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Diet quality, psychological factors and their associations with risk factors of cardiovascular disease: a cross-sectional pilot study

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ABSTRACT

Background Several modifiable risk factors, including dietary habits, are linked to cardiovascular disease (CVD) progression. However, lifestyle changes remain notoriously challenging, perhaps due to psychosocial factors. This pilot study aims to investigate the relationship between adherence to a healthy diet, CVD risk factors, psychological factors and sociodemographic variables among middle-aged adults in Sweden.

Methods Data were collected from March to December 2012 in the SCAPIS diet sub-study, where a total of 200 participants aged 50–64 years were enrolled. Dietary intake was assessed using the MiniMeal-Q food frequency questionnaire, and adherence to healthy eating patterns was evaluated using the Diet Quality Index-Swedish Nutrition Recommendations (DQI-SNR). Psychological factors, stress and sleep patterns were assessed through a comprehensive questionnaire. Statistical analyses included t-tests, analysis of variance, X^2 tests and logistic regression to identify predictors of unfavourable apolipoprotein (Apo) B/Apo A1 ratios.

Results Out of 200 participants, 182 had complete and reliable dietary data. The majority exhibited intermediate adherence to a healthy diet, with women showing better adherence to dietary fibre intake compared with men. Women with high dietary quality had better cardiovascular profiles, including higher levels of Apo A1 and high-density lipoprotein cholesterol, lower Apo B/Apo A1 ratios and higher plasma carotenoids. Significant predictors of unfavourable Apo B/Apo A1 ratios included low socioeconomic status (SES), higher body mass index, larger waist circumference and smoking. Stratified adjusted analyses revealed distinct predictors based on SES, with depression increasing the OR of an unfavourable lipid profile by 6.41 times (p=0.019) in low SES areas.

Conclusions This study highlights the potential of tailored recommendations considering socioeconomic and psychological factors. Addressing mental health and promoting physical activity may be crucial for CVD risk reduction, particularly in low SES areas. Further research is needed to confirm these findings in larger cohorts and to develop targeted interventions for diverse population groups.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Several modifiable and non-modifiable risk factors of cardiovascular disease (CVD) have been identified, and poor dietary habits are one of the leading risk factors.

WHAT THIS STUDY ADDS

⇒ This study showed that dietary quality was associated with other risk factors of CVD in women, but not in men. Several predictors of unfavourable ratios of apolipoprotein (Apo) B/Apo A1 were identified, with different predictors in low and high socioeconomic status (SES) areas. In low SES areas, depression, age and physical activity were independent predictors of unfavourable lipid profiles, while in high SES areas, body mass index and waist circumference were significant predictors.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study highlights the importance of tailored dietary recommendations and interventions that consider both socioeconomic and psychological factors. For individuals in low SES areas, addressing mental health and promoting physical activity may be crucial components of effective cardiovascular risk reduction strategies, while in higher SES populations, focusing on weight management and central obesity may yield better outcomes.

INTRODUCTION

Noncommunicable diseases (NCDs) pose a significant global health challenge, with cardiovascular disease (CVD) accounting for a substantial portion of the burden in terms of both mortality and disability-adjusted life years (DALYs).[1] Poor dietary habits are recognised as one of the leading modifiable risk factors for NCDs, including CVD.[2 3] These habits encompass low consumption of essential food groups such as whole grains, fruits, vegetables, nuts, seeds and seafood omega-3 fatty acids, alongside high intake of sugar-sweetened beverages, red meat and sodium.[4]

Notably, high intake of sodium and inadequate intake of whole grains, fruits and vegetables has been identified as the primary dietary risk factors for DALYs globally.[5]

In addition to dietary factors, several other modifiable and non-modifiable risk factors contribute to the development of CVD, including hypertension, dyslipidaemia, obesity, tobacco use and physical inactivity.[6] Dyslipidaemia, characterised by abnormal levels of lipids in the blood, is particularly influenced by the balance of specific apolipoproteins, such as the ratio of apolipoprotein B (Apo B) to Apo A1. An unfavourable Apo B/Apo A1 ratio is a strong predictor of cardiovascular events, highlighting the importance of lipid management in CVD prevention.[7–9] Despite the availability of evidence-based guidelines and recommendations, adherence to these guidelines remains suboptimal among individuals at risk for CVD. Implementing dietary modifications and adopting healthy lifestyle changes, such as smoking cessation, stress reduction and increased physical activity, presents considerable challenges. Also, the precise causal relationships between lifestyle factors and CVD risk have not been fully elucidated, and knowledge regarding gender differences and impact of the socioeconomic status (SES) is scarce.

