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# Association between dietary variety and anthropometric parameters in community-dwelling older adults: results of a population-based PolSenior study

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## Abstract

**Introduction and Objective.** Dietary variety (DV) is recognized as a key indicator of diet quality. It is based on the premise that eating a wide variety of foods ensures an adequate intake of essential nutrients which, in turn, leads to better diet quality. The aim of the study is to examine the relationships between DV, diet quality and selected anthropometric parameters in older adults.

**Materials and Method.** A cross-sectional analysis was conducted on 1,071 participants (average age: 72.8 years) from a population cohort of older adults living in Poland. DV was measured using the Dietary Variety Score (DVS) and Dietary Diversity Score (DDS), based on 3-day food records. The associations between DV and anthropometric parameters were examined using cluster analysis. Three clusters were identified: high DV (Cluster 1 – 33%), moderate DV (Cluster 2 – 41%) and low DV (Cluster 3 – 26%).

**Results.** Moderate DV showed a positive relationship with lower BMI values, particularly in women ($p<0.05$). High and moderate DV was inversely associated with lower values of abdominal adiposity measures, compared to the low DV in the women group only ($p<0.05$). The diet quality score was greater in the high DV, compared to the low DV (12.6 vs. 7.5; $p<0.001$). Low DV constituted a high-risk group and had the lowest intake of energy (100% participants) and almost all nutrients, especially protein (62%) and micronutrients (>30-96%; depending on the nutrient).

**Conclusions.** A higher degree of DV was associated with better anthropometric parameters in older adults. These relationships were more pronounced in women than in men. High DV improves the intake levels of energy, protein and micronutrients, and also enhances overall dietary quality. Older adults require personalized guidance and dietary support, including a high dietary variety of nutrient-dense foods/food groups.

## Key words

anthropometric parameters, nutrition, body mass index, waist circumference, older adults, waist-to-hip ratio, diet quality, dietary variety, PolSenior study

## INTRODUCTION AND OBJECTIVE

The increasing number of older adults and the rise in life expectancy are changing the age structure of populations worldwide and are responsible for the observed phenomenon of an aging society. According to Eurostat data, in 2023 over 21.3% of the population in Europe were aged 65 or over, with this figure estimated to further increase up to 32.5% by 2100 [1]. Changes in life expectancy are not reflected in healthy life expectancy, and in most countries the number of years of life lost to disability is increasing [1]. This makes it necessary to pay particular attention to the health situation and specific nutritional needs of older populations [2, 3].

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The aging process, which is associated with disturbances in homeostasis, causes a number of unfavourable changes, including changes in body composition. This leads to a decrease in lean mass, and especially muscle mass, while body weight and fat mass content increase [4]. Obesity is a major public health issue that is associated with an increased risk of non-communicable diseases and higher mortality rates, lower life expectancy and poorer clinical outcomes [5]. Body mass index (BMI) is a commonly used screening biomarker for assessing nutritional status, but in the light of changes in body composition and the distribution of fat tissue in the body, it may be insufficient, and some studies indicate that BMI is less reliable for diagnosing obesity in elderly populations. A solution to this discrepancy might be to use BMI in combination with waist circumference to increase the validity and accurate reporting of health status [6]. In addition, abdominal (visceral) obesity is particularly unfavourable because it is a major risk factor for systemic inflammation, insulin resistance and metabolic syndrome [7].

A healthy diet, rich in nutrient-dense and high-quality foods, is particularly important in older adults [2, 3, 4], among whom age-related chronic diseases are more prevalent [8]. Although the resting metabolic rate declines with aging [9], the majority of nutrient requirements remain unchanged or undergo only minimal changes, thus a diet containing more nutrient-dense foods to ensure an adequate supply of essential nutrients is desirable [3]. A balanced diet should be implemented to support healthy aging [2, 8]. Food-based dietary guidelines are intended to encourage older adults to eat varied meals and to increase their dietary variety (DV) by eating a variety of foods across and within food groups [10]. DV also frequently termed 'dietary diversity', refers to the variety of foods or food groups being consumed [11]. It is based on the premise that eating a wide variety of foods will ensure an adequate intake of essential nutrients which, in turn, will lead to better overall diet quality and health outcomes [12]. There is a significant link between high variety of diet and a lower incidence of frailty [13], while a high variety of diet also mitigates the effects of lower skeletal muscle mass on medical service utilization and expenditure [14]. Moreover, it may be a protective factor against cognitive decline [15], and is beneficial in relation to gut microbiota [16]. Additionally, evidence from recent studies in older populations suggests that dietary diversity is inversely associated with all-cause mortality [17]. With respect to dietary guidelines, DV is one of the main modifiable factors in dietary quality emphasized in terms of healthy aging [8, 18]. Some studies have shown that a more varied diet is associated with a better nutritional status and health status [19, 20].

In this context, a recently published retrospective population-based cohort study supports the concept that dietary diversity may offer greater adaptability for individuals residing in diverse cultural settings and improved health outcomes [21], and may by useful for public health research and nutrition interventions, especially for older adults [22]. To date, only a few studies have explored the effects of dietary variety patterns on anthropometric parameters, but the results are inconclusive [23]. Other studies have been conducted in young adults and adolescents [24]. A systematic review and results of a meta-analysis showed no significant association between DV-score and BMI status [25]. Considering the scare evidence in older adults, there is still a need for comprehensive research to examine this relationship among older adults, taking into account dietary habit factors. Therefore, the aim of this study is to examine the relationships between DV and selected anthropometric parameters in community-dwelling older adults within a nationwide study group, and to identify at-risk groups.

## MATERIALS AND METHOD

**Participants and study design.** PolSenior was a nationwide multi-disciplinary project conducted by the International Institute of Molecular and Cell Biology in Warsaw between 2008 – 2011 on a representative group of the Polish Caucasian population of older adults. The total number of participants was 5,695 (2,899 males and 2,796 females), of whom 4,979 were aged 65 years and over, and 716 were aged 55–59 years. Details of the study's eligibility criteria and measurement protocols are described elsewhere [26].

The present analysis was performed as a part of the PolSenior project, a cross-sectional study designed to examine food consumption habits, diet quality and anthropometric indices. Dietary data was submitted to the Department of Human Nutrition of the Warsaw University of Life Sciences by the coordinating centre exclusively for participants for whom nutritional examination was performed – a total of 2,046 participants. For the purposes of the current study, 1,071 participants (524 women and 547 men) were included in the analysis after applying exclusion criteria. The criteria for excluding participants from the analysis were: incomplete or incorrectly completed 3-day food record and incomplete anthropometric measurements. The field study consisted of 3 home visits by a trained medical professional. During these visits, detailed socio-economic and medical questionnaires were completed, as well as the 3-day food records for dietary assessment; basic anthropometric measurements were also taken. The general questionnaire included questions about age, gender, place of residence, marital status, level of education, lifestyle, and self-rated health status [26].

