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Sociodemographic, Lifestyle, and Dietary Factors Associated with Pre-Frailty and Frailty Among Community-Dwelling Older Adults in Poland: A Cross-Sectional Study

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Abstract

Background/Objectives: Frailty is more common in older women than in older men. This study examined sociodemographic and lifestyle factors, including dietary nutrient density, associated with pre-frailty or frailty in community-dwelling older adults in Poland. Methods: This cross-sectional study included 196 adults aged 60 years or older (114 women and 82 men). Frailty status was assessed using criteria based on the Cardiovascular Health Study phenotype. Pre-frail and frail participants were combined for analysis. Dietary nutrient density was assessed from three-day food records using the E-NRF7.3 index. Multivariable logistic regression models were fitted for the overall sample and separately for women. Results: Pre-frailty or frailty was identified in 52.6% of women and 26.8% of men. In the fully adjusted model for the overall sample, the odds of pre-frailty or frailty were higher among women than men (odds ratio [OR] = 2.63, 95% confidence interval [CI] 1.31–5.27), among participants who reported no summer sunlight exposure compared with frequent exposure (OR = 12.41, 95% CI 1.50–102.9), and among those who did not report vitamin D supplementation (OR = 2.35, 95% CI 1.12–4.91). Among women, older age was associated with higher odds (OR per year = 1.12, 95% CI 1.02–1.24). E-NRF7.3 scores were not significantly associated with pre-frailty or frailty after adjustment in either analysis. Conclusions: Pre-frailty or frailty was more common among women in this sample. The associations with summer sunlight exposure and vitamin D supplementation warrant further study. The wide confidence interval for sunlight exposure indicates substantial uncertainty about the magnitude of that association.

Keywords: frailty; day care senior centers; E-NRF7.3; dietary nutrient density; sex differences

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1. Introduction

Population aging poses a major public health challenge. According to current demographic projections, the proportion of individuals aged 60 and older will increase significantly over the next few decades, leading to a higher prevalence of age-related clinical syndromes [1]. Among these, frailty is a major concern in geriatric care. Characterized by a systemic loss of physiological reserve that lowers the threshold for stress resistance, this syndrome strongly drives adverse outcomes, including disability, institutionalization, falls, and elevated mortality [2,3].

The etiology of frailty is complex and multifactorial, spanning biological, clinical, lifestyle, and sociodemographic dimensions. Among lifestyle factors, adequate nutrition

characterized by high dietary nutrient density, regular physical activity and going outside, e.g., for a walk, as well as low-risk substance use behaviors play a central role in maintaining muscle mass, metabolic homeostasis, and functional independence in late life [4–7]. Conversely, physical inactivity, low dietary nutrient density, and hazardous alcohol consumption have been associated with functional decline and sarcopenia [5,8]. Furthermore, sociodemographic characteristics such as educational attainment, current occupation, living arrangements, and social support networks can influence individuals' access to health resources, dietary choices, and opportunities for physical activity [9].

Although epidemiological evidence consistently highlights a higher prevalence of frailty among older women—a paradox often referred to as the "male–female health–survival paradox", wherein women live longer but experience worse functional health and higher morbidity [10]—the distinct sex-specific mechanisms driving these associations remain insufficiently understood. Physical activity is a protective factor against frailty in both sexes, yet activity profiles and neuromuscular adaptations differ markedly between men and women [11]. Sociodemographic characteristics such as living arrangements, education, and current occupation may also be related to nutritional status and frailty in different ways in women and men [9,12].

Despite the growing body of literature on frailty syndrome, there remains a significant research gap regarding how sex modifies the protective or detrimental effects of specific lifestyle and sociodemographic factors on the occurrence of frailty syndrome. Most existing studies treat sex primarily as a confounding covariate in multivariate-adjusted models. Furthermore, the interplay between lifestyle patterns and sociodemographic status across different sex groups is rarely evaluated simultaneously within comprehensive epidemiological frameworks.

One of the important lifestyle factors influencing the health status of older adults is dietary behavior. Diet quality can be assessed using indicators that account for nutrient density, which reflects the amount of nutrients provided relative to the energy content of a food or diet. Although the concept of nutrient density has been well established in nutritional science for many years, its application in research on frailty syndrome represents a developing area of investigation [13]. Previous studies have linked overall diet quality and intakes of protein and micronutrients to frailty in older adults [5]. In this study we investigate the potential use of the E-NRF7.3 algorithm [14] as a predictor of frailty symptoms.

The study aimed to identify potentially modifiable lifestyle and sociodemographic factors associated with frailty symptoms using analyses in the overall sample and separately for women and men. The findings may provide a basis for formulating public health recommendations, as well as guidelines for prevention and nutritional care in geriatrics.