Understanding the barriers to achieving lifestyle modifications is crucial for motivating individuals at risk of CVD to adopt healthier behaviours. Recent research has highlighted the potential influence of factors such as sleep duration and stress levels on dietary habits and overall health outcomes.[10–12] For instance, studies have demonstrated associations between inadequate sleep duration and increased energy intake, suggesting a link between sleep patterns and dietary behaviours.[13] Suboptimal sleep duration has been proposed as a determinant of cardiometabolic disease, with poor dietary quality as a likely intermediate, but these hypotheses need to be confirmed.

In this study, we hypothesised that low adherence to the national dietary guidelines in Sweden may be associated with established risk factors for CVD, such as age, sex, smoking, blood pressure, blood lipid profile, body mass index (BMI) and physical activity. Furthermore, we aimed to explore whether psychological factors, such as reported stress levels and sleeping patterns, were associated with healthy dietary habits. To address these hypotheses, we investigated the association between dietary quality and CVD risk factors, while considering the potential influence of psychological factors such as stress and sleeping patterns. Additionally, we aimed to study how those factors related to the risk of having unfavourable ratios of Apo B/Apo A1, in a representative sample of the Swedish middle-aged population.

MATERIALS AND METHODS

Study design

This study is based on data assembled from March to December 2012 within the pilot study of the Swedish CArdioPulmonary bio Image study (SCAPIS). The study procedures and participants have previously been described in detail elsewhere.[14] The SCAPIS pilot study consisted of two visits to a local healthcare centre, with an additional visit for the SCAPIS dietary sub-study. After providing written informed consent, all participants filled in online questionnaires addressing physical and psychological well-being and underwent extensive examinations including anthropometric measurements and blood sampling. This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures were approved by the Gothenburg regional Ethics Committee (Dnr 1061–11 and 2019–05975).

Study population

In short, 2243 women and men were invited to the study using a computerised random selection from the population registry. In total 1111 women and men aged 50–64 years from six different areas (three areas considered to have low and high SES, respectively) in the Gothenburg region, Sweden, agreed to participate in the pilot study. Of these, 200 were enrolled in the SCAPIS diet sub-study at the Department of Internal Medicine and Clinical Nutrition, University of Gothenburg.

Dietary assessment

Intake of energy and nutrients were assessed by the web-based, self-administered, semi-quantitative food frequency questionnaire MiniMeal-Q. This food frequency questionnaire has been validated.[15] During the SCAPIS diet sub-study, the MiniMeal-Q was also validated for reported energy intake against objectively measured total energy expenditure using the doubly labelled water method,[16] and for the assessment of vegetables and fruits and wholegrain intake using carotenoids and alkylresorcinols as objective markers of dietary intake.[17] The questionnaire consists of both single food items and mixed dishes and includes follow-up questions only for foods consumed at least once a month. Due to its dynamic structure, intakes are assessed for between 75 and 126 food items in total. The time span covered is not strictly defined, but states to assess intakes during the past few months. Answering frequencies are mostly in a nine-grade scale from 'five times a day' to 'one-to-three times a month'. For the estimation of portion sizes on cooked dishes, five different photo-options are presented for (1) meat, chicken, fish and vegetarian substitutes; (2) potatoes, rice and pasta; and (3) vegetables. Other food items are calculated using standard portion sizes. All dietary data were linked to the Swedish food composition table (Livsmedelsdatabasen, version 2012-01-06) and calculated as the average intake of unit/day. Energy-adjusted intakes were calculated as g/MJ, the percentage of energy (E%) derived from fatty acids was calculated as ((g fat x 37 kJ)/total energy intake kJ) x100 and E% was derived from sucrose as ((g sucrose x 17 kJ)/total energy intake kJ) x100.

 Nybacka S, et al. bmjnph 2024;0:e001037. doi:10.1136/bmjnph-2024-001037

In this study, we excluded participants reporting unreliable habitual dietary intakes, defined as reporting <1000 kcal/day or >4500 kcal per day.

Healthy eating index

To assess the adherence to healthy eating patterns, a diet index developed and validated by Drake *et al* was applied[18] (DQI-SNR). The index assesses the adherence to the Swedish national dietary guidelines, which in turn are based on the Nordic nutrition recommendations. Six different dietary components are included in the index: dietary fibre, fruit and vegetables, fish and shellfish, saturated fatty acids (SFA), polyunsaturated fatty acids (PUFA) and sucrose. Cohering with any of the recommendations yielded one point, which sums to a total score range of 0–6 points. A score of '0' indicates no adherence with any of the recommended intake levels, and '6' indicates full adherence.

