

Prevalence, co-existence, and factors related to a change in geriatric giant syndromes over 2 years: results of the Second Wave of Cognition of Older People, Education, Recreational Activities, Nutrition, Comorbidities, Functional Capacity Studies (COPERNICUS)

Agnieszka Kujawska, Sławomir Kujawski, Jūratė Zupkauskienė, Jakub Husejko, Weronika Hajec, Claire E. Robertson, Mitchell G. Miglis, Nicholas McMahon, Melanie Dani, José Augusto Simões, Paweł Zalewski and Kornelia Kędziora-Kornatowska

This is the peer reviewed version of the following article: Agnieszka Kujawska, Sławomir Kujawski, Jūratė Zupkauskienė, Jakub Husejko, Weronika Hajec, Claire E. Robertson, Mitchell G. Miglis, Nicholas McMahon, Melanie Dani, José Augusto Simões, Paweł Zalewski and Kornelia Kędziora-Kornatowska 2025. Prevalence, co-existence, and factors related to a change in geriatric giant syndromes over 2 years: results of the Second Wave of Cognition of Older People, Education, Recreational Activities, Nutrition, Comorbidities, Functional Capacity Studies (COPERNICUS). *Psychogeriatrics*. 25 (3) e70018. <https://doi.org/10.1111/psyg.70018>, which has been published in final form at <https://doi.org/10.1111/psyg.70018>

This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Use of Self-Archived Versions. This article may not be enhanced, enriched or otherwise transformed into a derivative work, without express permission from Wiley or by statutory rights under applicable legislation. Copyright notices must not be removed, obscured or modified. The article must be linked to Wiley's version of record on Wiley Online Library and any embedding, framing or otherwise making available the article or pages thereof by third parties from platforms, services and websites other than Wiley Online Library must be prohibited.

The WestminsterResearch online digital archive at the University of Westminster aims to make the research output of the University available to a wider audience. Copyright and Moral Rights remain with the authors and/or copyright owners.

Prevalence, co-existence, and factors related to a change in geriatric giant syndromes over two years: Results of the Second Wave of Cognition of Older People, Education, Recreational Activities, Nutrition, Comorbidities, Functional Capacity Studies (COPERNICUS)

Agnieszka Kujawska^{1,2*}, Sławomir Kujawski¹, Jūratė Zupkauskienė³, Jakub Husejko⁴, Weronika Hajec^{5,6}, Claire E. Robertson⁷, Mitchell G. Miglis⁸, Nicholas McMahon⁹, Melanie Dani¹⁰, José Augusto Simões¹¹, Paweł Zalewski^{1,12} and Kornelia Kędziora-Kornatowska⁴

1. Department of Exercise Physiology and Functional Anatomy, Ludwik Rydygier Collegium Medicum in Bydgoszcz Nicolaus Copernicus University in Toruń, Świętojańska 20, 85-077 Bydgoszcz, Poland; agnieszka.kujawska@cm.umk.pl (A.K.); skujawski@cm.umk.pl (S.K.); p.zalewski@cm.umk.pl (P.Z.)

2. Cardiology and Cardiac Surgery Department, 10th Military Research Hospital and Polyclinic IPHC in Bydgoszcz, Poland

3. Clinic of Cardiac and Vascular Diseases, Faculty of Medicine, Vilnius University, Vilnius 08661, Lithuania; jurate.balsyte@mf.vu.lt

4. Department of Geriatrics, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń, 85-094 Bydgoszcz, Poland; kubahusejko@gmail.com (J.H.); kasiakor@interia.pl (K.K.-K.)

5. Department of Basic Clinical Skills and Postgraduate Education of Nurses and Midwives, Faculty of Health Sciences, Collegium Medicum im. L. Rydygier in Bydgoszcz, Nicolaus Copernicus University in Toruń, Collegium Medicum in Bydgoszcz, 85-094 Bydgoszcz, Poland; weronika.topka@wp.pl (W.H.)

6. Professor Franciszek Łukaszczyk Oncology Center, Department of Anesthesiology and Intensive Care, 85-796 Bydgoszcz, Poland

7. School of Life Sciences, University of Westminster, 115 New Cavendish Street, London W1W 6UW, UK; C.Robertson@westminster.ac.uk

8. Department of Neurology and Neurological Sciences, Stanford University School of Medicine, CA 94304, Palo Alto, CA, USA; mmiglis@stanford.edu

9. School of Human Movement and Nutrition Sciences, University of Queensland, St. Lucia,	29
QLD 4072, Australia; n.mcmahon2@uq.edu.au	30
10. Cutrale Peri-operative and Ageing Group, Imperial College London, London W12 0BZ,	31
UK; m.dani@imperial.ac.uk	32
11. Department of Medical Sciences, University of Beira Interior, Covilhã, 6200-506, Portugal;	33
jars@ubi.pt	34
12. Department of Experimental and Clinical Physiology, Laboratory of Centre for Preclinical	35
Research, Warsaw Medical University, 1b Banacha Street, 02-097, Warsaw, Poland	36
	37
	38
Corresponding Author: AK	39
Full name Agnieszka Kujawska	40
Department Department of Exercise Physiology and Functional Anatomy	41
Institute/University/Hospital Ludwik Rydygier Collegium Medicum in Bydgoszcz Nicolaus	42
Copernicus University in Toruń	43
Street Name & Number , Świętojańska 20	44
City, State, Postal code, Country Bydgoszcz, kujawsko-pomorskie, 85-077, Poland	45
Tel: +48 52 585 33 00	46
E-mail: agnieszka.kujawska@cm.umk.pl	47
	48
	49
Acknowledgments	50
None	51
	52
Funding information	53
None	54
	55
Ethics statement	56

The study was approved by the ethics committee of Nicolaus Copernicus University, Torun's
Ludwik Rydygier Memorial Collegium Medicum (KB 340/2015). All methods were carried out
in accordance with the Declaration of Helsinki.

Informed consent statement

Informed consent was obtained from all participants involved in the study.

Data availability

Data will be made available on request and sent via email to SK (skujawski@cm.umk.pl).

Declaration of competing interest

None.