2. Materials and Methods

2.1. Participants

This cross-sectional study was conducted between 2015 and 2021 among community-dwelling adults aged 60 years and older. Participants were recruited through leaflets and announcements at senior clubs and the University of the Third Age. Participation was voluntary. The required sample size was calculated based on published data from Poland, which indicated a frailty prevalence of 13.1% among older adults; the estimated required sample size was 180 participants [15]. The inclusion criteria were age ≥ 60 years, the ability to walk and the absence of advanced dementia. Initially, 239 people applied, of whom 229 met the eligibility criteria. The final analysis included only 196 individuals who completed all questionnaires.

The study protocol was approved by the ethics committee of the National Food and Nutrition Institute in Warsaw, Poland, on 3 April 2012. The study was conducted in accordance with the Declaration of Helsinki.

2.2. Frailty Assessment

Frailty was assessed in all 229 participants using criteria based on the Cardiovascular Health Study (CHS) frailty phenotype. The assessment comprised five components [2]: (1) shrinking (unintentional weight loss), (2) weakness, (3) exhaustion, (4) slow walking speed and (5) physical inactivity. Unintentional weight loss was defined as a self-reported loss of more than 4.5 kg or 5% of body weight within the preceding year. Muscle weakness was evaluated using the mean of three maximum grip strength measurements of the dominant hand, obtained via a handheld dynamometer (Smedlay, Japan); results were stratified by sex and BMI. Exhaustion was identified through two self-report items assessing energy and activity levels over the prior two weeks. Gait speed was measured over a distance of 4.5 m, with sex- and height-specific cut-off values used to identify slow walking speed. Physical inactivity was assessed using a self-reported questionnaire covering physical activity over the preceding year, with frailty defined as engaging in less than 2 h of sport or physical activity per week.

Participants who met at least three criteria were classified as "frail", those meeting one or two criteria were classified as "pre-frail", and individuals who met none of the criteria were classified as "non-frail". Due to the small number of frail participants, the pre-frail and frail groups were combined into a single group for analysis, reflecting common practice [16].

2.3. Sociodemographic and Lifestyle Data

A questionnaire was used to collect information on sex, age, educational level, marital status, number of people per household, current employment status, current and past physical activity, attendance at day care centers for older adults (DCCs), sunlight exposure during the previous summer, sunscreen use during the previous summer, dietary supplement intake (a positive response—regular or irregular but frequent use), smoking, alcohol intake (a positive response—drinking sometimes or frequently), and self-rated additional mental activity (e.g., playing bridge, chess, solving crosswords, or learning a foreign language regularly or frequently). Height and weight were measured to calculate body mass index (BMI).

Dietary intake was assessed using a three-day food record (two weekdays and one weekend day). Participants completed the records at home, and research assistants reviewed them for accuracy and completeness at a follow-up visit. The dietary data were then analyzed using the "Polish tables of composition and nutritional value" [17], providing the basis for the assessment of nutrient density. Intake analysis included dietary supplements. Dietary nutrient density was evaluated using the E-NRF7.3 algorithm [14]. This index is specifically designed to focus on the health needs of older adults. It takes into account seven nutrients to encourage: protein, fiber, folate, vitamin D, calcium, magnesium, and potassium, and three components to limit: saturated fat, sodium, and sugar. Essentially, the higher the score, the more valuable nutrients the food provides for every 100 kcal.

2.4. Statistical Analysis

Pearson's chi-square test was used to determine the association between the prevalence of FS and the analyzed data, with the exception of age and BMI (as quantitative data) for which the Kruskal–Wallis test was used. Continuous variables were summarized as means and standard deviations (SDs), and categorical variables were summarized as numbers

and percentages. Group comparisons were conducted in the overall sample and separately among women and men. Univariate analyses were made separately by sex. The results with p-values ≤ 0.05 were considered statistically significant.

Multivariable logistic regression, including all 196 participants, was used to estimate adjusted associations with the combined outcome of pre-frailty and frailty. The dependent variable was defined as combined pre-frail/frail status (coded as 1 for frail + pre-frail vs. 0 for non-frail). Regression models were constructed hierarchically in four sequential steps:

- Model 1 included basic demographic variables: sex (in the overall sample model) and age. Age is one of the strongest established determinants of frailty, reflecting the progressive accumulation of physiological deficits and age-related functional decline.
- Model 2 added dietary nutrient density (E-NRF7.3) to Model 1, which is an important determinant of healthy ageing and physical functioning. Adequate intake of protein, fiber, vitamins, and minerals may contribute to the maintenance of muscle mass, strength, and metabolic function.
- Model 3 added three variables to Model 1: sunlight exposure during the previous summer season ("often" as reference, vs. "sometimes" and "never"), sunscreen use during sun exposure ("always" as reference, vs. "often" and "never"), and regular vitamin D supplementation ("yes" as reference vs. "no"). Sunlight exposure is an important determinant of endogenous vitamin D synthesis, while sunscreen use may influence cutaneous vitamin D production. Vitamin D supplementation was included to account for an alternative source of vitamin D.
- Model 4 comprised the fully adjusted model, including sex, age, sunlight exposure, sunscreen use, vitamin D supplementation and dietary nutrient density (E-NRF7.3). This model enabled us to examine whether the associations observed in the preceding models remained after mutual adjustment for all selected variables.