**Ethical approval.** The study data protocol was approved by the Bioethics Committee of the Medical University of Silesia in Katowice, in compliance with Declaration of Helsinki (Ethical Approval No. KNW-6501–38/I/08). All the participants included in the study provided written informed consent.

**Dietary assessment.** The subjects' food intake data were collected using a standardized 3-day food records method over 3 consecutive days (2 weekdays, 1 weekend day), according to the written instructions. Respondents recorded the food items they consumed, including the name of the foods and beverages, amount consumed, brand names of products, cooking methods, recipes of composite dishes, and other details of interest (e.g. information on fat content, sweetening: sugar and/or sugar substitutes). The data on the foods and beverages consumed were derived using a combination of household units of measures (e.g. glasses, cups, spoons, etc.), natural units (e.g. eggs or apples, etc.), commercial units for products (e.g. chocolate bars and sweets), an album demonstrating serving sizes for food products and dishes, and estimates in grams or milliliters. The amounts of food consumed were then converted into energy and nutrients using dietary software DIETA v. 5.0 and its internal national food composition database [27].

The intake of energy and nutrients was compared to dietary reference intakes for the Polish population, including reference intakes for older adults. According to the national dietary reference intake [28], the Estimated Average Requirement (EAR) or Adequate Intake (AI) was used in the assessment of diets at an individual level, while estimated energy requirements (EER) based on the individual's age, gender, weight and level of physical activity, were used for measure energy intake. For nutrients with an EAR (cut-point method), the proportions of older adults with intakes less than the EAR was calculated. Intakes lower than the EAR indicate the estimated prevalence of inadequate intakes within the group. The AI was used for nutrients that did not have an EAR value. The percentage of persons consuming greater than or equal to the AI was calculated and it was determined that the prevalence of inadequacy is probably low. If a group's intake is below the AI, intake may need to increased, but it is not possible to quantify precisely the prevalence of inadequacy [28].

In this study, a general Diet Quality Index (DQI) was developed based on the number of nutrients for which consumption met the dietary reference values. To achieve this, points were assigned individually for each nutrient. When the nutrient intake was below the EAR/AI, a score of 0 was assigned. The primary score ranges from 0 (lowest) to a maximum of 20 points (highest), with higher scores indicating a high-quality, healthy diet, i.e. variety, adequacy and overall balance of intakes.

**Dietary variety assessment.** In the present study, the DV was assessed using 2 methods: the Dietary Variety Score (DVS) and Dietary Diversity Score (DDS). The DVS-score was defined as the number of different food and beverage items [29] consumed over 3 consecutive days during the study. A food item was counted only once, even if it was eaten more than once during 3 days – 1 point for each unique product/dish. All food items were included in the calculations, regardless of their weight. Dishes such as e.g. sandwiches were coded as bread plus the appropriate addition, such as sausage, cheese or vegetables. Mixed meals (i.e. soups, lasagna or pizza) were separated into components and were coded as individual dishes. Scores were presented as the sum of points obtained over 3 days.

The DDS-score was based on the number of different food groups (a food group was counted only once, even if it was eaten more than once) consumed over 3 consecutive days [30]. Twenty-six food groups generated by DIETA v. 5.0 were taken into account: 1) Vegetables and fruits, 2) Fruit and vegetable juices, beverages and nectars, 3) Potatoes, 4) Cereals, 5) Legumes, 6) Nuts and seeds, 7) Milk and unfermented milk products, 8) Fermented milk products, 9) Ripening cheeses, 10) Cottage cheeses, 11) Eggs, 12) Meat and poultry, 13) Processed meats and deli meats, 14) Fish and seafood, 15) Butter and cream, 16) Oils, 17) Margarines, 18) Other animal fats, 19) Cakes, 20) Sugar, 21) Honey, 22) Non-chocolate candies, 23) Salted snacks, 24) Other products (i.e. yeast, cocoa, mustard, gelatin), 25) Non-alcoholic beverages, 26) Alcoholic beverages. The final score is the mean of each item score within the range and the maximum which can be obtained for this indicator is 26.

Baseline DV data (DVS and DDV-score) were used to identify the dietary-variety patterns. A cluster analysis was performed to categorize participants according to their DV. The input variables were DVS and DDS-scores, energy intake (expressed as a percentage of age-specific EER), age and level of physical activity. All input variables were standardized to achieve a mean equal to 0 and a standard deviation equal to 1, and expressed as Z-score values. The K-means clustering algorithm of the procedure in STATISTICA software was used to classify the participants based on the Euclidean distances (a posteriori analysis). Finally, 3 clusters were defined and marked as high (Cluster 1), moderate (Cluster 2), and low dietary variety (Cluster 3).

**Anthropometric measurements.** Anthropometric measurements were taken by a trained medical professional during the first visit. A TANITA model BC-536 personal scale was used to measure body weight to the nearest 0.1 kg. Height was measured to the nearest 0.5 cm using a portable stadiometer. Participants were measured without any footwear or heavy clothing [26]. Body mass index (BMI) was calculated using the formula weight (kg) divided by the square of height ($m^2$) and was categorized as ≥ 25 kg/$m^2$ for overweight and ≥ 30.0 kg/$m^2$ for obesity [31].

Waist circumferences (WC) and hip circumferences (HC) were measured using an inelastic measuring tape to the nearest 0.5 cm. WC was measured at the midpoint between the lower costal rib and the iliac crest of the hip bone. WC value ≥ 80/94 cm (in female/male) indicates an increased risk of obesity-related diseases, while ≥ 88/102 cm (in female/male) indicates a high risk of these disease [32, 33]. Hip circumference was measured at the widest point of the buttocks by measuring parallel to the floor. Waist-to-hip ratio (WHR) was categorized as ≥ 0.90 for men and ≥ 0.85 for women [32], while waist-to-height ratio (WHtR) was considered as 0.5 for both genders [34, 35]. Other parameters, such as the WHR and WHtR, were obtained as the quotient of waist circumference expressed in centimeters to hip circumference or height, respectively, expressed in the same units.

**Statistical analysis.** Data are presented as mean and standard deviation (x ± SD) or median (25th and 75th percentiles) for continuous variables, and as frequencies (n) and percentages (%). Participant characteristics across subgroups were explored using a Chi-square analysis. The normality of continuous variables for the sake of comparison was tested using the Shapiro-Wilk test. The differences between means were evaluated using the Student's t-test, or Mann-Whitney tests. For the comparative analysis based on inter-3 groups (clusters), a one-way ANOVA adjusted by Bonferroni *post-hoc* analysis was employed. The independent variable was dietary-variety pattern, defined as high (Cluster 1), moderate (Cluster 2), and low dietary variety (Cluster 3). The dependent variables were adequacy of nutrient intakes, diet quality, and anthropometric measurements.

