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Gut Health and Its Association with Wellbeing and Nutrient Intake in Community-Dwelling Older Adults

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Abstract: Many of the increasing number of community-dwelling older adults will need increased healthcare in the future. By characterising gut health and its association with wellbeing and nutrient intake in this population, we aim to recognise areas along the gut–brain axis through which the health of community-dwelling older adults might be promoted. In this cross-sectional observational study, validated questionnaires were used to assess gut health, nutrient intake, and wellbeing in 241 community-dwelling older adults (≥65 years old). In total, 65% of the participants experienced at least one gastrointestinal symptom, of which females had more abdominal pain and constipation, while the oldest old (i.e., ≥80 years old) had more diarrhoea. Increased gastrointestinal symptoms correlated with more stress, anxiety, depression, and a decreased quality of life, in addition to dyspepsia which correlated with a lower E% of protein. Most of the participants did not reach the recommended intake for protein, fibre and polyunsaturated fats. Males had a lower intake of protein (E%) and fibre (g/MJ) than females, and the oldest old had a lower E% of protein than younger older adults. In conclusion, our results demonstrate that gastrointestinal symptoms are common, and most of the study participants had an imbalanced macronutrient intake, which could be a target for future possible dietary interventions to improve overall health.

Keywords: gastrointestinal symptoms; elderly; dietary intake; general health

1. Introduction

In recent decades, lifespans have dramatically increased due to improved health and longevity, leading to a global aging phenomenon [1,2]. This challenges healthcare and socioeconomic systems worldwide due to the increased prevalence of age-related diseases and hospitalisations. Hence, as the life expectancy of the population increases, there is a growing awareness of the importance of promoting optimal functionality [3] and health throughout life to increase the independence and wellbeing of older adults.

A well-functioning gastrointestinal (GI) tract has been identified as essential for health and wellbeing by older adults themselves [3,4], as well as through studies focusing on GI diseases, such as inflammatory bowel disease and irritable bowel syndrome, among older adults [5–7]. Ageing itself has been associated with several physiological changes within the GI tract leading to major consequences for the individual. For example, ageing is related to the decreased function of the lower oesophageal sphincter, delayed gastric emptying and hypochlorhydria as well as an altered enteric nervous system with resulting longer transit time in the colon [8–10]. Many of these changes can contribute to several GI symptoms as well as anorexia of ageing, which is an overall loss of appetite with a decreased sense of taste and an increased satiety, leading to an overall lowered energy intake associated with older age [8,11].

Dietary intake is one of the major factors that can influence GI health. Different food intakes and diets have been shown to influence the GI tract either directly, for example, by dietary fibres which are important for a healthy intestinal barrier and colonocytes [12] or indirectly, by influencing the gut microbiota composition [13,14]. As diet is a modifiable factor, it could act as a potential intervention target to improve gut health and reduce GI problems [14–16]. Particularly, interventions with probiotics and prebiotics have gained a large interest, and several randomised clinical trials (RCTs) have been conducted to promote healthy ageing; however, often with modest and contradicting results [17–19]. A common problem with intervention studies focusing on healthy ageing is the heterogeneity of the older population; thus, making it difficult to perform sufficiently powered studies particularly among community-dwelling older adults, i.e., independent living older adults, which is not a well-characterised population and is often excluded from research studies.

However, GI health among community-dwelling older adults, i.e., independent living older adults, has not been thoroughly elucidated, including how GI health influences their everyday lives. As community-dwelling older adults are a group which might need elevated health care resources in the near future, this is an essential group to include in RCTs when investigating healthy ageing to promote their maintained functionality for a longer time. In the present study, we hypothesise that GI symptoms are common among community-dwelling older adults and associated with lower wellbeing as well as changes in nutrient intake which could be suitable targets for future intervention studies focusing on improving gut health and wellbeing among older adults.

2. Materials and Methods

2.1. Study Participants

Participants were recruited by advertisements in local newspapers (2012–2013), reaching residents in the county of Örebro, Sweden, within a 45 km radius from the city centre of Örebro. All data collection occurred during 2013. Inclusion criterion was age ≥ 65 years. Exclusion criterion was any known GI disease with strictures, malignancies or ischemia, including inflammatory bowel disease. The newspaper advertisements were directed to older adults at or above the age of 65 years and aimed to recruit participants to map the general health status in the older population in the county of Örebro. In addition, simultaneous information regarding the possibility to enrol in an adjacent RCT was given in the advertisement. The RCT focused on the effects of probiotics on digestive health and wellbeing among community-dwelling older adults with identical inclusion and exclusion criteria [17]. As outlined in Figure 1, a total of 302 participants reported interest in participating and were assessed for eligibility; of these 241 were included in the final analyses as 39 individuals dropped out or were excluded due to an incomplete case report form (CRF), 18 individuals had a known GI disease, and 4 individuals were below 65 years old. In total, 214 of the recruited participants choose to enrol in the adjacent RCT.

2.2. Data Collection

All data sampling was conducted in the home environment of the participants with support from a contact person within the research group. A statistical power calculation was performed based on previous reports stating that the prevalence of individual gastrointestinal symptoms is approximately 20% among older adults [20]. Using the standard normal variate of 1.96, calculated as $p < 0.05$ (considered significant), we identified that a sample size between 196 to 245 individuals was needed to identify gastrointestinal symptoms with a prevalence of 15 to 20%.