Abstract:	71
Background: We prospectively examined the prevalence, co-existence, and change of geriatric giant syndromes in older people over 2 years.	72 73
Methods: Two hundred-five older subjects were examined before and after two years. Ten geriatric giants were assessed at both time points: cognitive impairment, depression, orthostatic hypotension, polypharmacy, sarcopenia, dynapenia, falls, chronic pain, fecal and urinary incontinence.	74 75 76 77
Results: Chronic pain, cognitive impairment, and urinary incontinence were three of the most commonly occurring geriatric giants at baseline (57%, 46%, and 40%. The presence of fecal incontinence, urinary incontinence, falls, depression, cognitive impairment, orthostatic hypotension, and polypharmacy was most strongly related to the number of geriatric giants in total at baseline ($p<0.05$). A higher intake of dietary antioxidants by one point was related to fewer geriatric giants after two years (by 0.04, after adjusting for confounding factors ($p=0.03$)).	78 79 80 81 82 83
Conclusions: Geriatric giant syndromes tend to coexist and change with high variability over two years. Higher intake of antioxidants with diet could be related to fewer geriatric giants over time.	84 85 86
	87
Keywords: mild cognitive impairment; orthostatic hypotension; geriatric giants; co-morbidities; longitudinal study	88 89

1. Introduction

91

Low birth and mortality rates observed globally have contributed to larger populations with more older people [1]. Theories highlight that while ageing is a linear process, variable impacts of biological, sociological, and environmental exposures imposed as early as pre-gestation variably impact life expectancy and health-related quality of life [2]. Understanding the diversity of features that impact our capacity to achieve longevity with good health requires careful review. The social construction of old age is affected by inequalities observed within populations and how societies are organised to facilitate the care of ageing communities. Concerns regarding a demographic timebomb - greater need than actual health and social-service provisions [3, 4] highlight the importance of Bernard Isaacs's (1924 - 1995) "Geriatric Giants". This term refers to a set of common, significant health issues that affect older adults, often leading to increased morbidity and mortality, and severely impacting quality of life. Aiming to facilitate the establishment of strategies to resolve some of the key issues facing elderly individuals: Incontinence, immobilisation, instability, and intellectual impairment, these 'giants' were recognised due to their prevalence, impact, and negative impacts on life expectancy [5].

The presence of one geriatric giant increases the risk of the occurrence of others. Research indicates that gender, body mass index (BMI), and polypharmacy are significant factors influencing the presence and co-occurrence of geriatric syndromes [6]. Low physical activity is often the strongest predictor of frailty and co-morbidities such as diabetes significantly increase the risk when they are present [6, 7]. In this study, we prospectively examine the extent to which certain geriatric giant syndromes co-exist (cognitive impairment, depression, orthostatic hypotension, polypharmacy, sarcopenia, dynapenia, falls, chronic pain, and urinary incontinence) highlighting how these profiles change over 2 years using data from the first and second wave of COPERNICUS.

Methods

117

The study recruitment method is depicted in Figure S1. Participants were recruited via radio and television commercials, public health lectures at Collegium Medicum, gatherings of Bydgoszcz-based groups for older people, and senior daycare facilities. These commercials offered adults aged 60 years and over the chance to participate in in-person health assessments that measured body composition, behavior, and general health. The Ludwik Rydygier Memorial Collegium Medicum at Bydgoszcz, Nicolaus Copernicus University, Torun, ethics committee accepted the study (KB 340/2015). Written, informed consent was obtained from each participant. The time frame for participant examinations was November 2015-February 2020 (the first wave took from 2015 to 2018, and the second wave from 2017 to 2020). 407 participants -95 men and 312 women-participated in the initial round of evaluations, and 205 of them-40 men and 165 women-returned two years later for a follow-up evaluation (Figure S1). The results of a comparison between re-examined and study dropout participants are described in our earlier publication [8]. All research was performed according to relevant guidelines/regulations and by the Declaration of Helsinki.

2.2. Assessment Methods

2.2.1. Geriatric Giants Assessment

Ten geriatric giants were assessed at baseline and after two years. These were: cognitive impairment, depression, orthostatic hypotension, polypharmacy, sarcopenia, dynapenia, falls, chronic pain, fecal and urinary incontinence. Table 1 illustrates the methodology and assessment criteria for each syndrome. The number of geriatric giant syndromes at baseline and after two years was compared. Data on the number of medications after two years was not available, so a change in polypharmacy was not calculated.

Table 1. Methodology of Geriatric Giants Presence Assessment

Geriatric giant	Tool used	Cut-offs	Reference for method and cut- off
Cognitive impairment	The Montreal Cognitive Assessment (MoCA)	<24 points	[9, 10]
Depression	The 15-item Geriatric Depression Scale (GDS)	>6 points	[11, 12]
OH	Active standing test (AS test)	The presence of OH was defined by a sustained drop in BP of ≥ 20 mmHg sBP and/or ≥ 10 mmHg dBP, or a decrease in sBP to <90 mmHg within three minutes of standing was observed	[13, 14]
Polypharmacy	Self-reported number of drugs taken	>4 drugs	[15]
Sarcopenia	Fat-Free Mass Index (FFMI)	<17.5 kg/m ² for men and <14.6 kg/m ² for women.	[16]
Dynapenia	Chair stand and/or Arm Curl tests (no. of reps)	The norm in relation to sex and age category	[17]
Falls	Self-reported number of falls in the last year	>0	[5]
Chronic pain	Self-reported chronic pain lasting longer than 3 months	N/A	[18, 19]
Incontinence	Self-reported urinary and fecal incontinence	N/A	N/A

2.2.2. Covariates

Applying a previously described questionnaire, the frequency of current physical, mental, and social activities was assessed [8]. Current smoking and socio-economic occupation categories were coded as binary values (yes and no, and lower and higher socio-economic occupations), respectively). The initial classification of occupational status included the following: white-collar workers, white-collar workers in managerial positions, owners of craft or entrepreneurial businesses, members of the armed forces or other uniformed services, sellers or employees of trade, farmers operating their farms, blue-collar workers (if qualified), and unskilled laborers. Subsequently, the remaining categories were classified as "higher socio-economic occupations" and the final three as "lower socio-economic occupations" using the 2018 Standard Occupational Classification System [20]. Ultimately, a dichotomous variable was developed that included the respondent's greatest occupational rank attained during their career. This variable served as a proxy for socio-economic status because this variable was not directly measured. Current health status self-assessment was done using a subjective scale, on which participants could use a scale ranging up to ten points (the best health state). To examine antioxidant intake with diet, participants were asked about the frequency of the products: green/white tea, chocolate, fish, coffee, red wine, vegetables, and fruit. The questionnaire regarding physical activity was composed of the following items: short walks around the house, long walks, gymnastics, cycling, running/jogging, swimming, skiing, team games, sailing, horse riding, Nordic walking, tennis/table tennis, dancing, and work on a garden plot or mushroom collection. The questionnaire on the frequency of cognitive activities consisted of the following items: reading newspapers and books, watching TV, listening to the radio, going to the café or restaurant, going to the cinema or theater, going to a concert, going to church, visiting friends or family, taking part in social group meetings, computer use, card game, chess/checkers, and solving crosswords. Frequency from the above-mentioned activities was coded into seven categories ("never", "once a year", "several times a year", "1-2 times a month", "once a week", "a few times a week", and "daily") with numbers from 0 ("never") to 6 ("daily"). The following questions on frequency of travel activities in the last 3 years were asked: 1-day trips without accommodation, multi-day sightseeing trips, pilgrimages, wandering (with