The statistical analyses were performed using STATISTICA software (StatSoft, Inc.; Tulsa, OK, USA: version 10). For all tests, a *p*-value of £ 0.05 was considered statistically significant.

## RESULTS

**Population description.** The study comprised 1,071 participants with a mean age of 73.8 years, consisting of 524 women and 547 men. The socio-demographic data and characteristics of the older adults are presented in Table 1. The age distribution was mostly even, the largest percentage was in the 65–74 age group, resided in rural and suburban areas, and had a primary and secondary education. Significant differences were observed between men and women in terms of level of education and marital status.

Participants' anthropometric data and general characteristics of the DVS and DDS scores are shown in Table 2. The mean BMI values for both groups were above the normal range, with women exhibiting a higher BMI than men (28.9 vs. 27.7 kg/$m^2$). The difference was statistically significant. Additionally, both groups exhibited mean values for WC and WHR, and a WHtR ratio that exceeded the reference values.

**Table 1.** Socio-demographic characteristics of the study population (n=1,071)

| Characteristics | Total | Women | | Men | | p-value* |
|---|---|---|---|---|---|---|
| | n=1,071 | n=524 | % | n=547 | % | |
| **Age group** | | | | | | |
| 55–64 y | 196 | 108 | 20.6 | 88 | 16.1 | 0.058 |
| 65–74 y | 384 | 192 | 36.6 | 192 | 35.1 | |
| 75–84 y | 259 | 110 | 21.0 | 149 | 27.2 | |
| > 85 y | 232 | 114 | 21.8 | 118 | 21.6 | |
| **Residence** | | | | | | |
| Rural | 387 | 192 | 36.6 | 195 | 35.6 | 0.897 |
| Suburban (up to 50,000 inhabitants) | 289 | 141 | 26.9 | 148 | 27.1 | |
| Towns (50,000 – 500,000 inhabitants) | 175 | 88 | 16.8 | 87 | 15.9 | |
| City (> 500,000 inhabitants) | 220 | 103 | 19.7 | 117 | 21.4 | |
| **Education** | | | | | | |
| | n=1,069 | n=523 | % | n=546 | % | |
| Elementary or less | 92 | 52 | 9.9 | 40 | 7.3 | <0.001 |
| Primary | 345 | 197 | 37.7 | 148 | 27.1 | |
| Middle secondary | 169 | 56 | 10.7 | 113 | 20.7 | |
| Secondary | 327 | 165 | 31.6 | 162 | 29.7 | |
| Higher | 136 | 53 | 10.1 | 83 | 15.2 | |
| **Marital status** | | | | | | |
| | n=1,068 | n=522 | % | n=546 | % | |
| Married / with partners | 610 | 199 | 38.1 | 411 | 75.3 | <0.001 |
| Widowed / divorced / single | 458 | 323 | 61.9 | 135 | 24.7 | |

* Chi-square test; bold values highlight statistically significant differences (p ≤0.05); NS – not significant.
Categorical variables are expressed as frequencies (n) and percentages (%)

The mean DVS value was significantly higher for women than for men, with values of 28.8 and 27.9 points, respectively (Tab. 2). The mean value (median) of dietary variety, measured by the DDS, was 16 points. This indicates that on average, regardless of gender, participants included products from 16 of the 26 available food groups in their diet during the 3 days of the study.

**Dietary variety assessment.** Table 3 shows the characteristics of consumption of various food items over 3 consecutive days, broken down by the 26 food groups (as an average value per day) in relation to gender. Among the food groups surveyed, all older participants consumed vegetables and fruits, cereals, and salted snacks. The average consumption of products in the remainder of the groups indicated was lower, and amounted to an average of approximately 4 products in the cereal group, and about 2 in each of the groups of meat and poultry, non-alcoholic beverages, and cold cuts, sausages and other meat products. Statistically significant differences in the consumption of food groups between men and women related to fermented milk products, cottage cheeses (more women than men), fish and seafood, other animal fats, and alcoholic drinks (more men than women).

**Dietary variety patterns and general characteristics by clusters.** Three major dietary variety patterns emerged from the cluster analysis (Fig. 1) and were marked as high (Cluster 1), moderate (Cluster 2), and low dietary variety (Cluster 3). The clusters identified comprised 33%, 41% and 26% older participants, respectively.

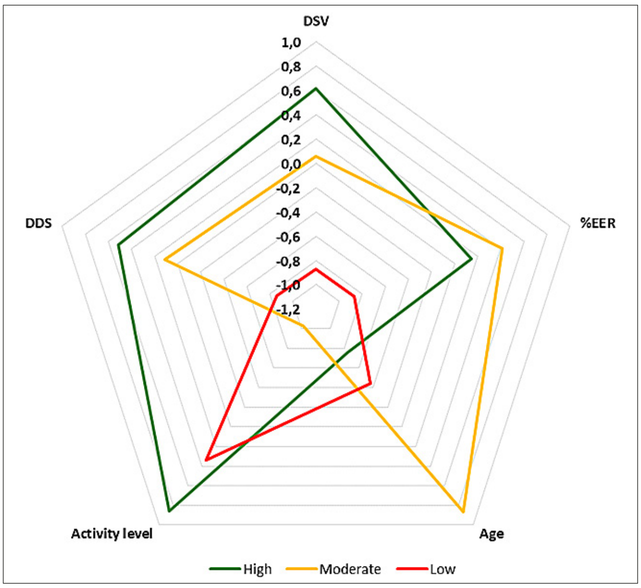


**Figure 1.** Dietary variety characteristics by clusters analysis according to the input variables (Z-scores) among older adults (N=1,071)
DDS – Dietary Diversity Score; DVS – Dietary Variety Score; EER – Estimated Energy Requirement, energy intake (expressed as percentage of age-specific EER), Age (years), Physical Activity level (score)

Table 4 shows the general characteristics of the participants in the 3 cluster groups. A statistically significant relationship was found between the degree of DV and socio-demographic factors, except for place of residence. Participants from Cluster 1 with the greatest DV were in the youngest age group compared to the other clusters. The average age for this