All demographic data were recorded in the CRF, except physical activity, which was measured using the Frändin–Grimby activity scale (FGAS) questionnaire, which was previously validated in an older population [21]. The FGAS questionnaire evaluates the self-reported estimated activity levels of respondents during summer and winter, respectively, using fixed response alternatives, ranging from 1 (representing barely any physical activity) to 6 (representing high–very high physical activity). Both summer and winter activity

levels were simultaneously scored. The average winter and summer score was then used as a value of overall physical activity.
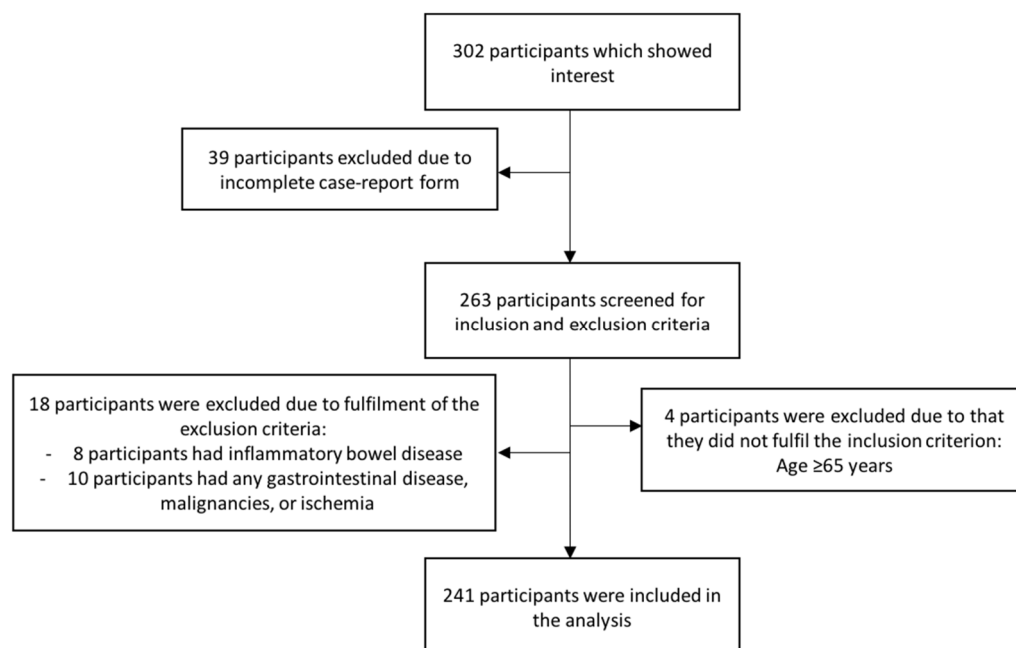
Figure 1. Participant flow.

2.2.1. Gastrointestinal Symptoms

The experience of GI symptoms was assessed using the Gastrointestinal Symptoms Rating Scale (GSRS), which was previously validated and used in an older population [22]. The scale measures 15 symptoms, belonging to five symptom domains: reflux, abdominal pain, dyspepsia, diarrhoea and constipation. All domains were individually scored to evaluate the prevalence of each symptom, while a total GSRS score (the mean score of all five symptom domains, including all 15 questions) was used to estimate the overall GI discomfort. A score > 2 on the total GSRS score was considered as having a GI symptom, as those individuals did report "mild problems" (a score of 3) on at least one individual GSRS domain. Similarly, the following division was made regarding symptom severity: 0–2 = no symptoms, >2–3 = mild symptoms, >3–4 = moderate symptoms, >4–5 fairly severe symptoms and >5 = severe symptoms.

2.2.2. Wellbeing

Health-related quality of life (HRQOL) was assessed through the EuroQol (EQ) version EQ-5D-5L [23]. This includes an index (EQ-index) as well as a visual analogue scale (EQ-VAS). The EQ-index is calculated from five questions about mobility, self-care, usual activities, pain/discomfort and anxiety/depression, from which the index value is calculated from 0 (lowest) and 1 (highest), according to a country specific chart. EQ-VAS is based on the respondent specification of their level of agreement on a VAS-scale with the statement "The best/worst health I can imagine" on a 0 (worst) to 100 (best) point scale.

Feelings related to anxiety and depression were estimated through the validated Hospital Anxiety and Depression Scale (HADS) [24]. The scale includes 14 questions related to depression and anxiety, respectively (7 questions each). Each question is rated on a 4-point scale (min = 0 to max = 3) using fixed respond alternatives. The questionnaire also includes a cut-off, where a total score > 7 on a subscale (anxiety or depression) represents a risk of depression/anxiety, respectively. Importantly, HADS is not a test for clinical diagnosis per se but rather a tool for quantifying symptoms related to depression and anxiety. However, for simplicity, the subscales will be referred to as depression and anxiety in this study.

For estimation of perceived stress, the validated Perceived Stress Scale (PSS) was used [25]. It includes 10 questions rated on a 5-point scale (min = 0 to max = 4) using fixed respond alternatives, from which a total score was used as an estimate of the overall perceived stress of the respondents.

2.2.3. Nutrient Intake

The nutrient intake was estimated using a semiquantitative food frequency questionnaire (FFQ) asking for dietary intake over the past year. The method was previously validated and described by Johansson I et al. [26]. Participants estimated their intake of 66 food items, rated from 0–8 (0 = never, 8 = 4 or more times a day). To facilitate inter-individual comparisons, the intake per day was expressed as a percent of total energy intake (E%), and intake of fibre was expressed as gram per megajoule (g/MJ). Dietary intakes were compared to the recommended dietary intake for the closest approximate ages according to the Nordic Nutritional Recommendations (NNRs) [27]. For macronutrients with a recommended range of intake, the lowest and the highest recommended intakes were used in the analyses for minimal and maximum recommended intakes, respectively. Estimated basic metabolic rate (eBMR) for each gender and age was assessed according to NNRs [27]. The eBMR was then compared to the total energy intake of the participant. A participant was considered a probable under-reporter if their energy intake was lower than their eBMR [28].