The cut-offs for adherence to the dietary components can be seen in table 1. As only a few individuals reported having consumed less than 10 E% of saturated fatty

Table 1 Characteristics of women and men included in the study and their respective diet quality index score, as well as the proportion who adhere to the specific variables within each dietary quality component

	All n=182	Women n=91	Men n=91	P value women vs men
Age, year mean±SD (range)	57.6±4.5 (50-65)	57.6±4.4 (50-65)	57.6±4.7 (50-65)	0.92
Body mass index, kg/m^2 mean±SD (range)	26.5±3.5 (18.3–38.4)	25.7±3.9 818.3–38.4)	27.3±2.9 (22.2–37.7)	**0.002**
Weight, kg mean±SD (range)	79.5±14.3 (45.6–120.8)	70.8±11.6 (45.6–109.6)	88.3±10.8 (67.0–120.8)	**<0.001**
Education level: university or college degree, N (%)	78 (43.3%)	41 (46.1%)	37 (40.7%)	0.55
Socioeconomic status area, low/high N (%)	67 (36.8%)/115 (63.2%)	36 (39.6%)/55 (60.4%)	31 (34.1%)/60 (65.9%)	0.54
Occupation, N (%)				
Working	136 (76.0%)	67 (74.4%)	69 (77.5%)	0.73
Unemployed	5 (2.8%)	2 (2.2%)	3 (3.3%)	0.99
Retired	19 (10.6%)	10 (11.1%)	9 (10.0%)	0.99
Disability pension	14 (7.8%)	10 (11.1%)	4 (4.4%)	0.16
Marital status, N (%)				
Single/unmarried	9 (4.9%)	3 (3.3%)	6 (6.6%)	0.50
Married or common-law spouse	154 (84.6%)	72 (79.1%)	82 (90.1%)	0.063
Divorced	14 (7.7%)	14 (15.4%)	3 (3.3%)	**<0.001**
Widow/widower	2 (1.1%)	2 (2.2%)	–	0.50
DQI-SNR score, total, N (%)				0.36
0	4 (2.2%)	4 (4.4%)	0 (0%)	0.12
1	25 (13.7%)	10 (11.0%)	15 (16.5%)	0.39
2	30 (16.5%)	14 (15.4%)	16 (17.6%)	0.84
3	49 (26.9%)	21 (23.1%)	28 (30.8%)	0.32
4	40 (22.0%)	22 (24.2%)	18 (19.8%)	0.59
5	24 (13.2%)	14 (15.4%)	10 (11.0%)	0.51
6	10 (5.5%)	6 (6.6%)	4 (4.4%)	0.75
DQI-SNR variables, adherence, N (%)				
SFA<12.7 E%/day	97 (53.3%)	46 (50.5%)	51 (56.0%)	0.55
PUFA 5–10 E%/day	106 (58.2%)	54 (59.3%)	52 (57.1%)	0.88
Fibre >3 g/MJ/day	67 (36.8%)	43 (47.3%)	24 (26.4%)	**0.005**
Fish >300 g/week	98 (53.8%)	45 (49.5%)	53 (58.2%)	0.30
Fruit and vegetables >400 g/day	54 (29.7%)	29 (31.9%)	25 (27.5%)	0.63
Sucrose <10 E%/day	150 (82.4%)	78 (85.7%)	72 (79.1%)	0.33

DQI-SNR, diet quality index – Swedish nutrition recommendations; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

acids, as the recommendations state, one SD was added to the cut-off limit for SFA and was set to 12.7 E%. This was performed according to the developers of the index. Also, for the intake of dietary fibre, we only considered the lower intake limit and set the cut-off limit to ≥3 g/MJ.

Index scores were used both as continuous values and divided into low diet quality (0–1 points), intermediate diet quality (2–4 points) and good diet quality (5–6 points).

Physical activity assessment

Physical activity levels were assessed in the SCAPIS diet sub-study using two core questions. Activity levels at work were rated as (1) sedentary, (2) light, (3) intermediate or (4) heavy workload, and activity at leisure time was rated as (1) sedentary, (2) moderate, (3) moderate to regular or (4) having regular physical activity.

Blood samples

A venous blood sample (100 mL) was collected from participants after an overnight fast and analysed for cholesterol, high-density lipoprotein (HDL), triglycerides, calculated low-density lipoprotein (LDL), Apo A1, Apo B, plasma glucose, HbA1c and creatinine with standard methods at the local hospital laboratory. Aliquots were also stored and later analysed for plasma carotenoids and alkylresorcinols. The plasma concentrations of six carotenoids (ie, lutein, zeaxanthin, β-cryptoxanthin, lycopene, α-carotene and β-carotene) were determined with high-performance liquid chromatography, and the method has been described elsewhere.[17] The plasma concentrations of five alkylresorcinol homologues (C:17:0 C:25:0), which act as biomarkers of whole grain intake, were determined by a gas chromatography mass spectrometry method as described previously.[19]

Anthropometry and blood pressure

Body weight was measured on a balance scale, with participants dressed in light clothing without shoes. Body height and waist and hip circumference were measured according to recommendations by the WHO.[20] Body mass index (BMI) was calculated as weight (kg) divided by the square of the height (m^2). Systolic and diastolic blood pressures were measured twice in each arm with an automatic device (Omron M10-IT, Omron Healthcare Co, Kyoto, Japan), and the mean of the measurements was used.