accommodation in hostels, campsites), stays at campsites, with accommodation, holiday/holiday stays, trips stationary, leisure trips to friends, stays on plot (outside your home), spa stays (prophylactically without referrals to the sanatorium), and stays in sanatoria based on a referral. Then, based on frequencies from the particular psychical, cognitive, and touristic activities were summed per patient. The higher the score, the more frequent physical, cognitive, and touristic activities are, respectively.

2.3. Sample Size Calculation and Power Analysis

The current study is a secondary analysis of data gathered in the COPERNICUS study [8]. Overall, 407 subjects (95 males) were examined at baseline, with 205 returning two years later for a second assessment (40 males). In the current study, post-hoc power analysis was done based on the relationship between correlation coefficients, sample size, and power [21]. Assuming the alternative Kendall coefficient as 0.4, null as 0.2, and a total sample size of 205, the power would be 80% or higher.

2.4 Statistical Analysis

The R environment was used to conduct statistical analysis [22]. The partial correlation between the total number of geriatric giants with the difference in the number of geriatric giants (after two years minus baseline) was examined using Spearman's rank correlation coefficient, while for the rest of the correlations measured Kendall rank correlation coefficient was used. All correlations were controlled for participants' age, sex, and years of education. Network graphing was performed using the qgraph package based on correlations that p-value <0.01 [23]. Antioxidants in diet and covariates (cognitive, physical, and touristic activity, age, education, sex, smoking status, socio-economic occupation category, and health status assessment) served as predictors for change in the number of geriatric giants over two years. A cumulative link model (CLM) was applied to predict changes in the number of geriatric giants in and two-time

points (before vs. after two years) using an ordinal package [24]. This model was used because we treated the change in the number of geriatric giants over two years as an ordinal variable. In addition, odds ratios for the thresholds are reported. To compare the two models—where the first model included all predictors and the second model excluded the antioxidant intake as a predictor—a likelihood ratio test of the cumulative link models was conducted. SjPlot was used to present the model results in a graphical form [25]. Shapiro-Wilk test was used to check the assumption of normality, the Goldfeld-Quandt test was used to test the assumption of heteroskedasticity, and the Durbin-Watson Test was used to test for autocorrelation.

3. Results

3.1. Sample description

In total, 205 subjects (40 males) were examined at both baseline and follow-up visits. The mean age of subjects re-examined after two years was 69.67 (CI=68.85; 70.5, range 60–88). Most subjects (84.39%) obtained full secondary education or higher. Table 2 shows demographic variables and confounders included in the linear mixed models.

Table 2. Demographic data on participants

Variable [unit]	Level	Mean $\pm$ SD/Median [min – max]/Count (%)
		N=205
Age [years]	NA	69.66 $\pm$ 6.0
Education [years]	NA	14.37 $\pm$ 3.4
Sex	Male	40 (19.5)
	Female	165 (80.5)
Current smoker [presence]	Yes	165 (80.5)
	No	38 (18.5)

Occupational status	lower	28 (14)
	higher	173 (86)
Health status assessment currently [0-10]	NA	7 [3 - 10]
Cognitive activity [points]	NA	44 [19 - 60]
Physical activity [points]	NA	20 [4 - 44]
Touristic activity [points]	NA	6 [0 - 15]

Table S1 presents the number of geriatric giant syndromes and the change in number over time (before and after 2 years). Table S2 presents the prevalence of each category of the number of geriatric giants. Figure 2 presents a change in the number of geriatric giants over time. The median number of geriatric giants was 3 before and 2 after two years (Table S1). Eleven participants (5%) had no geriatric giants at baseline and after 2 years. (Table S2). Forty-three and 60 participants (21 and 29%) had two geriatric giants at baseline and after two years respectively. Figure 2 and Table S3 present a change in the number of geriatric giants over time, and illustrate that the change in the number of geriatric giants was characterized by a rather high variance. For instance, 2 participants had no geriatric giants at baseline and after two years (Figure 2, Table S3). In 64 participants, the number of geriatric giants increased from zero to one after two years, in 4 participants it increased from zero to two geriatric giants after two years, and in 1 participant it increased from zero to four geriatric giants after two years (Figure 2, Table S3). On the other hand, 2 participants had four geriatric giants at the baseline and one after two years, 10 participants who had four geriatric giants before and two after two years, 12 participants who had four geriatric giants at the baseline and three after two years (Figure 2, Table S3). In overall, in 88 patients (42.9% of total sample) a decrease in number of geriatric

giants was noted, in 61 (29.8%) an increase was noted, while in 56 (27.3%) no change was noted.