2.3. Data Analysis and Statistics

Median values, with the interquartile range (IQR), were generated for all demographic and questionnaire data. Missing data of less than two items per questionnaire for HADS, GSRS and PSS were imputed by the arithmetic mean or according to the instruction for the specific questionnaire. In total, 25 individual items were imputed (FGAS: 10, GSRS: 3, HADS: 4 and PSS: 8). Forty-one individual questionnaire values had to be excluded from the descriptive and correlation analysis due to missing data in proportions that did not allow for questionnaire-specific imputation (FGAS: 4, FFQ: 16, GSRS: 1, PSS: 8, HADS: 7 and Euro-QoL: 5), and a further six individuals failed to answer one item of EQ-index; hence, no EQ-index score was calculated for these individuals. Stratifications were performed for: sex (male vs. females) and age, with cut-offs used in previous research [29,30] and defined by WHO [31,32]: younger older adults (65–79 years) vs. oldest old ($\geq$80 years). The differences between the groups were analysed using Mann–Whitney U test and chi-square test. For comparison between the variables, Spearman correlation was used with Benjamini–Hochberg adjustment for multiple comparisons. All these statistical analyses were performed using SPSS version 26 for Macintosh (SPSS software, IBM corporation, Armonk, NY, USA). Spearman correlations with controls for sex and age were performed with the function partial Spearman from package PResiduals in R v4.0.2 (R Core Team, 2020). The visualisation of the data biplots of principal component analysis (PCA) was created using functions prcomp and ggbiplot in R. For the PCA, missing values in the overall data set were imputed using R package mice, version 3.14.0 with default options. Statistical significance values were set to $p < 0.05$, or for the multiple analyses, corrected p-values were q < 0.05. The raw data and the codes for the analyses in R and SPSS have been uploaded to a Git data repository, "https://git.oru.se/the-ageing-gut/fart-2022 (accessed on 11 October 2022)".

3. Results

3.1. Demographic Data

The participant characteristics including demographic data, GI symptoms and wellbeing variables stratified by sex are found in Table 1. Table 2 presents the same information stratified by age. The participant characteristics stratified by having or not having a GI symptom are found in supplementary Table S1. The majority (95%) of the participants were born in Sweden. For the 12 individuals not born in Sweden, 50% were born in either

Finland or Norway, and only one participant was born outside of Europe. Of the older adults, a higher percentage of the oldest old were born outside of Sweden ($p = 0.014$) than the younger older adults. Regarding living situations, more males and the younger older adults had a live-in partner or were married than the females and the oldest old, respectively ($p = 0.001$ for both). No significant differences were found between males and females regarding age, smoking, the number of medications, physical activity and polypharmacy. The oldest old were less physical active ($p = 0.007$), had more medications ($p < 0.001$) and had a higher prevalence of polypharmacy ($p < 0.001$) than the younger older adults.

Table 1. Participant characteristics, gastrointestinal symptoms (GI) and wellbeing stratified by sex, compared with Mann–Whitney U and chi2.

Parameter	All Participants $n = 241$	Males $n = 82$	Females $n = 159$	*p*-Value
Age				
Years, median (IQR)	72 (69–76)	72 (69–78)	71 (69–75)	0.227
Have a live-in partner/married				
Yes % (*n*)	56% (136)	72% (59)	48% (77)	**0.001**
Have higher education				
Yes % (*n*)	42% (99)	48% (38)	39% (61)	0.211
Born in Sweden				
Yes % (*n*)	95% (229)	94% (77)	96% (150)	0.582
Smoking				
Smokers % (*n*)	5% (11)	4% (3)	5% (8)	0.629
Physical activity				
Score, median (IQR)	3.5 (3.0–4.0)	3.5 (3.0–4.0)	3.5 (3.0–4.0)	0.976
Polypharmacy				
≥5 medications % (*n*)	16% (39)	15% (12)	17% (27)	0.625
Number of medicines				
Median (IQR)	2.0 (1.0–4.0)	2.0 (0.8–3.3)	2.0 (1.0–4.0)	0.299
GI symptoms				
Score, median (IQR)				
Dyspepsia	2.0 (1.5–3.0)	2.0 (1.3–2.6)	2.0 (1.5–3.0)	0.068
Constipation	1.7 (1.0–2.7)	1.3 (1.0–2.0)	1.7 (1.3–3.0)	**0.003**
Abdominal pain	1.3 (1.0–2.0)	1.3 (1.0–1.7)	1.7 (1.0–2.3)	**0.002**
Diarrhoea	1.3 (1.0–2.3)	1.3 (1.0–2.2)	1.3 (1.0–2.3)	0.306
Reflux	1.0 (1.0–2.0)	1.0 (1.0–1.8)	1.0 (1.0–2.0)	0.936
Total mean score	1.7 (1.3–2.3)	1.6 (1.2–2.2)	1.8 (1.4–2.5)	**0.016**
Cut-off (>2), % (*n*)				
Dyspepsia	47% (113)	43% (35)	49% (78)	0.391
Constipation	31% (74)	20% (16)	37% (58)	**0.006**
Abdominal pain	23% (55)	14% (11)	28% (44)	**0.014**
Diarrhoea	26% (61)	25% (20)	26% (41)	0.790
Reflux	15% (35)	16% (13)	14% (22)	0.646
Have a GI symptom	65% (155)	62% (50)	67% (105)	0.392