Questionnaire assessing lifestyle factors

All participants filled in a questionnaire consisting of 140 questions assessing self-reported health, use of medication, lifestyle and psychosocial well-being including self-perceived stress and sleeping habits. A questionnaire assessing several psychological variables was used,[21] and the items in the questionnaire have previously been shown to relate to the risk of CVD.[21] The questionnaire has not been formally validated, but the items in the questionnaire have been used in clinical research in Gothenburg, Sweden, since the 1970s.

Psychological stress was assessed with a question that asked whether participants was feeling irritable, filled with anxiety or was having sleeping difficulties due to conditions at work or at home. The response options were as follows: (1) never experienced stress, (2) experienced some periods at home or at work, (3) experienced several periods at home or at work and (4) experienced permanent stress at home or at work. In our analyses, we defined chronic stress as 'experienced permanent stress at home or at work'.

Regarding depression, participants were asked whether they had felt sad, gloomy or depressed for 2 weeks or more during the past 12 months, with response options of (1) no and (2) yes. Generalised locus of control—that is, the perceived ability to control life circumstances—was determined by a scale from 0 to 4, with higher scores indicating less control over life circumstances. In our analyses, we defined a loss over control of life circumstances as ≥3.

Sleeping habits were assessed using three core questions: one question addressing the perceived quality of sleep, (very good, good, fairly good, bad or very bad); one question regarding the duration of sleep during nighttime (4 hours or less, 5 hours, 6 hours, 7 hours, 8 hours, 9 hours or 10 hours or more); and one question regarding having trouble falling at sleep at night (never/almost never, less than once/week, 1–2 times/week, 3–6 times/week, almost every night). In our analyses, we merged the categories 'bad' and 'very bad' sleep quality, a suboptimal sleep duration was either ≤5 hours or ≥9 hours of sleep/night and having trouble falling asleep was set to ≥once a week.

Statistical analyses

Clinical characteristics and quantitative variables are presented as mean±SD for the whole study population and also presented as women and men separately. Differences in means between the two groups were analysed by independent samples t-test for continuous normally distributed variables and with analysis of variance for three groups. The distributions of proportions were analysed using the chi-square test.

To study associations between a healthy dietary intake and risk factors of CVD, psychological factors, stress and sleep quality, we used cut-off values for the DQI-SNR with low, intermediate and high adherence to a healthy diet as grouping variables. Values for all groups were analysed, as well as comparisons between low adherence and high adherence.

To analyse predictors of having optimal ratios of Apo B/Apo A1, with cut-offs set for optimal ratios to <0.6 for women and <0.7 for men, logistic regression analyses were conducted with the dichotomous outcome variable 'optimal ratio', 1; 'suboptimal ratio', 2, presented with ORs and 95% CIs.

In the first set of unadjusted models, we strived to identify variables that could be effect-modifiers to stratify the analyses accordingly. Further, to control for potential confounding factors, multivariable logistic regression analyses were conducted. Two adjusted models were evaluated; the first model was adjusted for intake of prescription medication, age, BMI, smoking physical activity level; and in the second model, we also adjusted for dietary variables with potential to influence blood lipids, that is, diet index score, fibre intake and intake of saturated fat.

All statistical analyses were two-sided with a significance level at α <0.05. Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 29.0 (Armonk, NY: IBM Corp.).

RESULTS

Of the 200 women and men included in the SCAPIS diet sub-study, 190 had complete dietary data. Of these, eight individuals had reported unreliably low (n=6) or high (n=2) energy intakes and were thus excluded from these analyses. A total of 91 women and 91 men were included, with a mean age of 57.6±4.5 years and a mean BMI of 26.5±3.5 kg/m^2 (table 1). 37% of the participants lived in areas considered to be of low SES, whereas 63% were living in areas of high SES. The majority of participants was either married or lived with a common-law spouse (84.6%).

Regarding the diet quality, the majority of participants reported having an intermediate adherence to a healthy eating pattern (measured as DQI-SNR-score) (table 1). The mean diet index score was 3.2 for women and 3.0 for men (p=0.36). For women, 4.4% did not comply with any of the components in the diet index, whereas 6.6% adhered to all dietary components. For men, none reported zero adherence, and 4.4% reported adherence to all dietary components. The lowest adherence was found for fibre intake among men (26.4% adherence) and the highest for sucrose intake among women (82.4% adherence). Adherence to dietary fibre was the only component that differed significantly between women

Table 2 Clinical characteristics, psychological factors and sleep quality of women divided into low, moderate and high adherence to healthy eating patterns according to the diet quality index