Separate regression analyses were performed for the overall sample and for the subgroup of women. No analysis was performed for men due to an insufficient sample size and the absence of individuals meeting at least three criteria for frailty syndrome. Logistic regression results are presented as odds ratios (ORs) with corresponding 95% confidence intervals (CIs). We have considered p-values ≤ 0.05 as statistically significant, and values of $0.05 < p < 0.10$ were interpreted as indicating a statistical trend. Model convergence and potential complete or quasi-complete data separation were verified by inspecting the iteration history of the log-likelihood function.

Data were analyzed using Statistica software version 13.3 (TIBCO Software Inc., Palo Alto, CA, USA).

3. Results

3.1. Characteristics of Frailty Syndrome Groups

The analytical sample comprised 196 participants, including 114 women (58.2%) and 82 men (41.8%). Six participants (3.0%), all women, were classified as frail, meeting at least three frailty criteria. Seventy-six participants (38.8%) met one or two criteria and were classified as pre-frail; 54 (71.1%) of them were women. The remaining 114 participants (58.2%) met none of the frailty criteria and were classified as non-frail, including 54 women (47.4%). The distribution of frailty status differed significantly between women and men ($p = 0.001$; Table 1).

Table 1. Distribution of frailty status by sex.

Variable	Frail [%]	Pre-Frail [%]	Non-Frail [%]	*p*
Total (n = 196)	n = 6 [3.0]	n = 76 [38.8]	n = 114 [58.2]	-
Sex–Women (n = 114)	100.0	71.1	47.4	0.001 (1)

(1) Pearson Chi^2 test.

3.2. Sociodemographic and Lifestyle Characteristics by Frailty Status and Sex

Further analyses were conducted after dividing participants into two groups: pre-frail/frail status and non-frail status. Attendance at DCC was significantly associated with pre-frail/frail status, both in the study group as a whole ($p < 0.001$) and among women ($p = 0.001$) and men ($p = 0.005$) separately. Educational level was also significantly associated with pre-frail/frail status; regardless of sex, individuals in the pre-frail/frail group had a lower level of education (women: $p = 0.008$, men: $p = 0.041$). Women classified as pre-frail/frail were older (mean age: 73.1 vs. 70.6 years; $p = 0.015$) and had a higher mean BMI (29.5 vs. 27.7 kg/m^2; $p = 0.049$) than non-frail women. Neither comparison was statistically significant among men. In the overall sample, participants classified as having pre-frail/frail status were also older than non-frail participants (72.6 vs. 71.0 years; $p = 0.038$). In the overall sample, the proportion of participants classified as living alone was higher in the pre-frail/frail group than in the non-frail group (61.0% vs. 41.2%; $p = 0.006$). (Table 2).

Table 2. Sociodemographic and anthropometric characteristics by frailty status in the overall sample and by sex.

Variable	Total n = 196			Women n = 114 [58.2%]			Men n = 82 [41.8%]		
	Pre-Frail/Frail n = 82 (41.8%)	Non-Frail n = 114 (58.2%)	*p*	Pre-Frail/Frail n = 60 (52.6%)	Non-Frail n = 54 (47.4%)	*p*	Pre-Frail/Frail n = 22 (26.8%)	Non-Frail n = 60 (73.2%)	*p*
Age (yrs) mean (SD)	72.6 (6.1)	71.0 (4.7)	0.038 (1)	73.1 (5.8)	70.6 (4.4)	0.015 (1)	71.2 (6.6)	71.5 (4.9)	0.933 (1)
BMI (kg/m^2) mean (SD)	28.8 (4.7)	27.8 (4.0)	0.223 (1)	29.5 (4.9)	27.7 (4.1)	0.049 (1)	27.1 (3.4)	27.8 (4.0)	0.445 (1)
Educational level Primary Secondary Higher	 4 (4.9) 43 (52.4) 35 (42.7)	 1 (0.9) 34 (29.8) 79 (69.3)	0.001 (2)	 3 (5) 31 (51.7) 26 (43.3)	 1 (1.9) 14 (25.9) 39 (72.2)	0.008 (2)	 1 (4.6) 12 (54.5) 9 (40.9)	 0 (0.0) 20 (33.3) 40 (66.7)	0.041 (2)
Marital status Lives alone Married/ cohabiting	 50 (61.0) 32 (39.0)	 47 (41.2) 67 (58.8)	0.006 (2)	 44 (73.3) 16 (26.7)	 34 (63.0) 20 (37.0)	0.234 (2)	 6 (27.3) 16 (72.7)	 13 (21.7) 47 (78.3)	0.594 (2)
Attending day care senior centers–Yes (n = 21)	18 (22.0)	3 (2.6)	<0.001 (2)	13 (21.7)	1 (1.9)	0.001 (2)	5 (22.7)	2 (3.3)	0.005 (2)
Number of people per household 1 2 ≥3	 40 (48.8) 33 (40.2) 9 (11.0)	 45 (39.5) 53 (46.5) 16 (14.0)	0.421 (2)	 36 (60.0) 19 (31.7) 5 (8.3)	 34 (63.0) 15 (27.8) 5 (9.2)	0.899 (2)	 4 (18.2) 14 (63.4) 4 (18.2)	 11 (18.3) 38 (63.3) 11 (18.4)	0.999 (2)
Current occupation–Yes (n = 24)	8 (9.8)	16 (14.0)	0.367 (2)	3 (5.0)	4 (7.4)	0.593 (2)	5 (22.7)	12 (20.0)	0.787 (2)