Table 1. *Cont.*

Parameter	All Participants *n* = 241	Males *n* = 82	Females *n* = 159	*p*-Value
Depression				
Score, median (IQR)	2 (1–3)	2 (1–4)	1 (1–3)	0.059
Cut-off (>7), % (*n*)	4% (9)	9% (7)	1% (2)	**0.004**
Anxiety				
Score, median (IQR)	3 (1–5)	3 (1–5)	3 (1–5)	0.421
Cut-off (>7), % (*n*)	10% (23)	8% (6)	11% (17)	0.438
Stress				
Score, median (IQR)	10 (6–14)	9 (6–13)	10 (6–15)	0.370
Quality of life				
Median (IQR)				
EQ-index	0.8 (0.8–1.0)	0.9 (0.8–1.0)	0.8 (0.8–0.9)	**0.047**
EQ-VAS	80 (75–90)	80 (75–90)	80 (70–90)	0.709

IQR: interquartile range, quartile 1 and 3 within brackets; GI: gastrointestinal; EQ: EuroQol; $p < 0.05$ were considered significant, marked in bold.

Table 2. Participant characteristics, gastrointestinal (GI) symptoms and wellbeing stratified by age, compared with Mann–Whitney U and chi2.

Parameter	All Participants *n* = 241	Younger Older Adults (Age 65–79) *n* = 202	Oldest Old (Age ≥ 80) *n* = 39	*p*-Value
Age				
Years, median (IQR)	72 (69–76)	70 (68–74)	84 (81–89)	**<0.001**
Sex				
Females, % (*n*)	66% (159)	68% (138)	54% (21)	0.081
Have a live-in partner/married				
Yes % (*n*)	56% (136)	61% (124)	31% (12)	**0.001**
Have higher education				
Yes % (*n*)	42% (99)	42% (82)	46% (17)	0.717
Born in Sweden				
Yes % (*n*)	95% (229)	97% (195)	87% (34)	**0.014**
Smoking				
Smokers % (*n*)	5% (11)	5% (10)	3% (1)	0.513
Physical activity				
Score, median (IQR)	3.5 (3.0–4.0)	3.5 (3.0–4.0)	3.0 (2.5–4.0)	**0.007**
Polypharmacy				
≥5 medications, % (*n*)	16% (39)	11% (23)	41% (16)	**<0.001**
Number of medicines				
Median (IQR)	2 (1–4)	2 (1–3)	4 (2–6)	**<0.001**

Table 2. *Cont.*

Parameter	All Participants *n* = 241	Younger Older Adults (Age 65–79) *n* = 202	Oldest Old (Age ≥ 80) *n* = 39	*p*-Value
GI symptoms				
Score, median (IQR)				
Dyspepsia	2.0 (1.5–3.0)	2.0 (1.5–3.0)	2.0 (1.3–3.0)	0.952
Constipation	1.7 (1.0–2.7)	1.7 (1.0–2.7)	1.7 (1.3–3.8)	0.062
Abdominal pain	1.3 (1.0–2.0)	1.3 (1.0–2.0)	1.3 (1.0–2.1)	0.331
Diarrhoea	1.3 (1.0–2.3)	1.3 (1.0–2.0)	2.0 (1.3–3.0)	**0.009**
Reflux	1.0 (1.0–2.0)	1.0 (1.0–2.0)	1.0 (1.0–1.6)	0.678
Total mean score	1.7 (1.3–2.3)	1.7 (1.3–2.3)	2.1 (1.5–2.4)	0.110
Cut-off (>2), % (n)				
Dyspepsia	47% (113)	48% (96)	45% (17)	0.752
Constipation	31% (74)	29% (58)	42% (16)	0.114
Abdominal pain	23% (55)	23% (46)	24% (9)	0.902
Diarrhoea	26% (61)	23% (45)	42% (16)	**0.012**
Reflux	15% (35)	14% (28)	18% (7)	0.465
Have a GI symptom	65% (155)	64% (127)	74% (28)	0.241
Depression				
Score, median (IQR)	2 (1–3)	1 (1–3)	2 (1–5)	**0.023**
Cut-off (>7), % (n)	4% (9)	4% (7)	6% (2)	0.562
Anxiety				
Score, median (IQR)	3 (1–5)	3.0 (1–5)	3 (1–6)	0.748
Cut-off (>7), % (n)	10% (23)	10% (19)	11% (4)	0.779
Stress				
Score, median (IQR)	10 (6–14)	9 (6–14)	11 (8–15)	0.100
Quality of life				
Median (IQR)				
EQ-index	0.8 (0.8–1.0)	0.9 (0.8–1.0)	0.8 (0.7–0.9)	**0.001**
EQ-VAS	80 (75–90)	85 (75–90)	75 (60–85)	**0.001**

IQR: interquartile range, quartile 1 and 3 within brackets; GI: gastrointestinal; EQ: EuroQol; $p < 0.05$ were considered significant, marked in bold.