Women	Low n=14	Moderate n=57	High n=20	P value	P value
	mean±SD	mean±SD	mean±SD	all groups	low vs high
Body mass index, kg/m^2	26±5	26±4	26±4	0.93	0.70
Weight, kg	72±17	71±11	71±9	0.84	0.57
Waist circumference, cm	89±15	88±11	87±10	0.72	0.48
Hip circumference, cm	102±11	102±9	102±9	0.90	0.65
Age, y	57±4	58±4	58±5	0.87	0.59
Current smoker, N (%)	6 (42.9%)	6 (10.5%)	1 (5.0%)	**0.004**	**0.007**
Physical activity level	1.64±0.11	1.65±0.13	1.66±0.15	0.87	0.59
Stress (chronic stress), N (%)*	2 (14.3%)	13 (22.8%)	5 (25.0%)	0.74	0.45
Sleep quality (bad sleep), N (%)	6 (42.9%)	13 (22.8%)	5 (25.0%)	0.31	0.27
Difficulties falling asleep, N (%)†	6 (42.9%)	23 (40.4%)	11 (55.0%)	0.52	0.49
Sleep hours (suboptimal), N (%)‡	4 (28.6%)	6 (10.5%)	5 (25.0%)	0.14	0.82
Control in life (no control), N (%)	2 (14.3%)	12 (21.1%)	2 (10.0%)	0.50	0.70
Depressed during last year, N (%)	5 (38.5%)	15 (27.3%)	5 (25.0%)	0.67	0.41
Apo B	1.07±0.17	1.08±0.23	1.02±0.19	0.58	0.54
Apo A1	1.66±0.26	1.89±0.32	1.96±0.23	**0.008**	**0.002**
Ratio Apo B/Apo A1	0.67±0.15	0.60±0.19	0.53±0.14	0.074	**0.024**
Cholesterol, mmol/L	5.76±1.02	5.92±0.85	5.77±0.78	0.76	0.86
LDL cholesterol, mmol/L	3.76±0.86	3.73±0.89	3.48±0.84	0.59	0.42
HDL cholesterol, mmol/L	1.66±0.52	2.07±0.63	2.18±0.52	**0.027**	**0.010**
Triglycerides, mmol/L	1.33±0.58	1.02±0.52	1.05±0.46	0.13	0.11
Systolic blood pressure, mm Hg	130±18	122±19	114±13	**0.031**	**0.010**
Diastolic blood pressure, mm Hg	77±11	72±11	70±7	0.11	**0.037**
Total plasma carotenoids, µmol/L	1.59±0.85	2.68±1.19	2.72±1.30	**0.003**	**0.002**
Total plasma alkylresorcinols, nmol/L	19.0±11.3	26.7±19.1	27.2±25.8	0.40	0.28

*Defined as having permanent stress at home or work during the last year or longer.
†Defined as difficulties falling asleep at least once a week or more.
‡Defined as sleeping ≤5 hour or ≥9 hour of, on average per night.
Apo, apolipoprotein; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

and men, with more women being compliant (p=0.005) (table 1).

For women, several traditional risk factors of CVD were associated with the DQI-SNR. Thus, fewer smokers, higher Apo A1 levels, lower ratio of Apo B/Apo A1, higher HDL-cholesterol and lower systolic and diastolic blood pressure were found in women with a good diet quality compared with a low diet quality (all p<0.05), table 2. Also, levels of plasma carotenoids were higher among women with a good diet quality compared with low diet quality (p=0.002). For men, none of the variables were significantly associated with DQI-SNR but with a trend towards higher levels of plasma carotenoids in men with good diet quality compared with low diet quality (p=0.065; table 3).

To identify potential predictive factors for an unfavourable Apo B/Apo A1 ratio, we conducted a simple logistic regression analysis (table 4). Significant predictors of a poor lipid profile included living in low SES areas (high SES OR 0.39, p=0.033), higher BMI (OR 1.14, p=0.030), larger waist circumference (OR 1.04, p=0.038) and being a smoker (OR 2.77, p=0.037).

Recognising the significance of SES as a predictive factor, we performed additional analyses stratified by low and high SES (table 5). The stratified logistic regression analyses revealed distinct predictors of an unfavourable Apo B/Apo A1 ratio in each SES group. Among participants in low SES areas, significant predictors were younger age (OR 0.86, p=0.016), low physical activity level (OR 0.03, p=0.044) and depression (OR 4.21, p=0.016). Conversely, in high SES areas, higher BMI (OR 1.27, p<0.001) and larger waist circumference (OR 1.07, p<0.001) were significantly associated with a poor lipid profile.

