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Development of a diet quality index assessing adherence to the Swedish nutrition recommendations and dietary guidelines in the Malmö Diet and Cancer cohort

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Abstract

Objective: To develop a diet quality index (DQI) that assesses adherence to the Swedish nutrition recommendations (SNR) and the Swedish dietary guidelines (SDG).
Design: A cross-sectional study within the Malmö Diet and Cancer (MDC) cohort. A diet history method collected dietary data, a structured questionnaire lifestyle and socio-economic information, and anthropometric data were collected by direct measurements. The index (DQI-SNR) included six components: SFA, PUFA, fish and shellfish, dietary fibre, fruit and vegetables, and sucrose.
Setting: Malmö, Sweden.
Subjects: Men (*n* 4525) and women (*n* 8491) of the MDC cohort enrolled from September 1994 to October 1996.
Results: For participants with high DQI-SNR scores, nutrient and food intakes were close to recommendations. However, most of the study population exceeded the recommended intake for SFA (98 %) and few reached recommended intakes for dietary fibre (24 %), fruit and vegetables (32 %), vitamin D (18 %) and folate (2 %). A high DQI-SNR score was positively associated with age, physical activity, not smoking, past food habit change, education and socio-economic status. Individuals with high scores were more likely to have a diabetes diagnosis or experienced a cardiovascular event.
Conclusions: Results suggest that the DQI-SNR is a useful tool for assessing adherence to the SNR 2005 and the SDG in the MDC cohort. No index has previously been developed with the aim of evaluating adherence to the current dietary recommendations in Sweden. Further validation of the DQI-SNR, and evaluation of its utility, is needed.

Keywords
Diet
Index
Score
Pattern
Nutrition recommendations

Public Health Nutrition

The complex nature of diet, with specific combinations of foods and nutrients, impedes nutrition epidemiology when investigating diet–disease associations; therefore a dietary pattern approach may be more appropriate when investigating disease outcomes[1–7]. Diet quality indices consist of a combination of foods and/or nutrient components that together represent dietary guidelines[8–10]. The use of index-based dietary patterns is one way to address the complexity of diet, while at the same time evaluating the effectiveness of current dietary guidelines to prevent chronic diseases[11]. Recent reviews have reported more than twenty indices currently in existence[10–14]. Studies using dietary indices have found associations with nutrient adequacy[15–18], biomarkers of disease[19–21], premature mortality[22–26], CVD[27,28] and certain forms of cancer[29,30]. However, few previously constructed indices are suitable for direct application in a Swedish population since most include foods not typically consumed in Swedish diets or are based on dietary guidelines different from those in Sweden.

The official Swedish dietary guidelines consist of the Swedish nutrition recommendations (SNR) 2005 and the Swedish dietary guidelines (SDG)[31,32]. The SNR 2005 are based on the Nordic Nutrition Recommendations 2004 (NNR 2004) and include recommendations for the macronutrient composition of the diet, the daily micronutrient intake, and reference values for energy intake[33]. The NNR 2004 are based on available scientific evidence and provide a basis for evaluating the intake of nutrients in groups of healthy individuals[33]. The SDG are food-based

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dietary guidelines published by the Swedish National Food Administration which communicate the concept of a diet that fulfils the SNR 2005[32]. In order to illustrate the practical application of the SNR 2005, the Swedish Nutrition Recommendations Objectified (SNO) project developed a food intake pattern for adults based on seventy-one foods considered to be representative of Swedish eating habits[34]. A comparison between SNO and the most recent national dietary survey, Riksmaten 1997/98, formed the basis for the main SDG, which aim at increasing the population's intakes of fruit and vegetables, wholegrain products, fish and vegetable oils, and limiting intakes of animal fat, sugar and salt[32,35].

Despite increased public awareness of the importance of diet in decreasing the risk of chronic disease, large gaps remain between current recommendations and actual dietary practices in Sweden[35,36]. The nutritional problems in Sweden relate mainly to a macronutrient distribution with too much fat (especially saturated fat), refined sugar and alcohol, and too little complex carbohydrates and dietary fibre. Micronutrient intakes are generally sufficient apart from deficient intakes of vitamin D, folate and Fe in certain subgroups of the population, and an overconsumption of salt[33,35,36].

The aim of the present study was to develop and evaluate a diet quality index (DQI) that may be used as a tool to distinguish high- and low-quality diets by assessing adherence to the SNR 2005 and SDG.

