**Association between fat-soluble vitamins and self-reported health status: a cross-sectional analysis of the MARK-AGE cohort – Supplementary material**

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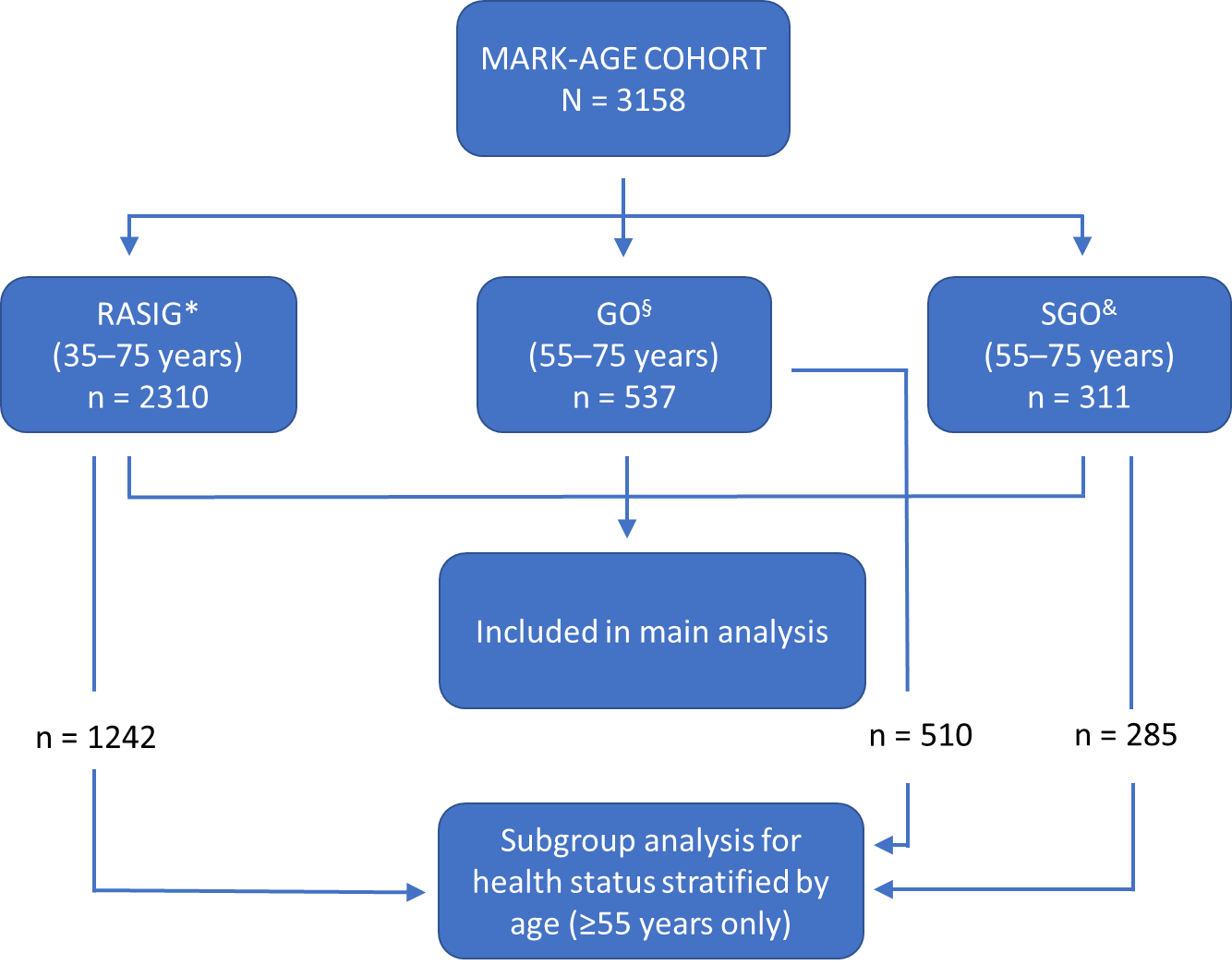
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**Analytical Methods**

Given the larger variation in age range for the RASIG group (35–75 years) compared to the GO and SGO groups (mainly 55–75 years), subgroup analyses stratified by age with participants ≥55 years only were carried out to compare health status (depicted in the flow chart below).