Finally, the impact of depression was further analysed using multivariable logistic regression, stratified by SES

Table 3 Clinical characteristics, psychological factors and sleep quality of men divided into low, moderate and high adherence to healthy eating patterns according to the diet quality index

Men	Low n=15	Moderate n=62	High n=14	P value	P value
	mean±SD	mean±SD	mean±SD	all groups	low vs high
Body mass index, kg/m^2	27±3	28±3	26±3	0.27	0.68
Weight, kg	88±12	90±10	83±11	0.074	0.21
Waist circumference, cm	100±9	101±9	95±7	0.099	0.18
Hip circumference, cm	102±8	103±6	99±7	0.084	0.19
Age, y	58±5	58±5	56±4	0.48	0.41
Current smoker, N (%)	2 (13.3%)	4 (6.5%)	2 (14.3%)	0.51	0.94
Physical activity level	1.61±0.12	1.63±0.13	1.66±0.09	0.53	0.28
Stress (chronic stress), N (%)*	0 (0%)	12 (19.4%)	2 (14.3%)	0.18	0.13
Sleep quality (bad sleep), N (%)	0 (0%)	6 (9.7%)	1 (7.1%)	0.45	0.29
Difficulties falling asleep, N (%)†	3 (20.0%)	17 (27.4%)	3 (21.4%)	0.79	0.92
Sleep hours (suboptimal), N (%)‡	3 (20.0%)	4 (6.5%)	2 (14.3%)	0.24	0.68
Control in life (no control), N (%)	3 (21.4%)	14 (22.6%)	3 (21.4%)	0.99	0.99
Depressed during last year, N (%)	2 (15.4%)	8 (12.9%)	4 (28.6%)	0.35	0.41
Apo B	1.13±0.26	1.14±0.25	1.12±0.28	0.93	0.92
Apo A1	1.71±0.22	1.62±0.27	1.56±0.22	0.32	0.14
Ratio Apo B/Apo A1	0.68±0.20	0.73±0.20	0.75±0.27	0.64	0.38
Cholesterol, mmol/L	5.73±0.94	5.80±1.02	5.54±1.23	0.71	0.62
LDL cholesterol, mmol/L	3.75±0.92	3.87±0.87	3.72±1.13	0.82	0.93
HDL cholesterol, mmol/L	1.65±0.45	1.53±0.44	1.48±0.43	0.52	0.29
Triglycerides, mmol/L	1.49±0.88	1.51±1.26	1.41±0.86	0.96	0.84
Systolic blood pressure, mm Hg	121±14	126±14	128±16	0.42	0.24
Diastolic blood pressure, mm Hg	74±6	76±7	76±10	0.69	0.34
Total plasma carotenoids, µmol/L	1.85±0.79	2.06±0.84	2.43±0.85	0.17	0.065
Total plasma alkylresorcinols, nmol/L	27.5±16.7	35.8±32.7	46.3±57.5	0.37	0.23

*Defined as having permanent stress at home or work during the last year or longer.
†Defined as difficulties falling asleep at least once a week or more.
‡Defined as sleeping ≤5 hours or ≥9 hours on average per night.
Apo, apolipoprotein; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

(table 6). In this model, the occurrence of depression was adjusted for variables including prescription medication use, age, BMI, smoking, physical activity level, diet index score, fibre intake and intake of saturated fat. Depression emerged as a statistically significant predictor of an unfavourable Apo B/Apo A1 ratio only among participants living in low SES areas (p=0.019), whereas no significant association was found in high SES areas (p=0.46). Depression increased the odds of an unfavourable Apo B/Apo A1 ratio by 6.41 times among individuals in low SES areas.

DISCUSSION

This pilot study aimed to explore the relationship between adherence to a healthy diet, various risk factors of CVD, psychological factors and sociodemographic variables in a cohort of middle-aged adults. We observed that low adherence to the Swedish national dietary guidelines was associated with risk factors of CVD in women, but not in men. Psychological factors, such as stress and sleep patterns, were not significantly linked to dietary habits. Several factors were identified as predictors of having an unfavourable ratio of Apo B/Apo A1, with different predictors depending on the SES status. However, as a pilot study, these findings should be interpreted with caution, as the sample size may have been too small to detect some associations reliably.

Our data showed that diet quality, as measured by the DQI-SNR, was overall similar in men and women, but more women met the recommended intake of dietary fibre. In a global perspective, women generally report better diet quality than men,[22 23] though results may vary with different diet quality indices.[24] The DQI-SNR we used is validated for the Swedish context and suited our dietary data,[18] though its limited scope in dietary components might overlook some aspects of diet quality.

Interestingly, women with higher diet quality had better cardiovascular profiles, including higher levels of Apo A1 and HDL cholesterol, lower Apo B/Apo A1 ratios and lower blood pressure. Consistent with our findings, a recent umbrella review of meta-analyses concluded that the DASH dietary pattern, similar to that of a healthy Swedish diet, was the most successful dietary pattern in lowering blood pressure.[25] Additionally, higher plasma carotenoid levels were observed in women with good diet quality, consistent with higher fruit and vegetable intake.[17] Conversely, no significant associations were found in men, although a trend towards higher plasma carotenoids with better diet quality was noted. The gender disparity between diet quality and cardiovascular

Table 4 Unadjusted logistic regression model of social, psychological and food-related factors that can predict an unfavourable ratio of Apo B/Apo A1 in women and men