Materials and methods

Study population

The Malmö Diet and Cancer (MDC) study is a population-based prospective cohort (*n* 28 098). Baseline examinations were conducted between 1991 and 1996, and eligible participants were men born between 1923 and 1945 and women born between 1923 and 1950, living in the city of Malmö and with Swedish reading and writing skills. The MDC study was approved by the Ethical Committee at the Medical Faculty, Lund University (LU 51-90). Details of the recruitment procedures and the cohort are given elsewhere[37,38]. The data collection included dietary habits, socio-economics, medical history and lifestyle habits using questionnaires and interview. Halfway through the baseline data collection, a change of coding routines was implemented in order to reduce interview time. For descriptive studies it has therefore been recommended to use the subset of the population that completed the baseline examinations after this revision[39]. Thus the present study is based on participants, men (*n* 4525) and women (*n* 8466), enrolled in the MDC study after 1 September 1994 (total *n* 12 991).

Dietary assessment

Information on dietary habits was obtained through a modified diet history method combining a 7 d menu book (collecting descriptions of prepared meals, nutrient supplements and cold beverages) and a 168-item quantitative diet questionnaire using both exact frequencies and a picture booklet to assess portion sizes of regularly eaten foods other than prepared meals during the past year. During a 1 h interview, the questionnaire and the menu book were checked so that reported food consumption did not overlap and detailed information was collected on cooking practices and recipes. Energy and nutrient intakes were computed from the reported food intake using the MDC Food and Nutrient Database, originating mainly from PC Kost2-93 of the National Food Administration in Uppsala, Sweden[40]. Data on the validity[41,42] and reproducibility[43] of the method have been published. The relative validity of the MDC method is high compared with other dietary assessment methods in similar populations[44,45].

Socio-economic and lifestyle variables

Information on socio-economic and lifestyle factors was collected from the extensive lifestyle and socio-economic questionnaire. A high educational level was defined in the present study as upper secondary school or higher (more than 11 years). The smoking habits of the participants were defined as current smokers (including irregular smokers), former smokers or never smokers. Leisure-time physical activity was assessed by a list of activities in the questionnaire, modified from the Minnesota Leisure Time Physical Activity Questionnaire[46–48]. Participants were asked to report how many minutes per week on average, and for each of the four seasons, they spend on a specific activity. A physical activity score was obtained by multiplying the number of minutes for each activity with an activity-specific factor. A high leisure-time physical activity was defined as individuals in the highest gender-specific tertile of activity score. Physical activity at work self-rated by participants as very light or light was defined as sedentary work. Alcohol habits were classified as zero, low, moderate or high consumption. Participants reporting no alcohol intake in the 7 d menu book and reporting no alcohol intake during the preceding year in the questionnaire were classified as zero alcohol consumers. For all other participants low, medium and high alcohol consumption level was set at alcohol intakes of <15, 15–30 and >30 g/d for women, and <20, 20–40 and >40 g/d for men. Mattisson *et al.*[49] have previously defined low, adequate and high energy reporters in the MDC cohort using the approach described by Goldberg *et al.*[50] and later refined by Black[51]. Energy misreporting was defined as having a ratio of energy intake to BMR outside the 95 % CI limits of the calculated physical activity level. Past food habit change was based on the questionnaire item 'Have you substantially changed your dietary habits because of illness or another reason?' Previous cardiovascular event (including coronary event or stroke) was determined though local registers and diabetes diagnosis was self-reported by the participants.

NS Public Health Nutrition

Table 1 Summary of the Swedish nutrition recommendations (SNR 2005) and the Swedish dietary guidelines (SDG)