(1) Kruskal–Wallis test; (2) Pearson Chi^2 test; SD—standard deviation.

A significantly higher proportion of women who met at least one FS symptom reported low levels of current physical activity ($p < 0.001$). Furthermore, sun exposure during the previous summer season, less frequent use of vitamin D supplements, a tendency to use sunscreen during the summer months and less frequent alcohol consumption were significantly associated with FS symptoms, in the entire group and also among women ($p < 0.050$). Among men, none of the lifestyle characteristics presented in Table 3 differed significantly by frailty symptoms. Dietary nutrient density was higher in the pre-frail/frail group in the overall sample and among women. (Table 3).

Table 3. Lifestyle characteristics and dietary nutrient density by frailty groups in the overall sample and by sex.

Variable	Total $n = 196$			Women $n = 114$ [58.2%]			Men $n = 82$ [41.8%]		
	Pre-Frail/Frail $n = 82$ (41.8%)	Non-Frail $n = 114$ (58.2%)	p	Pre-Frail/Frail $n = 60$ (52.6%)	Non-Frail $n = 54$ (47.4%)	p	Pre-Frail/Frail $n = 22$ (26.8%)	Non-Frail $n = 60$ (73.2%)	p
Self-rated current physical activity			<0.001 (1)			<0.001 (1)			0.175 (1)
High	11 (13.4)	41 (36.0)		7 (11.7)	20 (37.0)		4 (18.2)	21 (35.0)	
Average	42 (51.2)	62 (54.4)		29 (48.3)	29 (53.7)		13 (59.1)	33 (55.0)	
Low	29 (35.4)	11 (9.6)		24 (40.0)	5 (9.3)		5 (22.7)	6 (10.0)	
Self-rated past physical activity—at school period			0.450 (1)			0.851 (1)			0.525 (1)
High	46 (56.1)	74 (64.9)		32 (53.3)	29 (53.7)		14 (63.6)	45 (75.0)	
Average	32 (39.0)	35 (30.7)		25 (41.7)	21 (38.9)		7 (31.8)	14 (23.3)	
Low	4 (4.9)	5 (4.4)		3 (5.0)	4 (7.4)		1 (4.6)	1 (1.7)	
Self-rated past physical activity—in the age of 20–40			0.903 (1)			0.775 (1)			0.909 (1)
High	48 (58.5)	66 (57.9)		34 (56.7)	27 (50.0)		14 (63.6)	39 (65.0)	
Average	31 (37.8)	45 (39.5)		23 (38.3)	24 (44.4)		8 (36.4)	21 (35.0)	
Low	3 (3.7)	3 (2.6)		3 (5.0)	3 (5.6)		0 (0.0)	0 (0.0)	
Self-rated past physical activity—in the age of 40–60			0.336 (1)			0.198 (1)			0.953 (1)
High	29 (35.4)	51 (44.7)		19 (31.7)	26 (48.2)		10 (45.4)	25 (41.7)	
Average	43 (52.4)	54 (47.4)		32 (53.3)	22 (40.7)		11 (50.0)	32 (53.3)	
Low	10 (12.2)	9 (7.9)		9 (15.0)	6 (11.1)		1 (4.6)	3 (5.0)	
Self-rated additional mental activity			0.312 (1)			0.590 (1)			0.740 (1)
None	20 (24.4)	26 (22.8)		13 (21.6)	11 (20.4)		7 (31.8)	15 (25.0)	
Irregular	11 (13.4)	25 (21.9)		7 (11.7)	10 (18.5)		4 (18.2)	15 (25.0)	
Regular	51 (62.2)	63 (55.3)		40 (66.7)	33 (61.1)		11 (50.0)	30 (50.0)	
Smoking—Yes ($n = 16$)	7 (8.5)	9 (7.9)	0.871 (1)	2 (3.3)	3 (5.6)	0.563 (1)	5 (22.7)	6 (10.0)	0.134 (1)
Alcohol intake—Yes ($n = 140$)	46 (56.1)	94 (82.5)	<0.001 (1)	29 (48.3)	40 (74.1)	0.005 (1)	17 (77.3)	54 (90.0)	0.134 (1)
Exposed to sunlight last summer			<0.001 (1)			0.006 (1)			0.246 (1)
Never	13 (15.8)	1 (0.9)		12 (20.0)	1 (1.8)		1 (4.6)	0 (0.0)	
Sometimes	19 (23.2)	24 (21.0)		14 (23.3)	11 (20.4)		5 (22.7)	13 (21.7)	
Often	50 (61.0)	89 (78.1)		34 (56.7)	42 (77.8)		16 (72.7)	47 (78.3)	