**Table 2.** Anthropometric characteristics and DV measured with Dietary Variety Score (DVS) and Dietary Diversity Score (DDS) among older adults (n=1,071)

| Variables | Mean ± SD | Median | Min. | P25 | P75 | Max. | *p*-value* |
|---|---|---|---|---|---|---|---|
| *Anthropometric data* | | | | | | | |
| **BMI** (kg/m$^2$) | | | | | | | |
| Women | 28.9 ± 5.4 | 28.3 | 16.0 | 25.2 | 31.8 | 51.6 | 0.001 |
| Men | 27.7 ± 4.4 | 27.4 | 13.7 | 24.8 | 30.5 | 50.9 | |
| **Waist circumference** (cm) | | | | | | | |
| Women | 96.6 ± 13.2 | 96.0 | 53.0 | 88.0 | 106.0 | 143.0 | (-) |
| Men | 101.9 ± 11.8 | 101.5 | 54.0 | 94.0 | 110.0 | 144.0 | |
| **Hip circumference** (cm) | | | | | | | |
| Women | 110.0 ± 12.6 | 109.0 | 56.0 | 102.0 | 117.0 | 157.0 | (-) |
| Men | 105.4 ± 9.9 | 105.0 | 52.5 | 100.0 | 110.0 | 150.0 | |
| **WHR** ratio | | | | | | | |
| Women | 0.88 ± 0.09 | 0.88 | 0.52 | 0.83 | 0.92 | 1.52 | (-) |
| Men | 0.97 ± 0.08 | 0.96 | 0.55 | 0.92 | 1.01 | 1.61 | |
| **WHtR** ratio | | | | | | | |
| Women | 0.62 ± 0.09 | 0.61 | 0.35 | 0.55 | 0.67 | 0.92 | <0.001 |
| Men | 0.60 ± 0.07 | 0.60 | 0.32 | 0.56 | 0.65 | 0.86 | |
| *Dietary variety score* | | | | | | | |
| **DVS** (points) [1)] | | | | | | | |
| Women | 28.8 ± 6.8 | 28.5 | 9 | 24 | 33 | 58 | 0.032 |
| Men | 27.9 ± 6.2 | 27.0 | 5 | 22 | 33 | 50 | |
| **DDS** (points) [2)] | | | | | | | |
| Women | 15.9 ± 1.8 | 16.0 | 10 | 14 | 17 | 22 | 0.463 |
| Men | 15.8 ± 1.6 | 16.0 | 7 | 14 | 17 | 21 | |

* Student's t-test; bold values highlight statistically significant differences (p ≤0.05); NS – not significant.
Variables are shown as mean ± standard deviation (SD), median, range (min, max), and percentiles (P25, P75).
(-) For the parameters: waist circumference, hip circumference, WHR ratio – the significance of differences was not calculated due to natural variations and different reference values between sexes.
Abbreviations:
[1)] Data are presented as number of food items consumed during three days.
[2)] Data are presented as number of food groups consumed during three days.
Abbreviations: Body Mass index (BMI), waist-hip ratio (WHR), waist-to-height ratio (WHtR), DVS (Dietary Variety Score); DDS (Dietary Diversity Score)

**Table 3.** Distribution of main food groups and mean number of eaten food items per day (DVS) divided into 26 different food groups (DDS) among older adults (n=1,071)

| | Food groups | Women | Men | *p*-value* | DVS Mean ± SD$^2$ /per day |
|---|---|---|---|---|---|
| | | n (%)[1] | | | |
| 1 | Vegetables and fruits | 524 (100) | 547 (100) | NS | 6.8 ± 1.1 |
| 2 | Fruit and vegetable juices, beverages and nectars | 143 (27.3) | 125 (22.9) | NS | 0.9 ± 1.0 |
| 3 | Potatoes | 514 (98.1) | 529 (96.7) | NS | 1.2 ± 0.5 |
| 4 | Cereals | 524 (100) | 547 (100) | NS | 4.2 ± 1.8 |
| 5 | Legumes | 58 (11.1) | 80 (14.6) | NS | 0.1 ± 0.4 |
| 6 | Nuts and seeds | 56 (10.7) | 50 (9.1) | NS | 0.1 ± 0.3 |
| 7 | Milk and unfermented milk products | 492 (93.9) | 506 (92.5) | NS | 1.0 ± 0.9 |
| 8 | Fermented milk products | 197 (37.6) | 129 (23.6) | <0.001 | 0.4 ± 0.7 |
| 9 | Ripening cheeses | 305 (58.2) | 325 (59.4) | NS | 0.7 ± 0.7 |
| 10 | Cottage cheeses | 397 (78.8) | 375 (68.6) | 0.009 | 0.7 ± 0.6 |
| 11 | Eggs | 507 (96.8) | 516 (94.3) | NS | 0.7 ± 0.6 |
| 12 | Meat and poultry | 521 (99.4) | 545 (99.6) | NS | 2.2 ± 1.1 |
| 13 | Processed meat and meat products | 488 (93.1) | 518 (94.7) | NS | 2.0 ± 1.1 |
| 14 | Fish and seafood | 229 (43.7) | 253 (46.3) | 0.016 | 0.6 ± 0.8 |
| 15 | Butter and cream | 466 (88.9) | 478 (87.4) | NS | 1.3 ± 0.7 |
| 16 | Oils | 420 (80.2) | 430 (78.6) | NS | 1.0 ± 0.6 |
| 17 | Margarines | 371 (70.8) | 380 (69.5) | NS | 0.3 ± 0.5 |
| 18 | Other animal fats | 113 (21.6) | 195 (35.6) | <0.001 | 0.2 ± 0.4 |
| 19 | Cakes | 3 (0.6) | 10 (1.8) | NS | 1.1 ± 1.1 |
| 20 | Sugar | 513 (97.9) | 531 (97.1) | NS | 0.6 ± 0.7 |
| 21 | Honey | 110 (21.0) | 94 (17.2) | NS | 0.2 ± 0.4 |
| 22 | Non-chocolate candies | 21 (4.0) | 18 (3.3) | NS | 0.1 ± 0.3 |
| 23 | Salted snacks | 524 (100) | 547 (100) | NS | 0.3 ± 0.6 |
| 24 | Other products (yeast, cocoa, mustard, gelatine) | 274 (52.3) | 291 (53.2) | NS | 0.1 ± 0.3 |
| 25 | Non-alcoholic beverages | 518 (98.9) | 536 (98.0) | NS | 2.2 ± 0.8 |
| 26 | Alcoholic drinks | 23 (4.4) | 67 (12.2) | <0.001 | 0.1 ± 0.3 |

* Chi-square test, p-value ≤0.05 is statistically significant; NS – not significant.
1 Categorical variables are expressed as frequencies (n) and percentages (%); data are presented as number of food items consumed during three days.
2 Continuous variables are shown as mean ± standard deviation (SD).
Abbreviations: DVS (Dietary Variety Score); DDS (Dietary Diversity Score)

cluster was approximately 65 years, whereas for Clusters 2 and 3 this figure was approximately 84 and 69, respectively. Cluster 1 included significantly more women, participants from younger age groups, persons in relationships (marriage/ partnership), and participants with a secondary and higher level of education.