	Ratio good	Univariable model, all n=182	
	OR (ref)	**OR (CI)**	**P value**
Socioeconomic status (1=low, 2=high)	1.0	0.39 (0.16 to 0.93)	**0.033**
Body mass index, kg/m^2	1.0	1.14 (1.01 to 1.28)	**0.030**
Waist circumference, cm	1.0	1.04 (1.00 to 1.09)	**0.038**
Age, y	1.0	0.95 (0.86 to 1.04)	0.26
Current smoker	1.0	2.77 (1.06 to 7.25)	**0.037**
Physical activity level	1.0	0.10 (0.01 to 1.07)	0.057
Stress	1.0	0.73 (0.47 to 1.19)	0.21
Sleep quality	1.0	0.87 (0.60 to 1.28)	0.49
Difficulties falling asleep	1.0	1.07 (0.78 to 1.48)	0.66
Sleep hours	1.0	1.20 (0.84 to 1.73)	0.32
Control in life	1.0	1.21 (0.78 to 1.89)	0.39
Depressed during last year(1=no, 2=yes)	1.0	2.21 (0.84 to 5.68)	0.098
Diet index score	1.0	0.89 (0.68 to 1.17)	0.40
Total plasma carotenoids	1.0	1.18 (0.83 to 1.67)	0.36
Total plasma alkylresorcinols	1.0	0.99 (0.98 to 1.02)	0.85
Alcohol intake (g/day)	1.0	0.98 (0.94 to 1.02)	0.23
Dietary fibre intake (g/day)	1.0	1.00 (0.97 to 1.04)	0.88
Saturated fat intake (g/day)	1.0	0.99 (0.98 to 1.02)	0.93
Energy-adjusted fat (g/day)	1.0	1.04 (0.81 to 1.13)	0.78
Energy-adjusted carbohydrates (g/day)	1.0	1.05 (0.96 to 1.16)	0.31
Energy-adjusted protein (g/day)	1.0	0.89 (0.68 to 1.15)	0.36

Table 5 Unadjusted logistic regression models of background characteristics, psychological and food-related factors that predicted an unfavourable ratio of ApoB/ApoA1, in low and high SES areas, respectively

	Ratio good	Low SES		High SES	
	OR (ref)	OR (CI)	P value	OR (CI)	P value
Body mass index, kg/m^2	1.0	0.99 (0.85 to 1.15)	0.90	1.27 (1.11 to 1.44)	**<0.001**
Waist circumference, cm	1.0	0.99 (0.94 to 1.03)	0.56	1.07 (1.03 to 1.11)	**<0.001**
Age, y	1.0	0.86 (0.76 to 0.97)	**0.016**	0.94 (0.87 to 1.03)	0.17
Current smoker	1.0	2.08 (0.63 to 6.95)	0.23	3.19 (0.56 to 18.19)	0.19
Physical activity level	1.0	0.03 (0.01 to 0.90)	**0.044**	0.32 (0.01 to 8.91)	0.50
Stress	1.0	0.96 (0.59 to 1.55)	0.86	0.93 (0.59 to 1.46)	0.75
Sleep quality	1.0	1.04 (0.58 to 1.86)	0.89	0.78 (0.45 to 1.36)	0.38
Difficulties falling asleep	1.0	1.18 (0.82 to 1.71)	0.37	0.93 (0.67 to 1.28)	0.65
Sleep hours	1.0	0.85 (0.58 to 1.26)	0.42	1.30 (0.85 to 1.98)	0.23
Control in life	1.0	1.06 (0.67 to 1.68)	0.80	0.95 (0.63 to 1.41)	0.78
Depressed during last year (1=no, 2=yes)	1.0	4.21 (1.31 to 13.54)	**0.016**	0.52 (0.17 to 1.58)	0.25
Diet index score	1.0	0.99 (0.73 to 1.37)	0.99	0.91 (0.71 to 1.20)	0.54
Total plasma carotenoids	1.0	1.23 (0.80 to 1.90)	0.35	1.20 (0.83 to 1.75)	0.34
Total plasma alkylresorcinols	1.0	1.00 (0.99 to 1.01)	0.99	1.00 (0.99 to 1.02)	0.84
Alcohol intake (g/day)	1.0	0.99 (0.94 to 1.05)	0.72	0.97 (0.92 to 1.02)	0.28
Dietary fibre intake (g/day)	1.0	0.97 (0.93 to 1.02)	0.25	0.99 (0.96 to 1.03)	0.78
Saturated fat intake (g/day)	1.0	0.99 (0.95 to 1.02)	0.48	1.00 (0.97 to 1.04)	0.88
Energy-adjusted fat (g/day)	1.0	1.40 (0.97 to 2.02)	0.076	0.86 (0.66 to 1.11)	0.23
Energy-adjusted carbohydrates (g/day)	1.0	0.92 (0.81 to 1.04)	0.17	1.05 (0.95 to 1.15)	0.34
Energy-adjusted protein (g/day)	1.0	0.98 (0.73 to 1.32)	0.91	1.21 (0.94 to 1.55)	0.14

profile was unexpected and may partly be explained by the differences in the consumption of dietary fibre, but might as well be attributed to the better accuracy of dietary data reporting found in women compared with men.[16 17] This could also be caused by other unknown factors, which highlight the need for more research to better understand the interplay between diet and risk factors of CVD.