Table 3. *Cont.*

Variable	Total $n = 196$			Women $n = 114$ [58.2%]			Men $n = 82$ [41.8%]		
	Pre-Frail/Frail $n = 82$ (41.8%)	**Non-Frail $n = 114$ (58.2%)**	***p***	**Pre-Frail/Frail $n = 60$ (52.6%)**	**Non-Frail $n = 54$ (47.4%)**	***p***	**Pre-Frail/Frail $n = 22$ (26.8%)**	**Non-Frail $n = 60$ (73.2%)**	***p***
Use sun cream during last summer months			0.006 [1]			0.012 [1]			0.285 [1]
Always	20 (24.4)	12 (10.5)		17 (28.4)	9 (16.7)		3 (13.6)	3 (5.0)	
Often	18 (22.0)	45 (39.5)		14 (23.3)	27 (50.0)		4 (18.2)	18 (30.0)	
Never	44 (53.6)	57 (50.0)		29 (48.3)	18 (33.3)		15 (68.2)	39 (65.0)	
Vitamin D supplementation Yes ($n = 56$)	16 (19.5)	40 (35.1)	0.017 [1]	12 (20.0)	22 (40.7)	0.015 [1]	4 (18.2)	18 (30.0)	0.284 [1]
E-NRF7.3 mean (SD)	15.4 (8.1)	13.2 (9.6)	0.027 [2]	16.6 (7.9)	13.7 (8.6)	0.054 [2]	12.2 (8.1)	12.7 (10.5)	0.822 [2]
min–max	−0.61–33.8	−3.9–55.2		−0.04–33.8	−3.9–31.2		−0.61–31.8	−1.5–55.2	

[1] Pearson Chi^2 test; [2] Kruskal–Wallis test; E-NRF7.3—Elderly Nutrient-Rich Food score 7.3; SD—standard deviation.

3.3. Factors Associated with Frailty Status in Multivariable Logistic Regression

3.3.1. Models for the Overall Sample

In all models women had 2.6- to 3-fold higher odds of pre-frail/frail status than men with $p < 0.05$ (Model 1: OR = 3.01, Model 2: OR = 2.87, Model 3: OR = 2.72, Model 4: OR = 2.63). The association with age was close to the prespecified significance threshold in Models 1 and 2 ($p = 0.055$ and $p = 0.050$, respectively) and was not statistically significant in Models 3 and 4. Among lifestyle and environmental covariates, lack of sun exposure last summer showed the largest magnitude of association with pre-frail/frail status, corresponding to more than 12-fold higher odds in Model 4 compared to "often" exposure (OR = 12.41, 95% CI: 1.50–102.9, $p = 0.020$). Furthermore, non-supplementation with vitamin D more than doubled the odds of pre-frail/frail status in the overall sample (Model 4: OR = 2.35, 95% CI: 1.12–4.91, $p = 0.024$). Reporting sunscreen use as "often" compared to "always" use was associated with reduced odds (Model 4: OR = 0.26, 95% CI: 0.09–0.68, $p = 0.006$). Dietary nutrient density (E-NRF7.3) was not significantly associated with pre-frail/frail status in Model 4 (OR = 1.02, 95% CI: 0.99–1.06, $p = 0.210$; Table 4). Due to the low number of non-frail participants in the "never" sunlight exposure subgroup (n = 1), we verified that model convergence was achieved (6 iterations; final log-likelihood = −110.7943), with parameter estimates stabilizing and no evidence of complete or quasi-complete data separation. We have also performed an additional regression analysis to test model sensitivity by combining the sunlight exposure "never" and "sometimes" categories (n = 25 in the non-frail category), which confirmed that the main predictors—female sex, lack of vitamin D supplementation, and sunscreen use—remained statistically significant with consistent effect directions, and combined low sunlight exposure showed a positive trend. (Table S1).

Table 4. Multivariable logistic regression models for pre-frail/frail (n = 82) status in the overall sample (n = 196).