**Flow Chart:** Flow Chart depicting the main analyses for the overall cohort in addition to the subgroup analysis based on a cut-off of 55 years of age

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\*RASIG group (age-stratified individuals from the general population)

§GO group (Genetics of Healthy AgingGEHA offspring)

&SGO group (spouses from the recruited GO participants)

**Supplementary Table 1: Self-rated health status based on study group**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **RASIG** | **GO** | **SGO** |
| ***Health Status*** | (n=2310) | (n=537) | (n=311) |
| Excellent | 267 (11.6%) | 76 (14.2%) | 26 (8.4%) |
| Very good | 880 (38.1%) | 152 (28.3%) | 80 (25.7%) |
| Good | 897 (38.8%) | 236 (43.9%) | 159 (51.1%) |
| Fair/poor | 266 (11.5%) | 73 (13.6%) | 46 (14.8) |
| **≥ 55 years old** | **RASIG** | **GO** | **SGO** |
| ***Health Status*** | (n=1242) | (n=510) | (n=285) |
| Excellent | 107 (8.6) | 75 (14.7) | 23 (8.1) |
| Very good | 418 (33.7) | 143 (28.0) | 70 (24.6) |
| Good | 519 (41.8) | 221 (43.3) | 146 (51.2) |
| Fair/poor | 198 (15.9) | 71 (13.9) | 46 (16.1) |

The groups of study participants: RASIG (73.1%); GO (17.1%); SGO (9.8%) differed significantly based on the categories of self-rated health status (χ2(4)=41.49, P<0.001). The association was considered small (Cramer's V=0.081). The GO group had the highest percentage of participants rating health status as excellent (14.2%) and the SGO had the highest percentage for self-reported fair/poor health status (14.8%). Given, that the RASIG group included participants from the age of 35 years, a subgroup comparison between the three groups only including participants ≥55 years confirmed the above findings (χ2(4)=28.53, P<0.001; Cramer’s V=0.84).

**Supplementary Table 2: Self-rated health status according to country**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Austria** | **Belgium** | **Finland** | **Germany** | **Greece** | **Italy** | **Netherlands** | **Poland** |
| ***Health Status*** | (n=399) | (n=379) | (n=294) | (n=357) | (n=425) | (n=563) | (n=215) | (n=526) |
| Excellent | 81 (20.3%) | 60 (15.8%) | 42 (14.3%) | 45 (12.6%) | 56 (13.2%) | 44 (7.8%) | 38 (17.7%) | 3 (0.6%) |
| Very good | 205 (51.4%) | 147 (38.8%) | 109 (37.1%) | 153 (42.9%) | 160 (37.6%) | 178 (31.6%) | 67 (31.2%) | 93 (17.7%) |
| Good | 107 (26.8%) | 133 (35.1%) | 97 (33.0%) | 139 (38.9%) | 144 (33.9%) | 285 (50.6%) | 98 (45.6%) | 289 (54.9%) |
| Fair/poor | 6 (1.5%) | 39 (10.3) | 46 (15.6%) | 20 (5.6%) | 65 (15.3) | 56 (9.9) | 12 (5.6%) | 141 (26.8%) |
| **≥ 55 years old** | **Austria** | **Belgium** | **Finland** | **Germany** | **Greece** | **Italy** | **Netherlands** | **Poland** |
| ***Health Status*** | (n=200) | (n=273) | (n=258) | (n=198) | (n=218) | (n=349) | (n=212) | (n=329) |
| Excellent | 30 (15.0) | 43 (15.8) | 33 (12.6) | 23 (11.6) | 19 (8.7) | 19 (5.4) | 37 (17.5) | 1 (0.3) |
| Very good | 101 (50.5) | 92 (33.7) | 93 (36.0) | 85 (42.9) | 65 (29.8) | 91 (26.1) | 67 (31.6) | 37 (11.2) |
| Good | 65 (32.5) | 104 (38.1) | 88 (34.1) | 79 (39.9) | 83 (38.1) | 191 (54.7) | 96 (45.3) | 180 (54.7) |
| Fair/poor | 4 (2.0) | 34 (12.5) | 44 (17.1) | 11 (5.6) | 51 (23.4) | 48 (13.8) | 12 (5.7) | 111 (33.7) |

The highest percentage of participants reporting fair/poor health status was from Poland (26.8% in all ages; 33.7% in those ≥55 years), with the lowest reported from Austria with 1.5% (2% in ≥55 years). Health status category was statistically significantly associated with country (χ2(21)=421.58, P<0.001) with a moderate to small association (Cramer's V=0.21). Similar results were obtained when stratifying the cohort according to age for those 55 years and older (χ2(21)=313.41, P<0.001; Cramer's V=0.23).

**Supplementary Table 3: Univariate binary logistic regression analysis**

For binary logistic regression the dependent variable, health status categories were dichotomised as follows: excellent/very good/good versus fair/poor. The univariate analysis assessed vitamin D, retinol and α-tocopherol as well as the following confounders: sex, age group, education, marital status, BMI, smoking and alcohol consumption status, supplement use, number of current comorbidities, number of medications, hospital visits during the preceding 12 months, season of blood sampling, vitamin D status, quartiles for retinol and α-tocopherol, country of residence and study group.