Guidance/component	Description
SNR 2005	
Fat	
Total fat	25–35 %E
SFA and *trans* fatty acids	<10 %E (intake of *trans* fatty acids should be kept as low as possible)
MUFA	10–15 %E
PUFA	5–10 %E (approximately 1 %E from *n*-3 fatty acids)
Essential fatty acids (*n*-6 and *n*-3)	>3 %E (including at least 0·5 %E from *n*-3 fatty acids
Carbohydrates	
Total carbohydrates	50–60 %E
Dietary fibre	25–35 g/d (equivalent to approximately 3 g/MJ)
Added sugars	<10 %E
Protein	
Total protein	10–20 %E
Vitamins and minerals	Daily recommended intakes are available in SNR 2005[31]
Salt	6 g/d for women; 7 g/d for men
Alcohol	<5 %E (10 g/d for women; 20 g/d for men)
SDG	
Fruits and vegetables	500 g/d (at least 400 g/d excluding juices)
Fish and shellfish	2–3 times weekly (about 300 g raw fish, partly fatty)
Dietary fats and oils	Liquid margarine or oil in food preparation
Dry legumes	At least 50 ml cooked legumes daily (10 g dry)
Cereals, rice and potatoes	1–2 portions daily from potato, rice or pasta, bread or cereals to each meal, corresponds to 200–250 g cereals/grains daily; preferably wholegrain
Milk	$\frac{1}{2}$ litre low-fat milk/yoghurt daily, may partly be exchanged with low-fat cheese
Meat and meat products	140 g low-fat meat or meat products daily
Discretionary foods (primarily sweet foods)	Intake of snacks, ice cream, cakes, pastries, biscuits, sweets, chocolate, soft drinks and jam should be minimized and constitute no more than 10 %E

% E, percentage of energy.

Anthropometric variables

Nurses measured height (m), weight (kg), waist and hip circumferences (cm). BMI was calculated as weight divided by the square of height (kg/m^2). Blood pressure (mmHg) was measured after 10 min of rest.

Development of the diet quality index (DQI-SNR)

Index component selection

The SNR and SDG are overlapping and complementary, and therefore both were considered for identification of suitable index components (Table 1). Three main aspects were considered during the selection process. First, information on dietary intake of candidate components had to be available within the MDC cohort. Initial assessment therefore excluded *trans* fatty acids and salt intake, since information on these dietary factors was either lacking or had poor validity. Second, dietary components considered most important in assuring overall diet quality (i.e. food groups and macronutrients) in relation to chronic disease were primarily considered. Third, inter-correlation between components was investigated to assess the mutual independence between components[10,14].

Considering these three aspects, the following components were selected: SFA, PUFA, fish and shellfish, dietary fibre, fruit and vegetables, and sucrose. SFA and PUFA were selected to reflect the fat quality of the diet as well as reflecting the recommendation to use liquid margarine or vegetable oils in food preparation. There is a strong correlation between the subtypes of fat in the MDC cohort. The strong correlation ($r = 0{\cdot}65$) between MUFA and SFA in the MDC cohort suggests that the dietary sources of these two fats are mainly the same (i.e. from meat and dairy products). This has recently been highlighted by a pooled analysis of dietary fat and CHD[52]. Therefore, MUFA was not included as a component. In addition, SFA and PUFA jointly reflect total fat intake and low SFA intake is also likely to reflect a preference for low-fat dairy and low-fat meat products. The different subtypes of PUFA were similarly highly correlated ($r = 0{\cdot}97$) and total PUFA was therefore selected as an index component, as it is likely to reflect intakes of both α-linolenic acid and linoleic acid. Dietary fibre reflects intake of high-fibre cereals (i.e. whole grains; $r = 0{\cdot}39$) and fibre from fruit and vegetables ($r = 0{\cdot}63$). The food-based dietary guideline for increasing dietary fibre intake by choosing fibre-rich foods was recently changed to selecting primarily wholegrain cereals. However, there is no specified amount of recommended whole grains intake; therefore dietary fibre was included as a component to reflect this aspect of diet. Sucrose was included to reflect intake of refined sugars and consumption of sugar-rich foods. Table 2 shows a description of the DQI-SNR.

Cut-offs and scoring

A cut-off for each index component was assigned based on the recommended level of intake in the SNR 2005 or the SDG (see Table 1). A score of 1 was assigned to individuals complying with the recommendation and a score of 0 was assigned to those not complying with the

Table 2 DQI-SNR: components†, cut-offs‡ and differences in component adherence (%) between men (*n* 4525) and women (*n* 8491) of the Malmö Diet and Cancer cohort

Description of DQI-SNR		Adherence		
Index component	Cut-off	Men	Women	*P*§
SFA	≤14	23·3	24·4	0·189
PUFA	5–10	73·0	66·0	<0·0001
Fish and shellfish (g/week)	≥300	48·4	40·8	<0·0001
Dietary fibre (g/MJ)	2·4–3·6	17·1	31·0	<0·0001
Fruit and vegetables (g/d)	≥400	26·1	38·0	<0·0001
Sucrose	≤10	71·8	67·7	<0·0001