Variable	Model 1 *p*;OR (95%CI)	Model 2 *p*;OR (95%CI)	Model 3 *p*;OR (95%CI)	Model 4 *p*;OR (95%CI)
Sex Men * (*n* = 82) Women (*n* = 114)	<0.001;3.01 (1.62–5.58)	0.001;2.87 (1.54–5.35)	0.005;2.72 (1.36–5.44)	0.006;2.63 (1.31–5.27)
Age (per 1 year)	0.055;1.06 (0.99–1.12)	0.050;1.06 (1.00–1.12)	0.223;1.04 (0.98–1.12)	0.230;1.04 (0.97–1.11)
E-NRF7.3 (per 1 point)	-	0.200;1.02 (0.98–1.05)	-	0.210;1.02 (0.99–1.06)
Exposed to sunlight last summer Often * (*n* = 139) Sometimes (*n* = 43) Never (*n* = 14)	-	-	0.403;1.38 (0.65–2.93) 0.016;13.57 (1.64–112.5)	0.450;1.34 (0.63–2.85) 0.020;12.41 (1.50–102.9)
Use sun cream during sun exposition Always * (*n* = 32) Often (*n* = 63) Never (*n* = 101)	-	-	0.007;0.27 (0.10–0.69) 0.186;0.54 (0.22–1.35)	0.006;0.26 (0.09–0.68) 0.246;0.58 (0.23–1.46)
Vitamin D supplementation Yes * (*n* = 56) No (*n* = 140)	-	-	0.021;2.39 (1.14–4.99)	0.024;2.35 (1.12–4.91)

* reference; E-NRF7.3—Elderly Nutrient-Rich Food score 7.3; OR—odds ratio; CI—confidence interval.

3.3.2. Women Subgroup Models

In contrast to the total sample, age remained consistently associated with pre-frailty/frailty in women across all models, increasing odds by 11–12% per additional year of age (Model 1: OR = 1.11, Model 2: OR = 1.11; Model 3: OR = 1.12; Model 4: OR = 1.12). Lack of sunlight exposure last summer showed a particularly marked association among women, with nearly 13-fold higher odds of pre-frail/frail status in Model 4 (OR = 12.89, 95% CI: 1.41–117.3, $p = 0.023$). Additionally, lack of vitamin D supplementation was associated with higher odds of pre-frailty/frailty status in women (Model 4: OR = 2.61, 95% CI: 1.01–6.79, $p = 0.049$). Higher dietary nutrient density (E-NRF7.3) demonstrated a statistical trend toward higher pre-frail/frail status odds among women in Model 2 (OR = 1.05, $p = 0.058$) and in Model 4 (OR = 1.05, $p = 0.080$). (Table 5) Due to the low number of non-frail participants in the "never" sunlight exposure subgroup (n = 1), we verified that model convergence was achieved (7 iterations; final log-likelihood = −62.7032), with parameter estimates stabilizing and no evidence of complete or quasi-complete data separation. We also performed an additional regression analysis to test sensitivity by combining the sunlight exposure "never" and "sometimes" categories (n = 12 in the non-frail category), which confirmed that the main predictors—age, lack of vitamin D supplementation, and sunscreen use—remained statistically significant with consistent effect directions, while combined low sunlight exposure showed statistical significance. (Table S1).

Table 5. Multivariable logistic regression models for pre-frail/frail status (n = 60) among women (n = 114).

Variable	Model 1 *p*;OR (95%CI)	Model 2 *p*;OR (95%CI)	Model 3 *p*;OR (95%CI)	Model 4 *p*;OR (95%CI)
Age (per 1 year)	0.013;1.11 (1.02–1.20)	0.012;1.11 (1.02–1.21)	0.023;1.12 (1.02–1.23)	0.023;1.12 (1.02–1.24)
E-NRF7.3 (per 1 point)	-	0.058;1.05 (1.00–1.10)	-	0.080;1.05 (0.99–1.11)
Exposed to sunlight last summer Often * (n = 76) Sometimes (n = 25) Never (n = 13)	-	-	 0.401;1.54 (0.56–4.24) 0.017;14.77 (1.61–135.2)	 0.369;1.61 (0.57–4.49) 0.023;12.89 (1.41–117.3)
Use sun cream during sun exposition Always * (n = 26) Often (n = 41) Never (n = 47)	-	-	 0.024;0.28 (0.09–0.84) 0.415;0.63 (0.21–1.90)	 0.021;0.26 (0.09–0.82) 0.528;0.70 (0.23–2.13)
Vitamin D supplementation Yes * (n = 34) No (n = 80)	-	-	 0.033;2.77 (1.09–7.05)	 0.049;2.61 (1.01–6.79)

* reference; E-NRF7.3—Elderly Nutrient-Rich Food score 7.3; OR—odds ratio; CI—confidence interval.