Our logistic regression analyses indicated several predictors of an unfavourable Apo B/Apo A1 ratio, a key marker of cardiovascular risk. These predictors included living in low SES areas, higher BMI, larger waist circumference and smoking. Stratification by SES revealed distinct predictive factors of unfavourable lipid profiles: in low SES areas, age, low physical activity and depression were significant predictors, whereas in high SES areas, higher BMI and larger waist circumference were the main predictive factors. Contrary to our hypotheses, we did not find any significant associations between stress, sleep quality or sleep duration and unfavourable Apo B/Apo A1 ratios. One could speculate that our study was not sufficiently powered to show these associations, as a *post hoc* power calculation suggested that a sample size of 216 individuals would be needed to detect significant differences in sleep quality and diet adherence with 80% power. A previous cross-sectional study among 230 women with type 2 diabetes found associations between better diet quality and mental health status, where women in

Table 6 Multivariable logistic regression model of depression as predictor of an unfavourable ratio of ApoB/ApoA1, divided into individuals living in low and high socioeconomic status areas, respectively

	Ratio good	Low SES		High SES	
Depressed (1=no, 2=yes)	OR (ref)	OR (CI)	P value	OR (CI)	P value
Model 1*	1.0	4.45 (1.13 to 17.56)	**0.033**	0.65 (0.20 to 2.14)	0.48
Model 2†	1.0	6.41 (1.36 to 30.23)	**0.019**	0.64 (0.19 to 2.10)	0.46

*Model 1 adjusted for intake of prescription medication, age, body mass index, smoking and physical activity level.
†Model 2 adjusted for intake of prescription medication, age, body mass index, smoking, physical activity level, diet index score, fibre intake and intake of saturated fat.
SES, socioeconomic status.

the top tertile of diet quality had less risk of depression, anxiety, stress and poor sleep.[26] A meta-analysis by Kwok *et al*[27] showed a dose-response relationship between reported sleep duration >8 hours with an increased risk of all-cause mortality and that subjective poor sleep quality was associated with coronary heart disease. Similarly, a meta-analysis by Saz-Lara[28] showed that poor sleep quality was associated with arterial stiffness in the general population.

Depression emerged as a predictor of an unfavourable lipid profile in low SES participants, even after adjusting for known CVD risk factors like BMI, smoking and physical activity, increasing the odds by 6.4 times. This finding highlights the combined risk of poor mental health and socioeconomic disadvantage on CVD, and the findings are coherent with the REGARDS study,[29] which showed that participants who experienced both stress and depression had the greatest increase in risk of developing CVD, but only for those with low income (<$35 000) and not high income (≥$35 000). The variation in predictors across SES groups suggests that socioeconomic factors may modify the relationship between diet, lifestyle and cardiovascular risk. The absence of significant associations in high SES areas may reflect lifestyle factors that mitigate the impact of depression. The specific pathways are however yet to be elucidated.

Our results underscore the potential of tailored dietary recommendations and interventions that consider both socioeconomic and psychological factors. For individuals in low SES areas, addressing mental health and promoting physical activity may be crucial components of effective cardiovascular risk reduction strategies. Conversely, in higher SES populations, focusing on weight management and central obesity may yield better outcomes.

This study has both strengths and limitations that need to be addressed. A strength with this study is the use of comprehensive and detailed data, both regarding habitual diet, lifestyle factors, psychological factors, as well as biomarkers, to characterise the participants and to be able to account for various factors in the analyses. Also, the recruitment of participants based on a random selection of individuals in the general middle-aged population led to a representative sample with a variation in socioeconomic background, enhancing the generalisability of the results. A strength of the DQI-SNR is that it captures key elements of dietary factors associated with many different health outcomes, but with the drawback that it contains few dietary components. The use of other, more complex diet quality indices that capture more diverse aspects of food consumption might yield different results. As a limitation, the number of participants for an epidemiologic study need to be addressed. The decision of using data from the SCAPIS pilot study was based on the more detailed dietary and biomarker data available, enabling the application of the diet quality index. Thus, with the limited number of participants, these results need to be seen as hypotheses generating, and the results need to be confirmed in larger cohorts.

In conclusion, our study highlights the role of a healthy diet in cardiovascular health and the need for personalised interventions that account for sociodemographic disparities. The impact of psychological factors needs to be further explored, preferably using validated tools to assess the severity of psychological factors, as depression may mediate the association with diet and CVD risk. Future research should continue to explore these relationships using larger sample sizes to enable more robust results.

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