3.2. Gastrointestinal Symptoms

In total, 65% of the study population experienced one or several GI symptoms, of which 5% had severe symptoms. The symptoms in falling order from the highest to lowest prevalence were dyspepsia (47%), constipation (31%), diarrhoea (26%), abdominal pain (23%) and reflux (15%). When stratifying for sex and age, females had more constipation ($p = 0.006$ for the cut-off value and $p = 0.003$ for the median score), abdominal pain ($p = 0.014$ for the cut-off value and $p = 0.002$ for the median score) and a higher total GI symptom score ($p = 0.016$) than males, and the oldest old had more diarrhoea than the younger older adults ($p = 0.009$ for the cut-off value and $p = 0.012$ for the median score). Furthermore, females had a higher median score of total GI symptoms than males ($p = 0.016$). A stratification based on GI symptoms regarding participants characteristics and wellbeing can be found in Supplementary Table S1.

3.3. Nutrient Intake

The nutrient intakes are presented, stratified by sex in Table 3 and by age in Table 4. The participant intake of several macronutrients did not meet the NNR recommended intake. More than half of the population did not reach the recommended intake for fibre (57%) and protein (55%). The majority also had an unbalanced intake of fats: almost everyone had a higher intake of saturated fats (97%) than the recommended maximum,

while many did not reach the recommended minimal intake for polyunsaturated (50%) and monounsaturated fats (30%). Several sex differences were found regarding energy intake. As expected, the total energy intake was higher in males ($p < 0.001$). However, males had a lower E% intake of protein ($p = 0.001$) and g/MJ of fibre ($p = 0.005$) than females, as well as a higher E% intake of saturated fats ($p = 0.022$) than females. The only age difference was that the oldest old had a lower E% of protein than the younger older adults ($p = 0.033$). Under-reporting, by estimating whether the reported energy intake of participants is below their estimated basic metabolic rate (without including any physical activity level), was found in 45% of all participants and was more common among females and younger older adults ($p = 0.001$ and $p = 0.038$, respectively).

Table 3. Total energy intake and macronutrient intake across all participants stratified by sex and compared with Mann–Whitney U and chi2.

Macronutrient Intake	Recommended Intake *	All Participants $n = 225$	Males $n = 77$	Females $n = 148$	*p*-Value
Total energy intake MJ/day (median, IQR)	Male: 6.1 Female: 5.0	5.6 (4.6–7.3)	7.9 (6.1–9.8)	4.9 (4.2–5.9)	**<0.001**
Protein, E% E% (median, IQR) Below minimum recommendation, % (*n*)	15–20 E%	14.5 (12.8–16.4) 55% (120)	13.6 (12.4–15.3) 70% (54)	15.1 (13.3–16.8) 47% (70)	**0.001** **0.001**
Fibre, g/MJ g/MJ (median, IQR) Below minimum recommendation, % (*n*)	>3 g/MJ	2.8 (2.3–3.4) 57% (129)	2.7 (2.1–3.2) 65% (46)	3.0 (2.5–3.5) 53% (79)	**0.005** 0.096
Saturated fat, E% E% (median, IQR) Above maximum recommendation, % (*n*)	<10 E%	14.7 (12.9–17.3) 97% (218)	15.6 (13.3–17.8) 96% (74)	14.1 (12.3–16.9) 97% (144)	**0.022** 0.625
Monounsaturated fat, E% E% (median, IQR) Below minimum recommendation, % (*n*)	10–20 E%	11 (9.6–12.3) 30% (67)	10.8 (9.4–12.0) 32% (25)	11.2 (9.7–12.4) 28% (42)	0.111 0.525
Polyunsaturated fat, E% E% (median, IQR) Below minimum recommendation, % (*n*)	5–10 E%	5.0 (4.0–6.1) 50% (113)	4.9 (3.9–6.0) 52% (40)	5.0 (4.0–6.2) 49% (73)	0.570 0.709
Carbohydrates, E% E% (median, IQR)	45–60 E%	48.0 (42.8–51.7)	46.1 (40.5–51.2)	48.7 (43.6–52.6)	0.066
Probable under-reporters Energy intake < eBMR [†], % (*n*)	–	45% (99)	29% (22)	53% (77)	**0.001**

MJ: megajoule; IQR: interquartile range; E%: energy percentage; $p < 0.05$ were considered significant, marked in bold. * Recommended intake according to Nordic Nutrition Recommendations, 2012. [†] eBMR: estimated basic metabolic rate of older adults based on mean weight from Nordic Nutrition Recommendations. Due to the fact that 16 individuals did not accurately fill in their food frequency questionnaire, they were excluded in this analysis; hence, only 225 individuals were included here.

3.4. Wellbeing

A risk of depression and/or anxiety (HADS: subscale > 7) was present in 4% and 10% of the participants, respectively. Males had a higher prevalence for depression than females (9% vs. 1%, $p = 0.004$) but only a trend for a higher score of depression ($p = 0.059$). The opposite was seen in the oldest old, who reported higher scores related to depression ($p = 0.023$), but no difference was seen in the prevalence of depression. The overall HRQOL was reported as 80% with the EQ-VAS and 0.8 on the EQ-index. Females had a lower EQ-index than males ($p = 0.047$), and the oldest old also had significantly lower scores on the HRQOL parameters in the EQ-index ($p = 0.001$) and EQ-VAS ($p = 0.001$) than the younger older adults.