4. Discussion

The present study investigated the sociodemographic, lifestyle, and dietary factors associated with the combined outcome of pre-frailty and frailty among community-dwelling older Polish adults, with a specific focus on associations in women and men examined in sex-stratified analyses. Proportion of participants classified as pre-frail or frail was higher in women (52.6%) than in men (26.8%). This sex disparity aligns with broad national and international epidemiological data, including the Polish nationwide PolSenior2 study [18] and large-scale global meta-analyses [19,20]. This phenomenon reflects the well-documented "male–female health–survival paradox", wherein older women report higher morbidity and functional limitations despite a longer average life expectancy [10]. Nevertheless, the present study did not examine the mechanisms underlying this pattern.

Unadjusted analyses showed associations between several sociodemographic and behavioral characteristics and frailty status. In both women and men, higher education was less common in the pre-frail/frail group than in the non-frail group. Education serves as a key indicator of socioeconomic trajectory and health literacy, shaping access to healthcare resources, dietary quality, and opportunities for lifelong functional maintenance [9,12]. Furthermore, attending day care senior centers was a strong factor associated with belonging to the pre-frail/frail group, both in the group as a whole and when analyzed by sex. As indicated by Orellana et al. [21] and Sewo Sampaio et al. [22], older adults who use day care centers often exhibit greater physical dependency and social isolation, seeking structured care, social interaction, and rehabilitation. Interestingly, individuals with symptoms of FS were significantly older than robust individuals—both in the entire study group and among women—but no such association was observed among men. This finding contradicts the majority of studies, in which advanced age is a clear factor associated with the presence or severity of FS symptoms [6,14,18]. A strong association was found between low levels of current physical activity and symptoms of frailty syndrome, both in the entire study group and among women. We did not, however, find any influence of physical activity during past stages of life. Prospective dose–response meta-analyses demonstrate that regular physical activity directly counteracts sarcopenia, neuromuscular decline, and biological vulnerability

in older age [23–25]. However, it should be emphasized that one of the criteria for assessing frailty syndrome is the level of physical activity. This overlap of factors may partly explain the strong association observed. The percentage of people consuming alcohol, especially among women, was significantly higher in the non-frail group. This finding should not be interpreted as a protective effect of alcohol consumption per se; rather, it reflects the well-documented "sick quitter" phenomenon and health selection bias [26,27]. Older adults with chronic conditions, polypharmacy, or functional limitations may stop consuming alcohol due to medical contraindications or adverse drug–alcohol interactions [28].

In the multivariable models, sunlight exposure and vitamin D supplementation were associated with pre-frail/frail status. Participants who did not report vitamin D supplementation had higher odds of at least one of frailty symptoms in the fully adjusted model 4, both in the overall population (OR = 2.35) and among women (OR = 2.61). Lack of summer sunlight exposure was associated with a massive increase in pre-frail/frail odds in the total sample (OR = 12.41; 95% CI: 1.50–102.9) and among women (OR = 12.89; 95% CI: 1.41–117.3) (Model 4). However, the very wide confidence intervals and the small number of participants reporting no sunlight exposure indicate substantial uncertainty about the magnitude of these associations, and the magnitude of the association should be interpreted cautiously. An unexpected association was also observed for sunscreen use. Reporting sunscreen use as "often", compared with "always", was associated with lower odds of pre-frail/frail status in the overall sample (OR = 0.26; 95% CI: 0.09–0.68). This result should not be interpreted as evidence that frequent sunscreen use increases frailty. Sunscreen use may reflect differences in outdoor activity, sun-seeking behavior, health awareness and skin characteristics. Furthermore, the frequency of sunscreen application does not necessarily indicate the actual amount of UVB exposure. Nevertheless, age-related declines in serum vitamin D levels occur earlier and more rapidly in women [29]. Observational studies have reported lower circulating 25-hydroxyvitamin D concentrations in frail older individuals [30,31]. The randomized Sun-D Trial found that regular application of high-SPF sunscreen can reduce serum 25(OH)D concentrations under the investigated conditions [32]. However, because serum 25(OH)D was not directly measured, reverse causation cannot be ruled out: frail older women with mobility impairments or fatigue may spend considerably less time outdoors, leading to reduced sun exposure [7]. Current randomized controlled trial evidence indicates that while supplementation is vital for correcting deficiencies, it should be integrated into multidimensional lifestyle interventions rather than prescribed as a standalone anti-frailty therapy [33,34].