Respondents with a moderate level of dietary variety were assigned to Cluster 2 which included the most participants (41% in total). This cluster represented the largest proportion of men (45% of male participants) compared to other clusters. The participants constituted the oldest age group compared to other clusters, with the majority being 75 – 84-years-old, accounting for 84.6% of all participants in this age group. The cluster analysis also identified those with the lowest DV who were assigned to the least numerous Cluster 3 (26% of total participants). This cluster included 24.6% of all women and 26.7% of men. Participants in this cluster represented the average age group compared to the other clusters, with the majority of participants aged 65–74, accounting for nearly 42% of all participants in this age group (p<0.001).

Statistically significant differences in the degree of DV were noted for factors such as education and marital status (Tab. 4). Better-educated individuals had a more varied diet compared to those with lower levels of education (p<0.001). Statistically speaking, participants assigned to Cluster 1 were more likely to have tertiary and secondary education than participants from other clusters. Participants from the cluster with the most varied diet (Cluster 1) were more likely to have spouses than those assigned to the other clusters (p<0.001). Cluster 1 included the majority of respondents whose physical activity was predominantly at a moderate level (61% of the all participants), while Cluster 2 included participants with low levels of physical activity (p<0.001). Conversely, in Cluster 3, only 39% of participants exhibited a moderate level of activity (Tab. 4).

**Table 4.** Sociodemographic and lifestyle characteristics by dietary variety clusters among older adults (n=1,071)

| Variables | Dietary Variety Patterns | | | p-value* |
|---|---|---|---|---|
| | High | Moderate | Low | |
| | *(Cluster 1)* n=353 | *(Cluster 2)* n=443 | *(Cluster 3)* n=275 | |
| **Age** (years) | 65.1 ± 6.5[a] | 83.9 ± 5.8[b] | 68.6 ± 8.3[a] | <0.001[1)] |
| | 55-78 | 69-102 | 55-97 | |
| **Age group** | | | | |
| 55–64 y | 127 (64.8) | 0 (0) | 69 (35.2) | <0.001[2)] |
| 65–74 y | 216 (56.3) | 7 (1.8) | 161 (41.9) | |
| 75–84 y | 10 (3.9) | 219 (84.5) | 30 (11.6) | |
| > 85 y | 0 (0) | 217 (93.5) | 15 (6.5) | |
| **Sex** | | | | |
| Women | 197 (37.6) | 198 (37.8) | 129 (24.6) | 0.006[2)] |
| Men | 156 (28.5) | 245 (44.8) | 146 (26.7) | |
| **Marital status** | | | | |
| | n=351 | n=442 | n=275 | |
| Married / with partners | 254 (41.6) | 180 (29.5) | 176 (28.9) | <0.001[2)] |
| Widowed / divorced / single | 97 (21.2) | 262 (57.2) | 99 (21.6) | |
| **Residence** | | | | |
| Rural | 116 (30.0) | 163 (42.1) | 108 (27.9) | 0.175[2)] |
| Suburban (up to 50,000 inhabitants) | 110 (38.1) | 116 (40.1) | 63 (21.8) | |
| Towns (50,000 – 500,000 inhabitants) | 63 (36.0) | 72 (41.1) | 40 (22.9) | |
| City (> 500,000 inhabitants) | 64 (29.1) | 92 (41.8) | 64 (29.1) | |
| **Education level** | | | | |
| | n=352 | n=443 | n=275 | |
| Elementary or less | 5 (5.4) | 68 (73.9) | 19 (20.7) | <0.001[2)] |
| Primary | 79 (22.9) | 167 (48.4) | 99 (28.7) | |
| Middle secondary | 72 (42.6) | 49 (29.0) | 48 (28.4) | |
| Secondary | 140 (42.8) | 106 (32.4) | 81 (24.8) | |
| Higher | 56 (41.2) | 53 (39.0) | 27 (19.9) | |
| **Physical activity level** | | | | |
| Low | 2 (0.41) | 443 (89.9) | 48 (9.7) | <0.001[2)] |
| Moderate | 351 (60.7) | 0 (0) | 227 (39.3) | |

*[1)] ANOVA with adjustment by Bonferroni post-hoc test; [a,b] different letters indicate statistically significant differences between clusters. Bold values highlight statistically significant differences (p ≤0.05).
Variables are shown as mean ± standard deviation (SD) and range (min, max).
*[2)] Chi-square test. Data are presented as number (percentage), % calculated as share of subjects in a given category.

**Association between DV, diet quality and self-rated health status by clusters.** Table 5 shows the relevant information of the clusters in terms of the variables used to classify the participants. Individuals assigned to Cluster 1 had the highest degree of DV, as measured by both DVS and DDS, compared to the other two clusters. The mean DVS value was approximately 33 points in Cluster 1, 29 points in Cluster 2 and 22 points in Cluster 3 (p<001). The mean DDS values were higher in Cluster 1 and 2 compared to Cluster 3 (17 and 16 vs. 14 points, respectively (p<0.001). The daily energy intake was the highest for Cluster 2 (approx. 82% EER), a difference that was statistically significant compared to Clusters 1 and 3, i.e. 76% and 53% EER, respectively. The percentage of individuals meeting average daily energy adequacy (≥ EER) was 31% in Cluster 1, but much higher in Cluster 2 at 69%, while there were no such older participants in Cluster 3 (Tab. 5).

Individuals assigned to Cluster 1 with the most varied diet had also the highest DQI values as measured by the number of nutrients for which consumption met the age-specific nutrient requirements (Tab. 6). Thus, the average number of nutrients in Cluster 1 was 12.6 ± 3.1 (with a maximum value of 20), which was statistically significantly higher than in Clusters 2 and 3, i.e. 10.7 ± 3.9 and 7.5 ± 3.6, respectively.

Analysis of the number of meals consumed by participants assigned to particular clusters indicated that Cluster 1 had the highest percentage of participants who consumed 5 or 6 meals a day – 47% and 50%, respectively, in relation to the total number of persons in the given category (Tab. 5). With lower dietary variety scores (Cluster 3), the highest percentage of participants (49%) consumed only 3 meals a day (p<0.001).