Table 4. Total energy intake and macronutrient intake of all participants, stratified by age and compared with Mann–Whitney U and chi2.

| Macronutrient Intake	Recommended Intake *	All Participants $n = 225$	Younger Older Adults (Age 65–79) $n = 190$	Oldest Old (Age $\geq$ 80) $n = 35$	*p*-Value
Total energy intake MJ/day for males and females, median, (IQR)	Male: 6.1 Female: 5.0	7.9 (6.1–9.8) 4.9 (4.2–5.9)	7.8 (6.1–9.8) 4.8 (4.2–5.9)	7.9 (6.5–10.3) 5.2 (4.7–5.8)	0.446 0.461
Protein E% (median, IQR) Below minimum recommendation, % (*n*)	15–20 E%	14.5 (12.8–16.4) 55% (120)	14.9 (13.0–16.6) 52% (98)	13.6 (12.3–15.1) 74% (26)	**0.033** **0.013**
Fibre, g/MJ g/MJ (median, IQR) Below minimum recommendation, % (*n*)	>3 g/MJ	2.8 (2.3–3.4) 57% (129)	2.9 (2.3–3.4) 57% (108)	2.6 (2.3–3.6) 60% (21)	0.518 0.729
Saturated fat, E% E% (median, IQR) Above maximum recommendation, % (*n*)	<10 E%	14.7 (12.9–17.3) 97% (218)	14.7 (13.0–17.4) 97% (184)	14.2 (12.3–16.9) 97% (34)	0.657 0.925
Monounsaturated fat, E% E% (median, IQR) Below minimum recommendation, % (*n*)	10–20 E%	11 (9.6–12.3) 30% (67)	11.0 (9.8–12.3) 52 (27%)	10.7 (8.5–12.2) 43% (15)	0.208 0.066
Polyunsaturated fat, E% E% (median, IQR) Below minimum recommendation, % (*n*)	5–10 E%	5.0 (4.0–6.1) 50% (113)	5.1 (4.1–6.2) 48% (91)	4.4 (3.7–5.6) 63% (22)	0.057 0.104
Carbohydrates, E% E% (median, IQR)	45–60 E%	48.0 (42.8–51.7)	47.6 (42.3–51.7)	48.8 (44.3–54.6)	0.172
Probable under-reporters Energy intake < eBMR [†], % (*n*)	-	45% (99)	48% (89)	29% (10)	**0.038**

MJ: megajoule; g: gram; IQR: interquartile range; E%: energy percentage; $p < 0.05$ were considered significant, marked in bold. * Recommended intake according to Nordic Nutrition Recommendations, 2012. [†] eBMR: estimated basic metabolic rate of older adults based on mean weight from Nordic Nutrition Recommendations. Due to the fact that 16 individuals did not accurately fill in their food frequency questionnaire, they were excluded in this analysis; hence, only 225 individuals were included here.

3.5. Correlations

The associations between the data are visualised in a principal component analysis, as shown in Figure 2, while associations within the different age groups can be seen in supplementary Figure S1. Significant correlations were found between the mean GSRS score and depression (r = 0.176, q = 0.001), anxiety (r = 0.315, q < 0.001), stress (r = 0.249, q = 0.001) and decreased HRQOL (the EQ-index, r = −0.330, q < 0.001; the EQ-VAS, r = −0.368, q < 0.001). A similar pattern could be seen for all of the individual GI symptoms, except reflux which did not correlate to any wellbeing variable. Abdominal pain and diarrhoea showed the same correlation pattern (i.e., correlated with depression, anxiety, stress and decreased HRQOL), while constipation did not correlate with depression, and dyspepsia did not correlate with depression or stress. The only significant correlation with nutrient intake was between dyspepsia and the E% of protein intake (r = −0.187, q = 0.030).

On the other hand, several relationships were found between the demographic data and wellbeing variables. Higher physical activity correlated with less stress (r = −0.178, q = 0.039), less anxiety (r = −0.170, q = 0.047), higher HRQOL (the EQ-VAS, r = 0.280, q < 0.001; the EQ-index, r = 0.308, q < 0.001) and less medications (r = −0.263, q < 0.001). A higher number of medications correlated with decreased HRQOL (the EQ-VAS, r = −0.447, q < 0.001; the EQ-index, r = −0.348, q < 0.001). A higher age correlated with a higher number of medications (r = 0.275, q < 0.001), lower HRQOL (the EQ-VAS, r = −0.197,