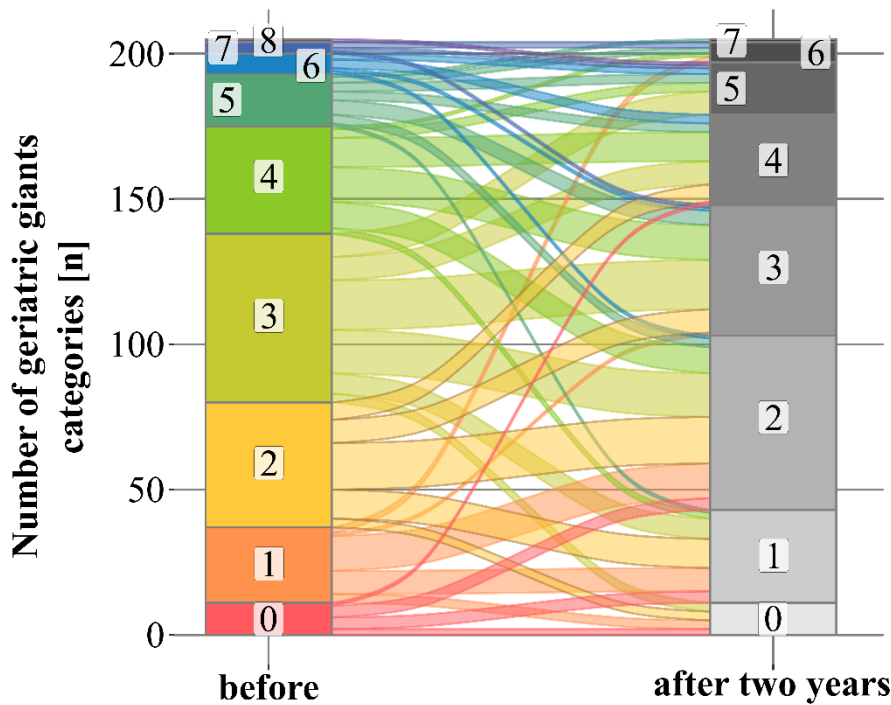


Figure 1. Alluvial diagram showing the change in the number of geriatric giants over time

3.2. Geriatric Giants Co-existence

As a part of an exploratory approach, we performed a network analysis of geriatric giant syndromes co-occurrence with the total number of syndromes, and with the change over two years (difference between the number of geriatric giants after two years minus baseline) (Figure 1). Table S4 presents the correlation matrix, on which basis network graph was created. Chronic pain, cognitive impairment, and urinary incontinence were three of the most commonly occurring geriatric giant syndromes at baseline (57%, 46%, and 40%, Table S4). Interestingly, the presence of urinary incontinence, falls, depression, cognitive impairment, orthostatic hypotension, and polypharmacy was most strongly related to the total number of geriatric giants

at baseline. There was no significant relationship between sarcopenia (defined as low skeletal muscle mass index) and dynapenia (defined as lower than normal strength in upper or lower limbs).

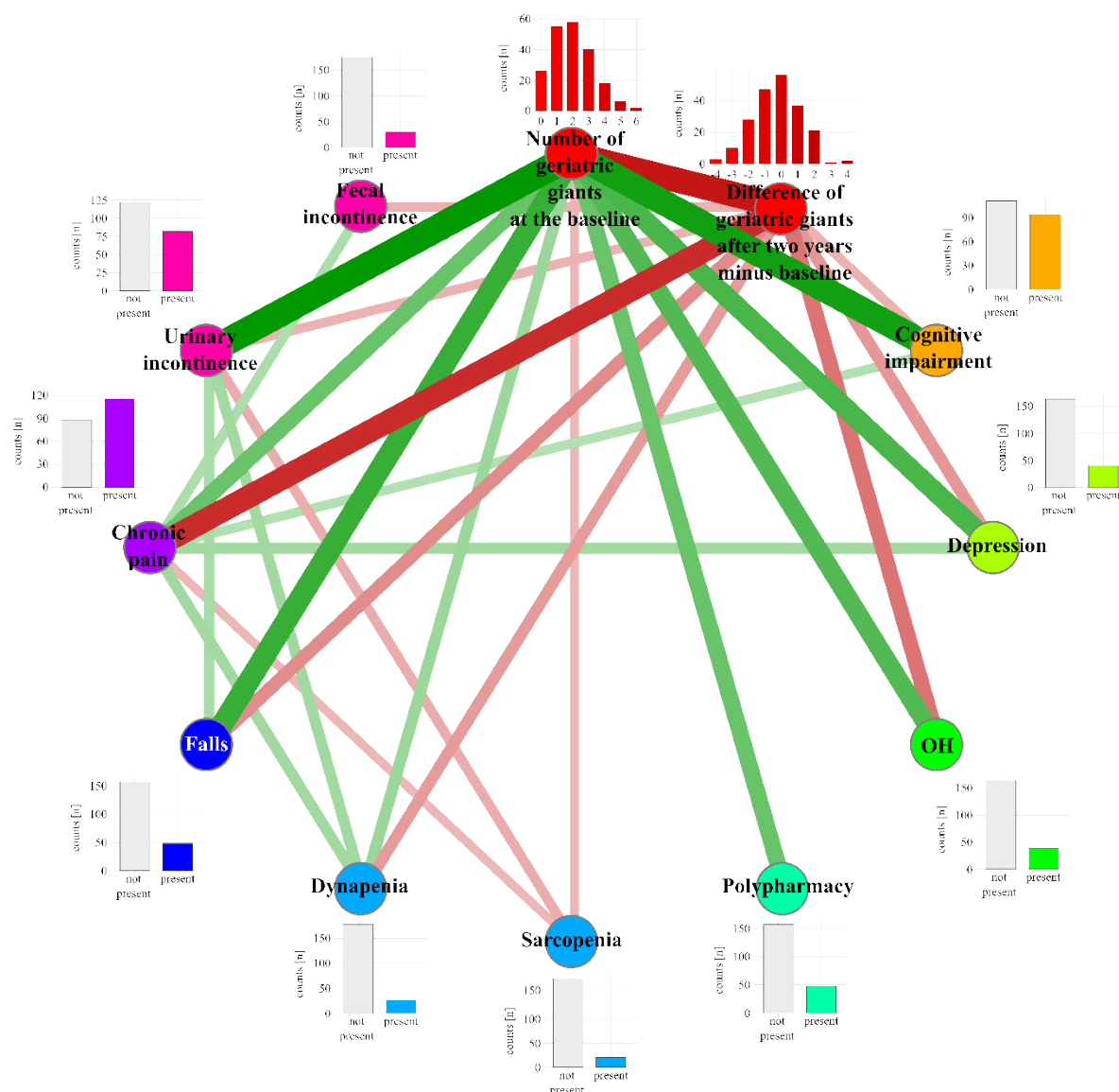


Figure 2. Network analysis of the co-occurrence of geriatric giants with the total number and the change over two years (difference between number of geriatric giants after two years minus baseline). Each node presents a variable, with a histogram showing the count (n) of the specific classes from the variable. Nodes were grouped according to pre-specified groups, to which each variable belongs. The color saturation and the width of the edges are proportional to the correlation coefficient between the two variables. Positive correlations are shown as green

edges, while negative as red edges. *OH* – orthostatic hypotension. Results are controlled for age, sex, and years of education.