Dietary nutrient density (E-NRF7.3) was not significantly associated with pre-frail/frail status in the fully adjusted overall model. Among women, higher E-NRF7.3 scores showed an unexpected tendency towards higher odds of pre-frailty/frailty, although the association did not reach statistical significance. In the broader nutritional literature, higher protein intake and better dietary quality have generally been associated with lower frailty risk [5]. However, E-NRF7.3 was specifically developed to assess nutrient density in older adults rather than to predict frailty or functional outcomes [14]. The total amount of energy and protein is crucial in the prevention and development of frailty syndrome [5,8]. E-NRF7.3 expresses the intake of selected nutrients per 100 kcal; therefore, expressing intake solely in terms of 100 kcal may be insufficient or not precise enough for a condition as specific as frailty syndrome. The tendency in the women group may stem from dietary compensation—where individuals experiencing early functional decline or receiving nutritional advice deliberately choose nutrient-dense foods—or from reduced total energy intake concentrating nutrient density per 100 kcal [16,17]. Further studies are needed to establish the clinical relevance of E-NRF7.3 in relation to frailty.

4.1. Implications for Clinical Practice and Public Health

These exploratory findings support further investigation of sociodemographic and lifestyle factors associated with pre-frail/frail status in older women and men. Whether preventive interventions should differ by sex remains an open question. Day care centers for older adults may provide opportunities for frailty assessment and referral, although the present study did not evaluate the effectiveness of screening in this setting. Interventions should prioritize structured multicomponent physical exercise—combining resistance, balance, and aerobic training—which remains the most effective non-pharmacological strategy to preserve physical function [25,34,35]. Furthermore, targeted nutritional support, routine evaluation of outdoor activity, and personalized vitamin D management should be routinely incorporated into primary geriatric care.

The E-NRF7.3 index may be useful for describing dietary nutrient density in older populations, although its ability to identify individuals at risk of frailty requires further validation. Its value for identifying older adults at risk of developing frailty remains to be established in prospective studies.

4.2. Strengths and Limitations

An important strength of this study is the simultaneous assessment of several potentially modifiable factors associated with frailty, including sunlight exposure, sunscreen use, vitamin D supplementation and dietary nutrient density.

Another strength of the study is the use of criteria based on the Cardiovascular Health Study frailty phenotype, including direct measurements of gait speed and handgrip strength.

Finally, a strong point is the method used to assess diet quality. First, nutrient intake was evaluated based on a three-day food record, covering two weekdays and one weekend day, which was verified by research assistants. Additionally, the E-NRF7.3 index was used, this is an additional advantage, as this tool was specifically developed to assess the nutritional density of diets in older populations.

Several limitations should nevertheless be acknowledged. First, the cross-sectional design precludes establishing the temporal sequence of the observed associations or drawing causal conclusions. In particular, reverse causality cannot be excluded, as individuals experiencing frailty may reduce their outdoor activities, change their dietary habits or modify their supplement use.

Second, the relatively small sample size (n = 196) and the limited number of participants classified as frail (n = 6) required combining pre-frail and frail individuals in one group and restricted the statistical power of the analyses, particularly in sex-stratified models. The wide confidence intervals observed for sunlight exposure indicate substantial uncertainty regarding the magnitude of the estimated associations. Only 22 men met the criteria for the combined outcome, and a separate regression model was not fitted for men. Third, serum 25(OH)D concentrations were not measured, and the analyses did not account for comorbidity, medication burden, depressive symptoms, or mild cognitive impairment. These factors may be associated with both the exposures and frailty status, which may have contributed to residual confounding.

Fourth, voluntary recruitment through senior clubs and the University of the Third Age may have selected participants who differed from the wider older population in social engagement, health, or functional status. The findings should therefore not be treated as representative of the entire population.

5. Conclusions

Pre-frailty/frailty symptoms were associated with lower educational level and day-care center attendance across the total sample and both sex groups.

In multivariable regression analysis, across the entire population, a lack of sun exposure and the lack of vitamin D supplementation were associated with the presence of pre-frailty/frailty symptoms, while "often" use of sunscreen—as opposed to "always"—was associated with lower odds (OR) of being pre-frail or frail. In the female subgroup, all the above factors were associated with the presence of pre-frailty/frailty, and age was additionally associated. The association between sunscreen use and frailty symptoms requires further investigation.

Dietary nutrient density assessed using the E-NRF7.3 index was not significantly associated with pre-frail/frail status after adjustment in either the overall sample or the analysis restricted to women; however, a non-significant positive trend was observed among women, suggesting that the relationship between dietary nutrient density and frailty requires further study. It should be clearly emphasized that because few participants were classified as frail, the results primarily relate to the pre-frail state.

These exploratory findings suggest that future studies should evaluate potential sex-related differences in factors associated with frailty to inform targeted geriatric prevention strategies. Day care senior centers represent potential platforms for early screening and targeted multidimensional interventions, including multicomponent exercise, outdoor mobility, and nutritional optimization to preserve functional independence in aging populations.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/healthcare14234125/s1, Table S1: Multivariable logistic regression models for pre-frail/frail status in the overall sample and women subgroup.

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