use of sex-specific medians as cutoff points, that is, this approach allows only relative but no absolute statements about the degree of adherence to a Mediterranean diet. Another controversial point is the exclusion of milk and milk products, which are seen as beneficial for bone and muscle health because of their protein and calcium content. Regarding the intake of milk and milk products in our sample, we found a slightly but not significantly lower intake in frail participants (data not shown). The uniform energy adjustment of the food intake to 2000 kcal for women and 2500 kcal for men according to Trichopoulou et al. (22) is also arguable. We used these values by reason of methodical comparability with the original MED score. Maybe an adjustment for the individual energy intake would be more reasonable.

An effect of a high dietary quality on frailty might be mediated by a high fruit and vegetable intake and low intake of animal products as proposed in the MED score. This thesis is supported by the results of Vercambre et al. (31) who found an association between a lower intake of vegetables and a higher IADL decline. Furthermore, vegetable foods are the main nutritional sources of carotenoids and vitamin C. Therefore, our results are in line with several studies describing a positive association between plasma carotenoid concentration and muscle strength (32) and performance of lower extremities (33–35). In addition to that Saito et al. (36) found a correlation of vitamin C plasma levels with handgrip strength as well as with one leg stand in community-dwelling older Japanese.

There is evidence that these associations are mediated by tissue damage caused by oxidative stress (37) and inflammatory processes (38,39). This is supported by the findings of the MED score being strongly associated with lower plasma concentrations of biomarkers of inflammation in middle-aged and older women (21). This effect on inflammatory processes may lie in the restriction of animal products and fats in the MED score (40). Animal foods and fats are the main sources of saturated fats, which have been found to be associated with higher blood concentrations of proinflammatory markers (41,42).

On the other hand, the MED score rewards a high consumption of fish, which has been found to be positively associated with grip strength in older men and women (43). An intervention study in adults aged around 65 years showed that a low-fat diet high in consumption of fish oil-derived PUFA was more effective to lower inflammatory markers than a diet low in consumption of fish oil-derived PUFA (44).

The assumption of anti-inflammatory effects of some components of the MED score is supported by the findings of Lopez-Garcia et al. (45) who detected a dietary pattern characterized by higher intakes of fruit, vegetables, legumes, fish, poultry, and whole grains being inversely associated with plasma concentrations of inflammation markers.

One important limitation of this study is its cross-sectional design that does not allow any statements on a causal relationship. Poor nutrition might contribute to frailty, but on the other hand frailty might also affect dietary intake, for example by impairments in going shopping, chewing, or swallowing (Table 2). Based on our data, it is not possible to decide, whether a Mediterranean diet prevents frailty or whether the diet is altered by frailty or comorbidity which might contribute to nutritional risk.

Another limitation is the small sample size, and the small group of frail participants, which limits the statistical power to detect significant associations, which we nevertheless detected. Furthermore, the sample consists of volunteers living close to the study center and may therefore lack representativeness for the older population in Germany. Nevertheless, a strong point of our study is that all FFQs have been conducted in personal interviews by a single experienced nutritionist. Secondly, for all assessments, well-validated tools have been used, and professional personnel was engaged. A strength of this study is also that the effects of food patterns instead of single nutrients were investigated, considering that foods and food components interact in their impact on health-related outcomes.

In conclusion, our results are in line with existing evidence relating diet to frailty. We found an association between adherence to a healthy dietary pattern and lower...
odds of being frail and in particular of the frailty criteria “low walking speed” and “low physical activity.”

Future studies with larger sample sizes and prospective or interventional design are needed to further improve our knowledge about the association between diet and frailty.

**Funding**

This work was partly supported by Nestlé HealthCare Nutrition, Lausanne, Switzerland, and the Theo and Friedel Schöller-Foundation, Nürnberg, Germany.

**Acknowledgments**

We thank Klaus Issel from the Michael-Bauer Heim and Dr. Cramer-Ebner from the Nürnbergstift for their help in approaching older individuals and Lisa Schmölz and Sabine Ehrhardt for their assistance in entering data. We especially thank all of the volunteers for their valuable cooperation. We thank Nestlé HealthCare Nutrition and the Theo und Friedel Schöller-Stiftung for their support.

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