DQI-SNR, diet quality index based on the Swedish nutrition recommendations 2005.
†Expressed as non-alcohol energy percentage (%E) unless otherwise noted.
‡Adherence provides 1 point to total score, non-adherence 0 points.
§*P* from χ^2 test. Values for non-adherence are not shown.

recommendation. A total score was created by summing the score of each component, thus total score ranged from 0 to 6. Using predefined cut-offs can cause problems when the population has intake levels that are not close to the recommendation. This was the case for SFA, where only 2 % of the MDC population complied with the recommendation (≤10 % of energy (%E)). Therefore, the cut-off for SFA was defined by adding one standard deviation of the mean population intake to the recommended level, resulting in a new cut-off (≤14 %E). The recommendation for dietary fibre intake is 25–35 g/d (approximately 3 g/MJ). The energy relative recommendation has no defined upper or lower limit, and therefore a similar approach was applied for the dietary fibre component (i.e. ±1 SD of the population mean). The fruit and vegetable component excludes fruit juices and the cut-off was therefore set at ≥400 g/d, instead of the recommended ≥500 g/d (including a maximum of 100 g fruit juices).

Evaluation of the diet quality index (DQI-SNR)

It is important that the index assesses diet quality independent of diet quantity. Because most nutrient intakes are positively correlated with energy intake, a diet quality index could overrate high-energy diets if intakes are measured in terms of absolute amounts. In nutrition epidemiology, energy-adjusted variables ensure the isoenergetic principle and in addition reduce the impact of measurement errors associated with self-reported data[53]. Recommendations for most of the index components are expressed in energy relative terms (%E or g/MJ). However, fish intake and fruit and vegetable intake are expressed as gram per week or d. Energy independence was therefore investigated by examining correlations between components, total score and total energy intake. In addition, since alcohol intake tends to dilute diet composition and has established health effects, we used non-alcohol energy intake for calculation of energy percentage (%E).

The face validity of the index, i.e. quantitative evaluation of how well the index measures what it is supposed to measure[54], was assessed in several ways. First, the correlation between the total score and the index components was investigated to assess the relative weight of components. Second, we examined how total score was associated with nutrient intakes and selected food groups. The nutrient variables investigated in the study included total energy intake and relative intakes of fat (total fat, SFA, MUFA, PUFA, *n*-6 and *n*-3 fatty acids), carbohydrates (including %E from total carbohydrates and dietary fibre intake), protein and alcohol. The intakes of selected vitamins and minerals (including retinol equivalents, vitamin D, vitamin E, thiamin, riboflavin, niacin equivalents, vitamin B_6, folic acid, vitamin B_{12}, ascorbic acid, Ca, P, K, Mg, Se, Zn and Fe) were assessed by investigating the proportion of the study sample reaching the recommended intake levels in the NNR 2004 (g/MJ)[33]. In addition, intakes of fruit and berries, vegetables, fish and shellfish, butter and margarines, cereals, high-fibre cereals, potatoes, rice and pasta, high- and low-fat dairy, high- and low-fat meat, soft drinks, cakes and biscuits, and sweets and chocolate were examined. Third, we examined the concurrent-criterion validity; whether the index can distinguish between groups of people with different lifestyle and socio-economic characteristics that have previously been observed to report diets of diverging quality[54].

Statistical analyses

The proportion of participants meeting each component cut-off was calculated and the χ^2 test was used to compare differences between men and women. Pearson partial correlations were estimated to evaluate inter-correlation among the index components as well as the correlation between index components, energy intake and total score; analysis was adjusted for age, sex and season (autumn, winter, spring, summer). Mean intakes of the DQI-SNR components by total index score were assessed while adjusting for age, season and total energy intake. Because there were few individuals in the low and high DQI-SNR score subgroups, subsequent analyses investigated categories of DQI-SNR score, i.e. low score (0 or 1 point), medium score (2 or 3 points) and high score (4–6 points). Mean nutrient and food intakes were investigated across categories of DQI-SNR score and linear trends across continuous DQI-SNR score were calculated adjusting for age, season and total energy intake. Associations between DQI-SNR score and participant characteristics were investigated using the linear regression coefficient for the DQI-SNR score for continuous variables and the logistic regression coefficient for the DQI-SNR score for dichotomous variables, while adjusting for age and total energy intake. Additional adjustments were made for leisure-time physical activity for anthropometric characteristics and for leisure-time physical activity and BMI for disease history characteristics. The SPSS statistical software package version 17 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses; $P < 0.05$ was considered significant.