In addition, it was shown that those with the most varied diet (Cluster 1) most often rated their health status in the range of 8–10 points (39.6%) and 6–7 points (38%) on an 11- point scale – where 0 represented the worst and 10 the best health status (Tab. 5). Those whose diet was moderately varied (Cluster 2) generally rated their health status in the range of 4–5 points (45% of this category). Since respondents in this cluster constituted the oldest age group among the participants, this may well explain the low scores for their self-rated health status (p<0.001). Those with the least varied diet (Cluster 3) mostly rated their health status similarly to

**Table 5.** Descriptive statistics of dietary variety patterns, diet quality assessment, and self-rated health status by dietary variety clusters among older adults (n=1,071)

| Variables | Dietary Variety Patterns | | | |
|---|---|---|---|---|
| | High *(Cluster 1)* n=353 | Moderate *(Cluster 2)* n=443 | Low *(Cluster 3)* n=275 | *p*-value* |
| **DVS** (points) | 33.1 ± 5.9[a] 20–58 | 28.8 ± 6.8[b] 9–50 | 21.6 ± 4.6[c] 5–33 | <0.001[1)] |
| **DDS** (points) | 17.0 ± 1.6[a] 13–22 | 16.1 ± 1.9[a] 11–21 | 13.9 ± 1.7[b] 7–18 | <0.001[1)] |
| **Energy intake** (percentage of the average energy intake for the EER) | | | | |
| % EER | 75.5 ± 18.7[a] 34-163 | 81.6 ± 20.4[b] 39-164 | 52.5 ± 11.4[c] 26-91 | <0.001[1)] |
| **Energy intake** (number and percentage of subjects with EER) | | | | |
| ≥EER | 320 (33.2) | 369 (38.3) | 275 (28.5) | <0.001[2)] |
| <EER | 33 (30.8) | 74 (69.2) | 0 (0.0) | |
| **Total DQI** (scoring criteria: 0-20 points) | | | | |
| **Number of nutrients** with adequate intakes | 12.6 ± 3.1[a] 4-19 | 10.7 ± 3.9[b] 3-19 | 7.5 ± 3.6[c] 0-15 | <0.001[1)] |
| **Mean number of daily meals** (intakes are rounded to whole numbers) | | | | |
| 2 | 1(33.3) | 1 (33.3) | 1 (33.3) | <0.001[2)] |
| 3 | 16 (8.8) | 76 (42.0) | 89 (49.2) | |
| 4 | 56 (27.9) | 91(45.3) | 54 (26.9) | |
| 5 | 82 (46.6) | 74 (42.0) | 20 (11.4) | |
| 6 | 21 (50) | 19 (45.2) | 2 (4.8) | |
| **Self-rated health status** (numerical scale: 0 – worst to 10 – best) | | | | |
| | n=346 | n=409 | n=269 | <0.001[2)] |
| 0-3 | 13 (21.3) | 31 (50.8) | 17 (27.9) | |
| 4-5 | 89 (26.8) | 150 (45.2) | 93 (28.0) | |
| 6-7 | 139 (38.0) | 131 (35.8) | 96 (26.2) | |
| 8-10 | 105 (39.6) | 97 (36.6) | 63 (23.8) | |

*[1)] ANOVA with adjustment by Bonferroni correction; [a,b,c] different letters indicate statistically significant differences between clusters. Variables are shown as mean ± standard deviation (SD) and range (min, max).
*[2)] Chi-square test. Data are presented as number (percentage), % calculated as share of subjects in a given category.
Abbreviations: DDS (Dietary Diversity Score), DVS (Dietary Variety Score); DQI (Diet Quality Index), in which higher scores indicate better diet quality; EER (Estimated Energy Requirement) - energy intake (expressed as percentage of age-specific EER), EAR (Estimated Average Requirement).

Cluster 2 – in the 4–5 point range, but this was applicable to a smaller percentage of participants (28% of total subjects in the given category).

**Relationship between DV and adequacy of nutrient intakes.** Table 6 shows that higher DV in older adults (Cluster 1 and 2) were less likely ($p < 0.001$) to be below the EAR for various nutrients, including protein, vitamins A and C, thiamin, riboflavin, niacin, folate, vitamins $B_6$ and $B_{12}$, calcium, magnesium, copper and zinc. In these clusters, consumers were also more likely ($p < 0.001$) to be above the AI for vitamins D and E and for potassium, compared to those with low DV (Cluster 3). The prevalence of inadequate intake of protein and most micronutrients, except phosphorus, was significantly higher in Cluster 3 than in Clusters 1 and 2. On average, greater DV dietary variety was associated with higher levels of energy (Tab. 5), protein and micronutrient intakes, but not with adequacies in all individuals (Tab. 6).

A substantial proportion of the older population (over 90%) had insufficient intakes of calcium and vitamin D in all clusters. Additionally, in Cluster 3, most individuals had intakes below the EAR for folate (96%) and magnesium (93%) (Tab. 6). Moreover, the highest percentage of older adults had intakes below the EAR for other nutrients. Inadequacies were observed for protein (62%), thiamine (65%), and vitamin $B_{12}$, while riboflavin, vitamin $B_6$, vitamin C (44–48%), niacin, vitamin A (36%), and zinc (67%) and copper (31%) intakes in this age group were inadequate relative to the EAR ($p < 0.001$).

**Association between DV and anthropometric measurements by clusters.** Table 7 provides anthropometric characteristics of respondents by clusters of dietary variety. The mean BMI value was statistically significantly lower in Cluster 2 (27.6 ± 4.9 kg/m$^2$) than in Clusters 1 and 3 (28.6 ± 4.8 and 29.2 ± 5.1 kg/m$^2$, respectively).

The WC values exceeded 88/102 cm (in female/male), indicating a high risk of obesity and metabolic comorbidities. Women in Cluster 3 had significantly larger WCs (100.4 ± 12.7 cm) compared to women in Clusters 1 and 2 (94.7 ± 12.7 and 96.2 ± 13.6 cm, respectively). The mean WHR ratio with the most varied diet (Cluster 1) was 0.87 ± 0.09 among women and 0.97 ± 0.07 among men (Tab. 7). Similar values were obtained for participants assigned to Clusters 2 and 3 ($p<0.001$). Statistically significant differences between Clusters 1 and 3 were identified for women only. Evaluation of the WHtR ratio showed that in all clusters, the average values obtained exceeded the reference values for this index (≤ 0.50). The mean value for this index in men was the same in each cluster at 0.60 ± 0.07, while in women in Clusters 2 and 3, this was statistically significantly higher than Cluster 1, in the range 0.63 ± 0.08 and 0.64 ± 0.08 vs. 0.60 ± 0.08, respectively (Tab. 7).