Figure 3 presents the dynamics over two years of all examined geriatric giants, except polypharmacy, for which follow up data was not available. Table S5 illustrates descriptive statics on the difference in number of geriatric giants (after two years vs. before). Difference ranged from -3 (three geriatric giants less after two years in comparison to before) to 3 (three geriatric giants more after two years in comparison to before) (Table S5).

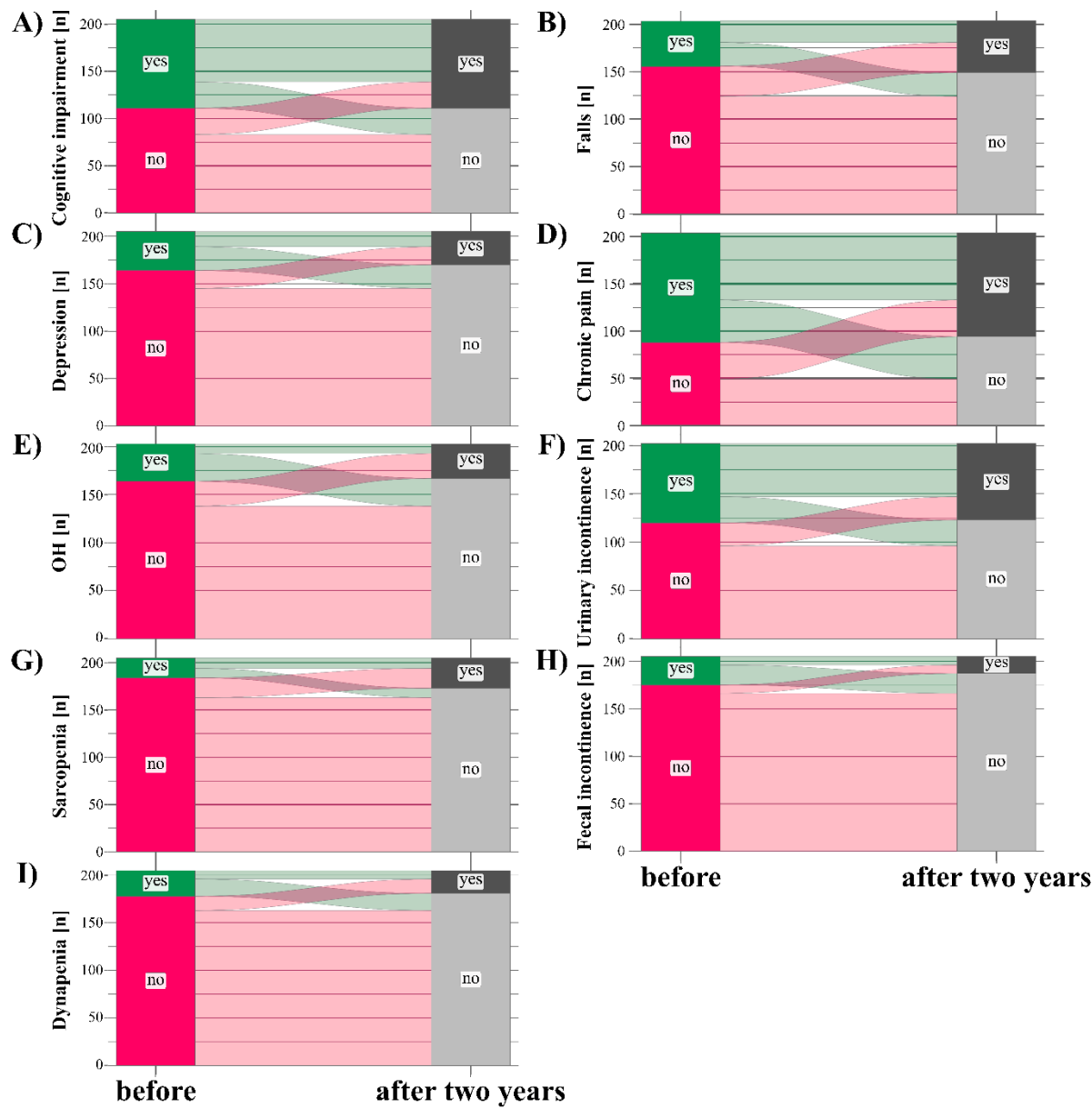


Figure 3. Alluvial diagram showing the change in the presence of geriatric giants over two years. The change in cognitive impairment is shown in panel A, falls in panel B, depression in panel C, chronic pain in panel D, OH (orthostatic hypotension) in panel E, Urinary incontinence in panel F, sarcopenia in panel G, fecal incontinence on panel H, dynapenia in panel I.

3.3. A cumulative link model (CLM) model to predict change in the number of geriatric giants over two years

Figure 3 and Table S6 present the results of the cumulative link model predicting the change over two years in the total number of geriatric giants (the difference between the number of geriatric giants after two years minus baseline, treated as an ordinal variable). The adjusted R² Nagelkerke value of the model was 0.07. For each one-point increase in self-reported antioxidant intake, there was an approximate 7% decrease in the odds of developing additional geriatric giants over two years, after adjusting for confounding factors (p=0.04) (Figure 4, Table S6). In addition, the same model without antioxidants included as a predictor in the diet was significantly worse, according to the results of a likelihood ratio test of the cumulative link models (p=0.04). The adjusted R² Nagelkerke value of the model was 0.05 (Table S7).