The following variables contained missing values (ordered as presented in table): BMI (n=1), Hospitalisation status (n=6), 25-hydroxyvitamin D (n=140), α-tocopherol (n=136), retinol (n=136).

|  |  |  |
| --- | --- | --- |
|  | **OR (95% CI)** | **P** |
|  |  |  |
| Sex: Male | 0.916 (0.740, 1.135) | 0.42 |
| Age group: 35-44 | Reference | < 0.001 |
| Age group 45-54 | 2.222 (1.294, 3.815) | 0.004 |
| Age group 55-64 | 4.185 (2.563, 6.834) | < 0.001 |
| Age group 65-75 | 5.005 (3.073, 8.150) | < 0.001 |
| Education: University degree | Reference | < 0.001 |
| Finished school | 1.753 (1.359, 2.260) | < 0.001 |
| Elementary unfinished | 5.232 (2.386, 11.473) | < 0.001 |
| Married | Reference | 0.006 |
| Never | 0.878 (0.602, 1.281) | 0.49 |
| Divorced | 1.386 (1.025, 1.874) | 0.034 |
| Widow | 1.768 (1.191, 2.623) | 0.005 |
| BMI (kg/m2) | 1.106 (1.083, 1.130) | < 0.001 |
| Supplements: yes | 0.856 (0.689, 1.063) | 0.16 |
| Alcohol consumption: yes | 0.455 (0.352, 0.589) | < 0.001 |
| Smoker: no | Reference | < 0.001 |
| Smoker: current | 1.894 (1.437, 2.497) | < 0.001 |
| Smoker: previous | 1.253 (0.980, 1.601) | 0.07 |
| Meds (0) | Reference | < 0.001 |
| Meds (1-2) | 1.923 (1.400, 2.639) | < 0.001 |
| Meds (3-4) | 5.713 (4.137, 7.889) | < 0.001 |
| Meds (5+) | 11.166 (7.999, 15.589) | < 0.001 |
| Comorbidities (0-1) | Reference | < 0.001 |
| Comorbidities (2-3) | 1.994 (1.320, 3.012) | < 0.001 |
| Comorbidities (4+) | 10.062 (6.992, 14.481) | < 0.001 |
| Hospitalised past 12 mo: yes | 2.193 (1.658, 2.901) | < 0.001 |
| Summer | Reference | < 0.001 |
| Spring | 1.577 (1.120, 2.220) | 0.009 |
| Winter | 1.993 (1.408, 2.820) | < 0.001 |
| Autumn | 2.320 (1.633, 3.294) | < 0.001 |
| Optimal vitamin D | Reference | < 0.001 |
| Insufficient vitamin D | 1.604 (0.953, 2.700) | 0.075 |
| Vitamin D deficiency | 2.636 (1.596, 4.354) | < 0.001 |
| Severe vitamin D deficiency | 4.153 (2.419, 7.130) | < 0.001 |
| α-Tocopherol quartiles (µmol) >33.37 | Reference | 0.38 |
| 28.22-33.37 | 1.012 (0.733, 1.399) | 0.941 |
| 23.85-28.21 | 1.183 (0.864, 1.620) | 0.294 |
| <23.85 | 1.256 (0.921, 1.713) | 0.150 |
| Retinol quartile (µmol) (>2.02) | Reference | 0.017 |
| 1.73-2.02 | 0.917 (0.661, 1.272) | 0.604 |
| 1.45-1.72 | 1.019 (0.743, 1.398) | 0.91 |
| <1.45 | 1.438 (1.063, 1.945) | 0.02 |
| Germany | Reference | < 0.001 |
| Finland | 3.125 (1.803, 5.417) | < 0.001 |
| Belgium | 1.933 (1.104, 3.383) | 0.021 |
| Netherlands | 0.996 (0.477, 2.981) | 0.99 |
| Poland | 6.171 (3.778, 10.079) | < 0.001 |
| Greece | 3.042 (1.804, 5.131) | < 0.001 |
| Austria | 0.257 (0.102, 0.648) | 0.004 |
| Italy | 1.861 (1.097, 3.158) | 0.02 |
| Study group: RASIG | Reference | 0.14 |
| GO | 1.209 (0.916, 1.596) | 0.18 |
| SGO | 1.334 (0.951, 1.870) | 0.09 |

**Supplementary Table 4: Univariate ordinal logistic regression analysis**

Ordinal logistic regression was performed to determine the effect of the three fat-soluble vitamins on the four groups of SRH (excellent, very good, good, fair/good) as the dependent variable taking into account possible confounders. The following predictor variables were assessed in a univariate analysis: sex, age group, education, marital status, BMI, smoking and alcohol consumption status, supplement use, number of current comorbidities, number of medications, hospital visits during the preceding 12 months, season of blood sampling, vitamin D status, quartiles for retinol and α-tocopherol, country of residence and study group.