**Table 6.** Prevalence of inadequate protein, and vitamin and mineral intakes by dietary variety clusters among older adults (n=1,071)

| Nutrients | Dietary Variety Patterns | | | *p*-value* |
|---|---|---|---|---|
| | High | Moderate | Low | |
| | *(Cluster 1)* n=353 | *(Cluster 2)* n=443 | *(Cluster 3)* n=275 | |
| *Nutrients with EAR[1] (number and percentage of respondents with below the EAR)* | | | | |
| Protein | 57 (16.1) | 119 (26.9) | 170 (61.8) | <0.001 |
| Vitamin A | 46 (13.0) | 121 (27.3) | 98 (35,6) | <0.001 |
| Vitamin C | 125 (35.4) | 265 (59.8) | 209 (76.0) | <0.001 |
| Thiamin | 112 (31.7) | 238 (53.7) | 179 (65.1) | <0.001 |
| Riboflavin | 26 (7.4) | 80 (18.1) | 124 (45.1) | <0.001 |
| Niacin | 45 (12.7) | 117 (26.4) | 101 (36.7) | <0.001 |
| Vitamin $B_6$ | 62 (17.6) | 149 (33.6) | 133 (48.7) | <0.001 |
| Vitamin $B_{12}$ | 66 (18.7) | 114 (25.7) | 122 (44.4) | <0.001 |
| Folate | 250 (70.8) | 380 (85.8) | 264 (96.0) | <0.001 |
| Calcium | 318 (90.1) | 411 (92.8) | 264 (96.0) | 0.198 |
| Phosphorous | 0 (0.0) | 8 (1.8) | 34 (12.4) | <0.001 |
| Magnesium | 155 (43.9) | 309 (69.8) | 256 (93.1) | <0.001 |
| Copper | 28 (7.9) | 51 (11.5) | 86 (31.3) | <0.001 |
| Zinc | 81 (22.9) | 199 (44.9) | 184 (66.9) | <0.001 |
| *Nutrients with AI[2] (number and percentage of respondents with above the AI)* | | | | |
| Vitamin D | 5 (1.4) | 5 (1.1) | 1 (0.4) | 0.215 |
| Vitamin E | 168 (47.6) | 116 (26.2) | 28 (10.2) | <0.001 |
| Potassium | 124 (35.1) | 78 (17.6) | 17 (6.2) | <0.001 |

[1]EAR (Estimated Average Requirement); ); the prevalence of inadequacy within in group was evaluated as the percentage of participants below the EAR value (cut-point method); percent less than the EAR.
[2]AI (Adequate Intake); assessing intake with an AI for vitamin D, E and potassium, the adequacy is estimated based on AI values (EAR is not available); if a group has a mean or median intake at or above AI, there is a low prevalence of inadequate intakes.
* Chi-square test. Data are presented as number (percentage), % calculated as share of subjects in a given cluster.

**Table 7.** Anthropometric characteristics by dietary variety clusters among older adults (n=1,071)

| Variables | Dietary Variety Patterns | | | | | | p-value* |
|---|---|---|---|---|---|---|---|
| | High | | Moderate | | Low | | |
| | *(Cluster 1)* n=353 | | (Cluster 2) n=443 | | *(Cluster 3)* n=275 | | |
| | Mean ± SD | Range | Mean ± SD | Range | Mean ± SD | Range | |
| **BMI** ($kg/m^2$) | | | | | | | |
| Total | n=353 | | n=443 | | n=272 | | 0.0007 |
| | 28.6 ± 4.8[a] | 16.7-51.6 | 27.6 ± 4.9[b] | 13.7-50.9 | 29.2 ± 5.1[a] | 17.4-47.3 | |
| Women | n=197 | | n=198 | | n=129 | | 0.0009 |
| | 29.0 ± 5.2[ab] | 16.7-51.6 | 28.0 ± 5.5[a] | 16.0-49.2 | 30.3 ± 5.4[b] | 17.9-47.3 | |
| Men | n=156 | | n=245 | | n=146 | | 0.0635 |
| | 28.1 ± 4.1 | 19.1-43.5 | 27.3 ± 4.4 | 13.7-50.9 | 28.2 ± 4.3 | 17.6-45.1 | |
| **WC** (cm) | | | | | | | |
| Women | n=196 | | n=189 | | n=126 | | 0.0006 |
| | 94.7 ± 12.7[a] | 58-129 | 96.2 ± 13.6[a] | 53-143 | 100.4 ± 12.7[b] | 72-136 | |
| Men | n=153 | | n=239 | | n=146 | | 0.2352 |
| | 102.8 ± 11.5 | 65-143 | 101.0 ± 12.0 | 54-135 | 102.6 ± 12.0 | 73-144 | |
| **WHR** ratio | | | | | | | |
| Women | n=196 | | n=187 | | n=126 | | 0.0090 |
| | 0.87 ± 0.09[a] | 0.60-1.50 | 0.88 ± 0.10[ab] | 0.50-1.50 | 0.90 ± 0.08[b] | 0.70-1.20 | |
| Men | n=153 | | n=237 | | n=146 | | 0.3952 |
| | 0.97 ± 0.07 | 0.80-1.20 | 0.96 ± 0.09 | 0.50-1.60 | 0.97 ± 0.07 | 0.80-1.20 | |
| **WHtR** ratio | | | | | | | |
| Women | n=196 | | n=189 | | n=126 | | 0.0001 |
| | 0.60 ± 0.08[a] | 0.38-0.83 | 0.63 ± 0.08[b] | 0.35-0.92 | 0.64 ± 0.08[b] | 0.43-0.87 | |
| Men | n=153 | | n=239 | | n=146 | | 0.9556 |
| | 0.60 ± 0.07 | 0.38-0.85 | 0.60 ± 0.07 | 0.31-0.86 | 0.60 ± 0.07 | 0.42-0.86 | |

* ANOVA with adjustment by Bonferroni correction;. [a,b,c] different letters indicate statistically significant differences between clusters; bold values highlight statistically significant differences ($p \leq 0.05$).
Variables are shown as mean ± standard deviation (SD) and range (min, max).
Abbreviations: Body Mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), waist-to-height ratio (WHtR).

## DISCUSSION

In this study, community-dwelling older adults in Poland were examined to determine the association between dietary variety, diet quality and anthropometric parameters. Body composition changes with increasing age. A common age-related change is the loss of muscle mass with a simultaneous increase in fat mass [36]. BMI is the most commonly used anthropometric measure, which is a combination of fat and muscle mass, with the result that the loss of muscle mass can be masked by the increase in fat mass [37]. Therefore, a different anthropometric measurement was used in this study.

To the best of the authors' knowledge, the association between anthropometric parameters (BMI, WC, and WHR and WHtR ratio) and DV measured simultaneously by the DVS and DDS-score in older adult, has not been previously described. It was found that higher DV based on the *'a posteriori'* approach (derived from cluster analysis) was associated with decreased visceral obesity. It was observed that variably measured dietary variety was inconsistently associated with overweight/obesity outcomes, and that some results differed by DV clusters in men and women. Only for women with the lowest DV were the results statistically significant for associations with a higher WC and WHR and WHtR ratio ($p<0.05$). Some studies have shown that gender may be a differentiating factor. In a study among older adults in Japan, low dietary variety was associated with obesity in women [38]. A study of individuals aged 60 and above in 2 regions of Poland found that population characteristics, such as female gender, are associated with higher diet quality among older adults [39]. In a study among German adults aged 65 years or older (n=1,687), dietary risk behaviou (defined as the uency of consumption of vegetables/fruit, whole grains and dairy products below national dietary recommendations) were also negatively associated with female gender [40].