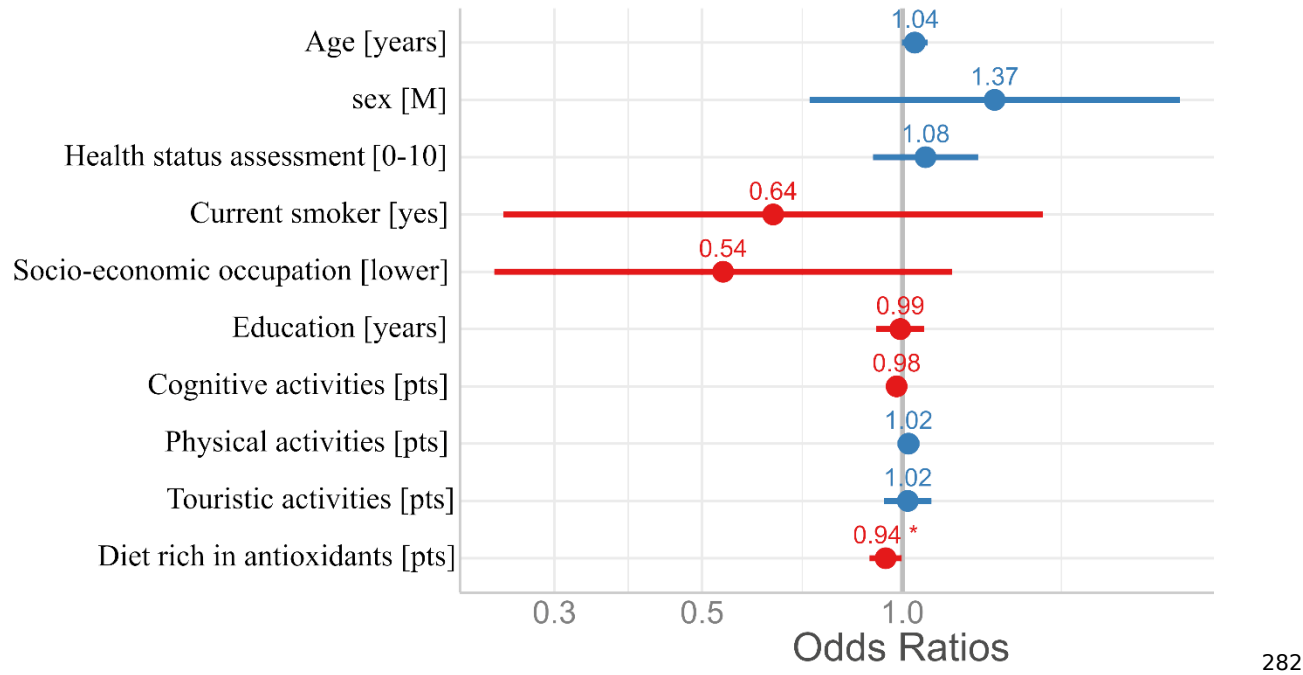


Figure 4. Results of cumulative link model with the change over two years in the total number of geriatric giants (difference between number of geriatric giants after two years minus baseline) as a dependent, ordinal variable. Dots show odds ratio, while horizontal lines refer to the 95% confidence intervals of odd ratios

4. Discussion

In the current study, a high variability in changes in the number of geriatric giants was noted over two years. In addition, chronic pain, cognitive impairment, and urinary incontinence were three of the most commonly co-existing geriatric giants in older people at baseline, occurring in 40 percent and more of the examined sample. Interestingly, the presence of fecal incontinence, urinary incontinence, falls, depression, cognitive impairment, orthostatic hypotension, and polypharmacy was most strongly related to the total number of geriatric giants at baseline. Total self-reported dietary antioxidant intake was related to a decrease in geriatric giants after two years by 0.04 after adjusting for confounding factors.

A somewhat surprising result from the current study is that in 42.9 percent of subjects, a decrease in the number of geriatric giants was noted, in 29.8 percent an increase was reported, while in 27.3 percent no change was noted. The results from this study described a relatively young group of participants with relatively good health, as evidenced by a small number of geriatric giants per individual– thus may not be representative of the wider geriatric population. However, the results of the current study illustrate the fluid nature of these syndromes which can occur, be treated successfully, then resolved, over 2 years. As the data published so far on the geriatric giants' dynamics over time is relatively sparse, further studies should be done in this area. Studies published so far on this matter seem to support the concept of frailty as a dynamic state that can change with the management of underlying factors. Effective management and early intervention targeting these factors may help mitigate their impact and potentially slow the progression [26].

An inverse relationship between the presence of particular geriatric giants, such as falls, and chronic pain, with the difference in the number of geriatric giants over two years was noted. This suggests that the number of geriatric giants tends to decrease when there is the presence of particular geriatric giants at the baseline. This result could be explained by the nature of our sample. Chronic pain was the only geriatric giant present in the majority of the sample at the baseline, the rest occurred in the minority. From an analytical standpoint, a higher number of geriatric giants at the baseline allows for having a negative delta value (change of geriatric giants after two years minus baseline) in particular participants. In patients with 0 and 1 geriatric giants at the baseline, there was virtually no or just one degree of freedom in terms of a decrease of geriatric giants over time. Therefore, having more geriatric giants allowed for a greater decrease in the number over two years. Further studies should prospectively analyze the relationship in time over the presence of geriatric giants as risk factors for developing others. For instance, chronic pain was a significant predictor of falls [27].

The co-occurrence of particular geriatric giants is compelling, but not surprising. For example, chronic pain co-occurred with depression and dynapenia. The relationship between certain health issues at baseline and an increase in the number of geriatric giants (such as immobility, instability, incontinence, and impaired intellect/memory) later on can be explained through a multifactorial lens [28]. These baseline factors are interrelated and can create a vicious cycle where physical and cognitive changes reinforce each other. For instance, cognitive impairment can lead to falls [29], which can cause injuries leading to immobility. Immobility, in turn, can lead to further cognitive decline and depression, exacerbating the overall decline in health and increasing the development of further geriatric giants over time. The association between chronic pain and depression is highly recognized and well-established; low muscle strength may be a natural consequence of chronic pain through lower physical activity and disuse [30]. Incontinence occurred with dynapenia, sarcopenia, and falls: an individual with low muscle mass and low muscle strength will have much more difficulty in toileting effectively. However, it seems that the interrelationship between sarcopenia, dynapenia, and mobility impairment is highly complex [31, 32].

Surprisingly, sarcopenia (defined as lowered muscle mass index) was not strongly related to the presence of dynapenia (defined as lowered strength of lower and/or upper limbs) at the baseline. Presumably, it might be explained by the relatively young age of participants at the baseline, and this relationship would become apparent in the older samples. Lack of association between sarcopenia and dynapenia at baseline, challenging the often-assumed close relationship between muscle mass and strength in older adults. This observation might be related to the fact that the examined sample was relatively young. In addition, it aligns with emerging research suggesting that strength decline may precede significant muscle mass loss in the aging process [31, 33]. The dissociation between sarcopenia and dynapenia in our relatively young older adult sample (mean age 69.67 years) may reflect the complex interplay of factors influencing muscle health, including neural adaptations, which can affect strength independently of muscle mass [34]. A relatively high proportion of patients that had a particular geriatric giant at the baseline, and recovered from it after two years, thus decreasing the total number of overall syndromes after two years.