q = 0.016; the EQ-index, r = −0.188, q = 0.020) and a higher score of depression (r = 0.174, q = 0.041).
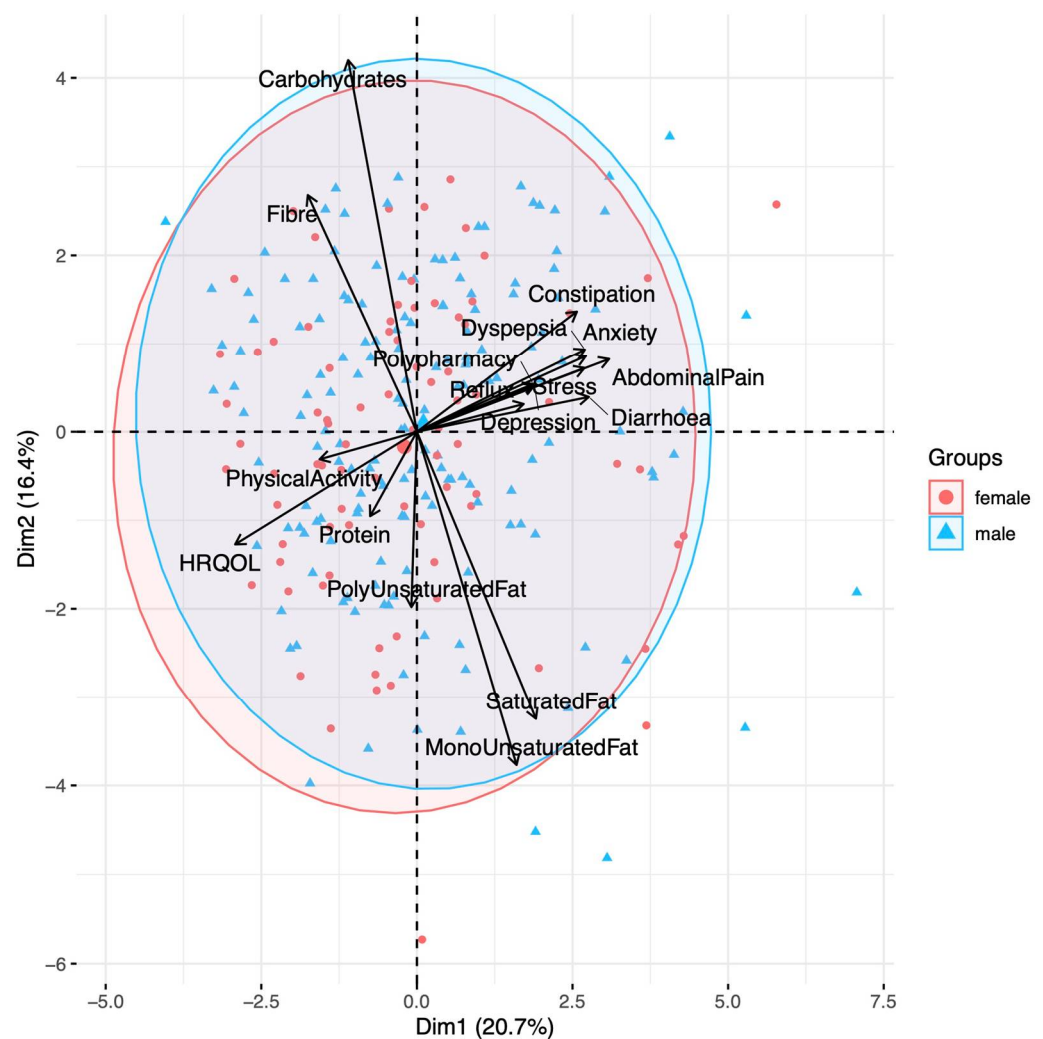
Figure 2. Principal component analysis displaying the relationship between all investigated parameters. Red circles show females, and blue triangles show men. The main components of each dimension can be seen in supplementary Table S2. The five different gastrointestinal (GI) symptoms (dyspepsia, abdominal pain, constipation, diarrhoea and reflux) are grouped together with stress, anxiety, depression and polypharmacy. Health-related quality of life (HRQOL), as depicted by EuroQol (EQ)-index, is grouped together with physical activity. The highest degree of separation was observed between GI symptoms to both HRQOL (EQ-index) and physical activity. A less degree of separation was seen between protein intake and GI symptoms, stress, polypharmacy, anxiety and depression. Carbohydrates and fats, the two major sources of energy, had the highest degree of separation as expected.

When adjusting for the covariates of age and sex, all of the correlations remained significant except for four specific ones which were lost: the correlation of constipation with depression, dyspepsia with anxiety as well as the correlation of physical activity with anxiety and depression. All individual Spearman correlations can be found in a dataset uploaded to the Git repository: "https://git.oru.se/the-ageing-gut/fart-2022 (accessed on 11 October 2022)".

4. Discussion

As community-dwelling older adults are not a thoroughly investigated population, this study was performed to open up new therapeutic approaches to promote health and longevity. Our results demonstrate that the prevalence of overall GI symptoms was as high as 65% in this population and that the GI symptoms correlated with a decreased wellbeing on all of the measured wellbeing variables included, i.e., depression, anxiety, stress and HRQOL. This is in line with previous results from our group where we identified that older adults suffering from GI symptoms display increased psychological distress as well as signs of a perturbed intestinal barrier function [3]. Furthermore, we confirmed that the majority of older adults did not reach the recommended intake for several of the macronutrients, including protein and fibre and had an imbalanced intake of saturated vs. unsaturated fats, which is similar to what has been previously seen [33]. When compared to a Swedish national dietary survey of the traditional eating patterns of 18–80-year-olds, a relatively similar E% distribution of macronutrients was found similar to this study [34]. The highest difference was found among males regarding protein (13.6 E% in this study vs. 17.1 E% in the national survey) and saturated fat intake (15.6 E% in this study vs. 12.8 E% in the national survey).

In addition, we observed that overall GI symptoms as well as the specific symptoms of abdominal pain, diarrhoea, constipation and dyspepsia correlated to a decreased well-being, which is consistent with previous studies [5,6,35–37]. However, in contrast to the previous research, we found no correlation between reflux and wellbeing, whereas gastro-oesophageal reflux disease has previously been associated with anxiety and depression [38,39]. In the present study, reflux was the least prevalent symptom, and hence, the lack of associations is more likely to be due to a low power. It is important to note that older adults experiencing severe reflux might have been excluded from participating as any known GI disease was an exclusion criterion.

The overall prevalence of GI symptoms reported here (65%) were slightly higher than previously reported among older populations in other countries [40–42]. However, when comparing individual GI symptoms, the prevalence did correspond to previous findings [43–45], except for dyspepsia and diarrhoea for which the prevalence was observed to be slightly higher in our study population [46,47]. This could be due to the subjective measurements the prevalence observations rely on. In addition, it is possible that the study has attracted individuals experiencing GI symptoms as one of our aims was to map the GI health in this population. Moreover, most of our study population were females, who are known to have higher GI symptoms than males [41,48]. Therefore, while GI symptoms do seem to be very prevalent among community-dwelling older adults according to our results and previous findings, further studies will need to validate their prevalence in larger cohorts.