In the present study, the mean BMI value was significantly lower in Cluster 2 than in Clusters 1 and 3. Based on these results, it would seem that both low and high dietary variety can have a negative effect on maintaining normal body weight. The results of the meta-analysis showed no significant association between dietary diversity and obesity and BMI status [25]. This finding does not support greater dietary diversity as an effective strategy for preventing obesity, since greater dietary diversity can be associated with suboptimal dietary patterns, such as higher intake of processed foods, refined grains and sugar-sweetened beverages [8, 10, 11]. Furthermore, there is evidence that overweight and obesity in older adults may be protective and associated with reduced mortality. This phenomenon is referred to in the literature as the 'obesity paradox' [41]. A study in a Polish population showed that respondents with both lower (<18.0) and greater (≥35.0) BMI had significantly higher disability levels and risk of chronic diseases than those in the normal weight and overweight categories [42]. Nevertheless, because BMI does not reflect body composition, the term 'BMI paradox' would be more appropriate [43]. Recent studies confirm that body composition and fat distribution may become relatively more important than BMI [44, 45]. Other studies show that low muscle mass can contribute to adverse health outcomes and impaired physical function. Muscle mass-calf circumference and mid-arm circumference declined earlier and more steeply than BMI in older-old adults [46]. Lin et al. [47] observed that individuals with overweight and higher dietary diversity had higher intrinsic capacity, defined as 3 or more unimpaired domains of cognition, locomotion, sensory, vitality and psychology [47].

Many studies have reported that older adults remain the most vulnerable group for malnutrition and micronutrient deficiency [23, 48]. Unintentional weight loss in older individuals is associated with frailty, poor quality of life, and accelerated rates of morbidity and mortality [17, 49]. Therefore, some authors emphasize that the energy value of the diet should be taken into account in assessing the diversity of a diet [8,19,20]. In the low dietary variety group, the energy intake in all participants was lower than the EER. This may indicate a higher risk of insufficient dietary intake in this group compared to the other groups. This is confirmed by another Polish study which showed that a lower food intake variety increased the risk of malnutrition [50].

The current study shows a significantly higher number of nutrients with an adequacy intake among participants with high DV in comparison to those with low DV ($p<0.05$). The cluster with the lowest variety (Cluster 3) contained the most individuals with deficient energy and protein intake, as well as inadequate intake of vitamins and minerals, hence, this population group represents a risk group regarding inadequate intake of nutrients. The lowest dietary variety in these individuals was associated with poorer self-rated health outcomes. Inadequate dietary intake is associated with many adverse health outcomes [51]. These results highlight the importance of DV evaluation in older adults, and also results suggest that there is a need to provide guidance, interventions and education for older adults, especially for populations at risk of low dietary variety, in order to improve nutrient intake, particularly protein, vitamins D, E, C, folate, calcium, magnesium, potassium and zinc. This age group requires diets with high nutrient density and variety. Inadequate intake of protein and micronutrients is primarily responsible for the deficiencies that are due to poor quality of diet and monotonous diets [50, 52].

Furthermore, the number of meals can also make a difference. In this study, a positive association was found between the degree of dietary variety and the number of meals consumed during the day. Individuals who eat at least 5 meals a day chose a higher number of both product groups (higher DDS-score) and of the products themselves (higher DVS-score). The results of the meta-analysis showed a significant small to medium effect of food variety on intake of a meal. However, authors have shown that heterogeneity was considerable across studies [53].

In the present study, high DV was associated with positive outcomes such as high nutrient intake, improved self-reported health status and improved anthropometric measurements. Overall, the decrease in food intake is associated with nutrient deficiencies and therefore potential adverse nutritional and health consequences [13, 14, 36, 48]. Eating a variety of foods is one of the main strategies for improving the nutritional status and energy, protein, and micronutrient intakes [19, 20, 50]. Nevertheless, in older populations this is difficult for households because there is a problem with food supply and because of the significance of the micronutrient balance. Combined with a decline in ability to absorb some nutrients intestinally, a loss of appetite resulting in decreased food intake and reduced energy requirements, meeting nutritional requirements, can become a serious challenge [54]. This is where nutrition-based healthy dietary variety, foods fortified with micronutrients and supplements play a significant role in improving nutritional status [55].

Evidence from a recent long-term follow-up of a 15-year study in older adults has suggested that the variety, rather than quantity, of fruit and vegetable intake (excluding potatoes, legumes and fruit juices) was associated with a lower risk of mortality in older adults. In this context, dietary guidelines may recommend increasing the variety in those intakes, especially green, red/purple and white fruit and vegetables in older populations [56]. On the other hand, social and psychological issues and physical inactivity could limit the ability of older adults to consume sufficient amounts, and to have an adequate diet in terms of fruit and vegetables [57]. Innovative approaches should prioritize food variety in order to promote improved nutrition and overall well-being in communities of older adults, such as culinary medicine and several educational components (cooking, food delivery, individualized counselling) [58]. These factors should be studied in more detail in future studies.

**Strengths and limitations of the study.** To the best of the authors' knowledge, this is the first study to investigate DV-specific patterns and anthropometric variables in older adults using a national dataset from the PolSenior projects. The strength of the study lies in the methodology used to collect data from large-scale community-dwelling older populations and the high number of participants (N=1,071), including over one-fifth aged 85 years and older, and equal proportions of men and women. A unique feature of this study is its dietary data collection approach, including the use of the 3-day food records and various DV-scores, as well as anthropometric measurements. The dietary assessment approach used in this study made it possible to provide estimates of habitual dietary intake. All questionnaires, including anthropometric measurements, were conducted at participants' homes by trained professionals.

The limitation of the study is that it was a cross-sectional survey; it was therefore not possible to establish a causal relationship between variables or to assess changes over time. Although cross-sectional studies provide valuable information on the relationship between dietary variety and nutritional status, as measured by anthropometric parameters, longitudinal studies could provide additional value, especially in examining dietary habits and their impact on health outcomes over time.

## CONCLUSIONS

A higher degree of DV was associated with more proper nutritional status in an older population, as assessed by anthropometric parameters. Although the values of these parameters were exceeded in most participants, they were more balanced in participants with the most varied diet. These relationships were more pronounced in women than in men. A higher DV was positively associated with energy, protein and micronutrient intakes, and with favourable weight and visceral obesity-related parameters, and negatively with a high prevalence of energy and nutrient inadequacy in older adults.

The positive relationship between the degree of DV and the nutritional status of the older population indicates the desirability of educational activities promoting dietary variety as a rational/appropriate approach to nutrition in older adults. In older adults, there is a need to provide guidance, interventions and education, especially for at-risk populations, in order to improve nutrient intake. Both the number of products consumed in a given period and the number of product groups should be taken into consideration. Innovative approaches should prioritize dietary variety in order to promote improved nutrition and overall diet quality in older adults.

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