The following variables contained missing values (ordered as presented in table): BMI (n=1), Hospitalisation status (n=6), 25-hydroxyvitamin D (n=140), α-tocopherol (n=136), retinol (n=136).

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **OR (95% CI)** | **P** |
|  |  |  |  |
| Sex: Male |  | 0.834 (0.734, 0.949) | 0.006 |
| Age group: 35-44 |  | Reference | < 0.001 |
| Age group 45-54 |  | 1.153 (0.981, 1.354) | 0.08 |
| Age group 55-64 |  | 1.686 (1.401, 2.029) | < 0.001 |
| Age group 65-75 |  | 2.749 (2.247, 3.364) | < 0.001 |
| Education: University degree |  | Reference | < 0.001 |
| Finished school |  | 2.222 (1.145, 4.313) | 0.02 |
| Elementary unfinished |  | 3.386 (1.735, 6.608) | < 0.001 |
| Married |  | Reference | 0.004 |
| Never |  | 1.578 (1.194, 2.087) | 0.001 |
| Divorced |  | 1.636 (1.172, 2.284) | 0.004 |
| Widow |  | 1.306 (0.945, 1.805) | 0.11 |
| BMI (kg/m2) |  | 0.911 (0.897, 0.924) | < 0.001 |
| Supplements: yes |  | 0.980 (0.859, 1.119) | 0.76 |
| Alcohol consumption: yes |  | 0.496 (0.412, 0.597) | < 0.001 |
| Smoker: no |  | Reference | < 0.001 |
| Smoker: previous |  | 1.325 (1.093, 1.608) | 0.004 |
| Smoker: current |  | 1.834 (1.527, 2.202) | < 0.001 |
| Meds (0) |  | Reference | < 0.001 |
| Meds (1-2) |  | 1.898 (1.435, 2.512) | < 0.001 |
| Meds (3-4) |  | 4.962 (3.854, 6.389) | < 0.001 |
| Meds (5+) |  | 8.492 (6.618, 10.897) | < 0.001 |
| Comorbidities (0-1) |  | Reference | < 0.001 |
| Comorbidities (2-3) |  | 3.487 (2.954, 4.116) | < 0.001 |
| Comorbidities (4+) |  | 6.330 (5.319, 7.533) | < 0.001 |
| Hospitalised past 12 mo: yes |  | 1.806 (1.470, 2.219) | < 0.001 |
| Summer |  | Reference | < 0.001 |
| Spring |  | 1.194 (0.987, 1.446) | 0.07 |
| Winter |  | 1.406 (1.173, 1.684) | < 0.001 |
| Autumn |  | 1.553 (1.275, 1.892) | < 0.001 |
| Optimal vitamin D |  | Reference | < 0.001 |
| Insufficient vitamin D |  | 1.404 (1.131, 1.744) | 0.002 |
| Vitamin D deficiency |  | 1.864 (1.494, 2.327) | < 0.001 |
| Severe vitamin D deficiency |  | 2.903 (2.192, 3.844) | < 0.001 |
| α-Tocopherol quartiles (µmol) >33.37 |  | Reference | 0.48 |
| 28.22-33.37 |  | 0.927 (0.770, 1.116) | 0.42 |
| 23.85-28.21 |  | 1.074 (0.892, 1.292) | 0.45 |
| <23.85 |  | 1.022 (0.849, 1.230) | 0.82 |
| Retinol quartile (µmol) (>2.02) |  | Reference | < 0.001 |
| 1.73-2.02 |  | 1.381 (1.147, 1.664) | 0.001 |
| 1.45-1.72 |  | 1.498 (1.240, 1.809) | < 0.001 |
| <1.45 |  | 1.426 (1.183, 1.719) | < 0.001 |
| Germany |  | Reference | < 0.001 |
| Finland |  | 1.286 (0.966, 1.711) | 0.09 |
| Belgium |  | 0.721 (0.554, 0.937) | 0.014 |
| Netherlands |  | 2.387 (1.802, 3.162) | < 0.001 |
| Poland |  | 0.971 (0.737, 1.280) | 0.83 |
| Greece |  | 0.257 (0.196, 0.337) | < 0.001 |
| Austria |  | 1.183 (0.854, 1.638) | 0.31 |
| Italy |  | 1.242 (0.937, 1.647) | 0.13 |
| Study group: RASIG |  | Reference | < 0.001 |
| GO |  | 1.381 (1.066, 1.789) | 0.014 |
| SGO |  | 1.663 (1.335, 2.072) | < 0.001 |