In our study, being female was related to fewer geriatric giants over two years highlighting that life expectancy after age 65 is consistently higher in females than males [35]. Despite the perception that lower retirement ages enjoyed by women could offer greater opportunities for health engagement, self-reports of health quality reduce after work cessation, and approximately half (48 percent) of people ages 65 years and older report some limitations with their daily activities (with notable variations within and between countries). Issues including reduced access, utilisation, and quality of outcomes linked to health care resources make adaptations to any losses or challenges associated with increasing age (e.g., psychological strategies, physical and social support) vital, especially when multiple ‘geriatric giants’ co-present.

In our sample, cognitive, physical, and touristic activity levels were not significantly related to the odds ratio for change in the number of geriatric giants over two years in a sample of older participants in Poland. In the contrary, a study from the Middle East found that low physical activity was the best predictor of frailty [8]. Those conclusions create an opportunity for further

trials to examine the effectiveness of non-pharmacological interventions. Notably, our study found that a diet rich in antioxidants was associated with a decrease in the number of geriatric giants over two years. This protective effect of dietary antioxidants supports previous research on their role in reducing oxidative stress and inflammation, potentially mitigating age-related decline [36, 37]. However, it's crucial to interpret these findings cautiously, particularly regarding antioxidant sources like red wine. While moderate red wine consumption has been associated with some health benefits due to its antioxidant content [38], it's important to acknowledge that even low amounts of alcohol can have detrimental effects on older adults, including increased fall risk, potential drug interactions, dehydration, and negative impacts on cognitive function and sleep quality [39]. Therefore, the potential benefits of antioxidants should be considered in the context of their sources, with a preference for non-alcoholic options such as fruits, vegetables, and tea in the older adult population. In addition, the applied model in the current study explained less than 20% of the total variance, therefore it might be assumed that its predictive power is limited.

One of the study's limitations lies in how geriatric giants are assessed. Typically, one or more variables are measured, on which basis another, binary variable is created, showing the presence or absence of particular geriatric giants. However, such a methodology can lead to the loss of information. Even more information might be lost when the total number of geriatric giants is analyzed based on binary variables, that were derivatives of continuous or ordinal measurements. Therefore, the construction of a continuous, composite score to calculate geriatric giants' presence and severity measure is advised. In addition, geriatric giants listed here are not exhaustive and only provide a snapshot of each participant's health status. A validated frailty measure, as well as scores of physical activity, would also be informative. Additionally, participant-reported dietary recall measures are notoriously difficult to rely on to provide a comprehensive evaluation of an individual's diet. In this study, socio-economic status was not evaluated directly. It limits the ability to compare results from the current study with previous, in which women from lower socioeconomic backgrounds exhibit higher rates of urinary incontinence and depression [6]. Instead, data on socio-economic occupation category was

collected and dichotomized variable (as lower socio-economic occupations vs. higher socio-economic occupations) was taken into analyzes. Such approach can lead to information loss, as well is far from precise assessment of socio-economic status. Last but not least, a potential limitation is the underrepresentation of males (19.5 percent) in the analyzed sample. It was directly related to a lower response rate of males to our advertisements propagated through mass media. In future studies on aging in Poland, it's essential to select recruitment methods thoughtfully to minimize potential bias, ensuring that the representation of males is adequately included.

5. Conclusions

In the current study, chronic pain, cognitive impairment, and incontinence were three of the most common geriatric giant syndromes in participants over the age of 60 years, occurring in 40% percent and more of the examined sample. Chronic pain co-occurred with depression and dynapenia. Incontinence co-occurred with dynapenia, sarcopenia, and falls. In addition, a higher frequency of intake of products high in antioxidants related to an increase in odds of developing additional geriatric giant over two years, after adjusting for confounding factors.

References

1. Stolnitz GJ. The demographic transition: From high to low birth rates and death rates. In: Population studies and development. Routledge; 2017. p. 30-46.
2. Mulley GP. Frailty: Embracing complexity. Age Ageing. 2012;41(4):431-4.
3. Ehrlich PR, Ehrlich AH. The population explosion. Simon and Schuster; 1990.
4. UN DESA, Gapminder. World population prospects 2019: Highlights. United Nations; 2019.
5. Bowling A, Ebrahim S. Handbook of health research methods: investigation, measurement and analysis. McGraw-Hill Education (UK); 2005.

6. Badrkhahn SZ, Ala M, Fakhrzadeh H, Yaghoob A, Mirzamohamadi S, Masoud Arzaghi S, Shahabi S, Sharif F, Ostovar A, Fahimfar N, Nabipour I, Larijani B, Shafee G, Heshmat R. The prevalence and predictors of geriatric giants in community-dwelling older adults: a cross-sectional study from the Middle East. *Sci Rep.* 2023;13:12401. Available from: <https://doi.org/10.1038/s41598-023-39614-4> (accessed November 12, 2024).
7. Lewandowicz A, Skowronek P, Maksymiuk-Kłos A, Piątkiewicz P. The giant geriatric syndromes are intensified by diabetes complications. *Gerontol Geriatr Med.* 2018;4:1-9.
8. Kujawski S, Kujawska A, Perkowski R, Androsiuk-Perkowska J, Hajec W, Kwiatkowska M, Skierkowska N, Husejko J, Bieniek D, Newton JL, Morten KJ. Cognitive function changes in older people. Results of second wave of cognition of older people, education, recreational activities, nutrition, comorbidities, functional capacity studies (COPERNICUS). *Front Aging Neurosci.* 2021 May 6;13:653570..
9. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc.* 2005;53(4):695-9.
10. Thomann AE, Goettel N, Monsch RJ, Berres M, Jahn T, Steiner LA, et al. The Montreal Cognitive Assessment: Normative Data from a German-Speaking Cohort and Comparison with International Normative Samples. *J Alzheimers Dis.* 2020;73(2):691-702.
11. Almeida OP, Almeida SA. Short versions of the geriatric depression scale: a study of their validity for the diagnosis of a major depressive episode according to ICD-10 and DSM-IV. *Int J Geriatr Psychiatry.* 1999;14(10):858-65.
12. Conradsson M, Rosendahl E, Littbrand H, Gustafson Y, Olofsson B, Lövheim H. Usefulness of the Geriatric Depression Scale 15-item version among very old people with and without cognitive impairment. *Aging Ment Health.* 2013;17(5):638-45.