In the present study, we observed that females had a higher GI symptom score than males, as well as a higher prevalence of abdominal pain and constipation, which is in accordance with previous studies [43,49]. We also observed that the oldest old had more diarrhoea than the younger older adults, which is consistent with previous research [47]. The increase in diarrhoea with age has previously been associated with the intake of several different drugs, including antibiotics and proton pump inhibitors [47]. In the present study, the oldest old had a higher intake of medications as well as an increased prevalence of polypharmacy and thus, an increased risk of drug-induced diarrhoea.

Therefore, while GI symptoms do seem to be very prevalent among community-dwelling older adults according to our results, further studies will need to validate this prevalence. Our results further demonstrate an imbalance in fat intake (E%), where 97% of the study participants exceeded the recommended maximum intake for saturated fats, with males reporting higher intakes than females, while 30% and 50% did not reach the recommended minimum intake of mono- and polyunsaturated fats, respectively. Many studies have previously seen a higher morbidity with saturated fats and a lower morbidity

with mono- and polyunsaturated fats [50,51]. Furthermore, the iso-energetic substitution of saturated fats to unsaturated fats has also shown to reduce mortality risk [51].

More than half of the study population also had a lower intake of fibre (g/MJ) and protein (E%) than the recommended intake, where both the oldest old and males reported a lower protein intake. In addition, males also reported a lower fibre intake than females. However, further studies will need to confirm the clinical significance of these findings. A low fibre intake of g/day has been associated with constipation and inflammatory bowel disease [12,52,53]. Moreover, an adequate protein intake in older adults is important to prevent sarcopenia and frailty [54–56]. Thus, promoting a more balanced diet with more mono- and polyunsaturated fats instead of saturated fats, in combination with increased fibre and protein, could be one way to improve GI and the overall health of older adults. This might be especially important for males, who reported a higher saturated fat intake and lower fibre and lower protein intakes than females. Given the observations of a low fibre diet, decreased wellbeing and alleviated GI symptoms among community-dwelling older adults, it would be intriguing to investigate the effect of dietary supplementation such as psychobiotics which might confer a positive effect on mental health as well as GI symptoms.

In addition to the generally low protein E% intake, we also saw a correlation between low protein E% intake and dyspepsia but no correlation with either fat or carbohydrate E%, which has been previously reported [57,58]. The possible association between low protein intake and dyspepsia has been supported in a few previous studies [59,60]; however, overall, little is known about protein intake and dyspepsia [57]. Hence, whether the low protein E% intake reflects a higher E% of fat and carbohydrates instead or another unknown factor is unclear.

Furthermore, we found more signs of depression both amongst males and the oldest old. Similar to our study, a meta-analysis found that older adults aged ≥75 years have previously been associated with higher depression scores than younger older adults [61]; however, in contrast with the previous research [61–63], we found that males had higher signs of depression than females. Hence, this is something that should be further investigated and validated with other tests, especially as there are many factors not included here which fell outside the scope of this study and could influence the scores of depression [61,63].

This study also has other limitations which need to be taken into consideration. The results in this study are based on self-reported data and rely on the honesty of respondents and an accurate understanding and interpretation of the questions asked. The study is an observational study; hence, no causative conclusions can be made, and further studies are needed to identify the underlying mechanisms. In addition, the population is mainly an urban-based population within a single city; hence, there is a need for further validation in another cohort. Furthermore, the dietary intake was self-assessed by an FFQ estimating the intake over the previous year and has not been validated in a population above 61 years old [26,64]. Hence, for an accurate estimation of dietary intake, a second instrument (e.g., repeated 24-h dietary recall) is needed. Using retrospective data collection of dietary intake can lead to recall bias and under-reporting [65]. The mean self-reported daily energy intake was found to be low, 6.1 MJ/day for men and 5.0 MJ/day for women, which is lower than the median energy requirement for sedentary individuals similar to their age, which is 8.5 MJ/day for men and 7.1 MJ/day for women [27]. This might be more among the females, as almost half of the study population were probably under-reporters, i.e., those estimating their energy intake below a calculated estimated metabolic rate. Unfortunately, we did not have information for body mass or previous changes in body mass at the data collection and therefore, could not perform a more accurate estimation of individual energy requirements. Hence, all macronutrient intakes were only reported as E% (e.g., the proportion of total energy intake) or for fibre, g/MJ, to allow for comparisons between participants.

5. Conclusions

In conclusion, our results demonstrate that not only do most of the community-dwelling older adults suffer from at least one GI symptom, but it is also clear that gut problems correlate with a decreased wellbeing or vice versa. In addition, a low protein E% intake was associated with dyspepsia; however, this association must be further validated as little is known about this association. Furthermore, we found that older adults displayed a possible imbalanced macronutrient intake with lower fibre, protein and polyunsaturated fat intake and a higher intake of saturated fat intake than the recommended intake. Overall, our findings show how older adults still living at home are experiencing gut health and wellbeing, such as anxiety and depression. These data might be important to take into consideration in future research studies or implementations within the care setting of the municipality to improve overall health along the gut–brain axis in the older population.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/gastroent13040035/s1: A supplementary Table S1 is available showing all participant characteristics and wellbeing stratified by the presence of gastrointestinal (GI) symptoms. A supplementary Table S2 is available showing the weights of the first two components of the PCA in Figure 2 and Supplementary Figure S1. A supplementary Figure S1 is provided illustrating the relationship between all investigated parameters within the different age groups.

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