13. Freeman R, Wieling W, Axelrod FB, Benditt DG, Benarroch E, Biaggioni I, et al.	446
Consensus statement on the definition of orthostatic hypotension, neurally mediated	447
syncope and the postural tachycardia syndrome. Clin Auton Res. 2011;21(2):69-72.	448
14. Brignole M, Moya A, de Lange FJ, Deharo JC, Elliott PM, Fanciulli A, et al. 2018 ESC	449
Guidelines for the diagnosis and management of syncope. Eur Heart J.	450
2018;39(21):1883-948.	451
15. Chen LK, Hwang AC, Liu LK, Lee WJ, Peng LN. Polypharmacy in Aging. J Clin Med.	452
2021;10(4):753.	453
16. Kawakami R, Miyachi M, Sawada SS, Torii S, Midorikawa T, Tanisawa K, et al. Cut-	454
offs for calf circumference as a screening tool for low muscle mass: WASEDA'S Health	455
Study. Geriatr Gerontol Int. 2020;20(10):943-50.	456
17. Jones CJ, Rikli RE. Measuring functional fitness of older adults. J Active Aging.	457
2002;1:24-30.	458
18. Treede RD, Rief W, Barke A, Aziz Q, Bennett MI, Benoliel R, et al. Chronic pain as a	459
symptom or a disease: the IASP Classification of Chronic Pain for the International	460
Classification of Diseases (ICD-11). Pain. 2019;160(1):19-27.	461
19. Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. J	462
Clin Nurs. 2005;14(7):798-804.	463
20. U.S. Bureau of Labor Statistics. 2018 Standard Occupational Classification System.	464
Available at: https://www.bls.gov/soc/2018/major_groups.htm (accessed November 12,	465
2024).	466
21. May WL, Looney SW. Sample size charts for Spearman and Kendall coefficients. J	467
Biom Biostat. 2020;11(2):440.	468
22. R Core Team. R: A language and environment for statistical computing. R Foundation	469
for Statistical Computing, Vienna, Austria. 2020.	470
23. Epskamp S, Cramer AO, Waldorp LJ, Schmittmann VD, Borsboom D. qgraph: Network	471
Visualizations of Relationships in Psychometric Data. J Stat Softw. 2012;48(4):1-18.	472

24. Christensen R. ordinal—Regression Models for Ordinal Data. R package version 2023.12-4.1. Available at: <https://CRAN.R-project.org/package=ordinal> (accessed November 12, 2024).
25. Lüdtke D. sjPlot: Data Visualization for Statistics in Social Science. R package version 2.8.10. 2024.
26. Berg RL, Cassells JS. The second fifty years: Promoting health and preventing disability. Washington (DC): National Academies Press; 1992. doi:10.17226/1578
27. Gálvez-Barrón C, Formiga F, Miñarro A, Macho O, Narvaiza L, Dapena MD, Pujol R, Rodríguez-Molinero A. Pain and recurrent falls in the older and oldest-old non-institutionalized population. BMC geriatrics. 2020 Dec;20:1-9.
28. Lin SI, Chang KC, Lee HC, Yang YC, Tsao JY. Problems and fall risk determinants of quality of life in older adults with increased risk of falling. Geriatr Gerontol Int. 2015;15(5):579-587. doi:10.1111/ggi.12320
29. Best JR, Liu-Ambrose T, Boudreau RM, Ayonayon HN, Satterfield S, Simonsick EM, Studenski S, Yaffe K, Newman AB, Rosano C, Health, Aging and Body Composition Study. An evaluation of the longitudinal, bidirectional associations between gait speed and cognition in older women and men. Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences. 2016 Dec 14;71(12):1616-23.
30. Ashe MC, Miller WC, Eng JJ, Noreau L. Older adults, chronic disease and leisure-time physical activity. Gerontology. 2009 Jun 20;55(1):64-72.
31. Clark BC, Manini TM. Sarcopenia $\neq$ dynapenia. J Gerontol A Biol Sci Med Sci. 2008;63(8):829-834. doi:10.1093/gerona/63.8.829
32. Neves T, Lopes MM, Souza MC, Ferriolli E, Fett CA, Fett WR. Sarcopenia versus dynapenia: functional performance and physical disability in cross sectional study. J Aging Res Clin Pract. 2018;7:60-8.
33. Goodpaster BH, Park SW, Harris TB, Kritchevsky SB, Nevitt M, Schwartz AV, et al. The loss of skeletal muscle strength, mass, and quality in older adults: The health, aging

and body composition study. J Gerontol A Biol Sci Med Sci. 2006;61(10):1059-1064. doi:10.1093/gerona/61.10.1059

34. Manini TM, Clark BC. Dynapenia and aging: An update. J Gerontol A Biol Sci Med Sci. 2012;67(1):28-40. doi:10.1093/gerona/glr010

35. OECD. Health at a glance 2023: OECD indicators. Paris: OECD Publishing; 2023. doi:10.1787/4dd50c09-en

36. Fusco D, Colloca G, Lo Monaco MR, Cesari M. Effects of antioxidant supplementation on the aging process. Clin Interv Aging. 2007;2(3):377-387. doi:10.2147/cia.S12159918

37. Calder PC, Bosco N, Bourdet-Sicard R, Capuron L, Delzenne N, Doré J, et al. Health relevance of the modification of low grade inflammation in ageing (inflammageing) and the role of nutrition. Ageing Res Rev. 2017;40:95-119. doi:10.1016/j.arr.2017.09.001

38. Artero A, Artero A, Tarín JJ, Cano A. The impact of moderate wine consumption on health. Maturitas. 2015;80(1):3-13. doi:10.1016/j.maturitas.2014.09.007

39. Barry KL, Blow FC. Drinking over the lifespan: Focus on older adults. Alcohol Res. 2016;38(1):115-120.

CRedit authorship contribution statement

AK and SK: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration, Funding acquisition. JZ, CER, MGM, NM, MD, JAS,: Writing - Review & Editing. JH, WH: Investigation, Writing - Review & Editing. PZ and KKK: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Supervision, Project administration, Funding acquisition. All authors read and approved the final manuscript.