Results

Table 2 describes the construction of the DQI-SNR and shows the percentage of men and women adhering to the selected cut-offs. Table 3 shows the correlation coefficients for components, total score and total energy intake. Most components showed low to intermediate intercorrelation. Dietary fibre was negatively correlated with SFA ($r = -0{\cdot}52$). There was also a positive correlation between fruit and vegetables and dietary fibre ($r = 0{\cdot}63$). Total score showed energy independence ($r = -0{\cdot}04$); however, there was some correlation between the individual components and total energy intake. Correlations between individual components and total score ranged from $|r = 0{\cdot}21|$ to $|r = 0{\cdot}53|$.

Population median intake and interquartile range of the DQI-SNR components are shown in Table 4, along with mean intakes of the components across total index score. All trends across score were significant ($P < 0{\cdot}0001$). Mean relative intakes of macronutrients across categories of DQI-SNR score (low, medium and high) are shown in Table 5. All trends were significant with $P < 0{\cdot}0001$; however, the trends were not as clear as for all macronutrients (i.e. total fat and total carbohydrate). Figures 1(a) and 1(b) respectively show the mean intakes of different food groups in the categories of DQI-SNR score among men and women. Participants with a high DQI-SNR score had significantly higher intakes of fruit and berries, vegetables, fish and shellfish, margarines, cereals, high-fibre cereals, low-fat dairy products and meat (all P for

Table 3 Partial correlations† between DQI-SNR components‡, total score and total energy intake among men and women (*n* 12 991) of the Malmö Diet and Cancer cohort

	Energy	SFA	PUFA	Fish and shellfish	Dietary fibre	Fruit and vegetables	Sucrose	Total score
Energy	1·00							
SFA	0·28*	1·00						
PUFA	0·03*	−0·06*	1·00					
Fish and shellfish	0·16*	−0·06*	0·14*	1·00				
Dietary fibre	−0·22*	−0·52*	−0·12*	0·03*	1·00			
Fruit and vegetables	0·18*	−0·28*	−0·08*	0·14*	0·63*	1·00		
Sucrose	0·15*	−0·18*	−0·20*	−0·08*	−0·13*	0·04*	1·00	
Total score	−0·04*	−0·38*	−0·21*	0·40*	0·53*	0·50*	−0·32*	1·00

DQI-SNR, diet quality index based on the Swedish nutrition recommendations 2005.
*$P < 0{\cdot}01$.
†Adjusted for gender, age and season.
‡Dietary variables are expressed as percentage of energy (%E) from non-alcohol energy intake (SFA; PUFA; sucrose), g/MJ (dietary fibre), g/week (fish and shellfish) or g/d (fruit and vegetables).

Table 4 Population median intake and interquartile range of the specific DQI-SNR components†, total energy intake‡ and adjusted mean intakes§ of the DQI-SNR components by index score, among men (*n* 4525) and women (*n* 8491) of the Malmö Diet and Cancer cohort

			DQI-SNR score							
	Median intake	IQR	0	1	2	3	4	5	6	*P* for trend
MEN										
Number of participants			140	634	1462	1338	638	249	64	
Energy intake (MJ/d)			10·9	10·4	10·5	10·6	10·5	10·1	10·2	0·081
SFA	16·3	2·1–38·7	19·2	18·3	17·7	16·7	14·9	13·2	12·1	<0·0001
PUFA	5·9	1·8–15·2	4·3	5·4	6·3	6·4	6·4	6·5	6·4	<0·0001
Fish and shellfish (g/week)	291	0–3690	125	190	267	425	485	503	673	<0·0001
Dietary fibre (g/MJ)	1·9	0·5–8·5	1·6	1·6	1·8	2·0	2·4	2·8	2·9	<0·0001
Fruit and vegetables (g/d)	289	0–3859	216	243	267	324	453	540	603	<0·0001
Sucrose	7·8	0·5–35·5	13·8	10·8	8·3	7·4	7·2	7·2	6·6	<0·0001
WOMEN										
Number of participants			315	1237	2482	2231	1377	668	156	
Energy intake (MJ/d)			8·4	8·4	8·1	8·3	8·1	7·9	7·9	<0·0001
SFA	16·2	3·6–36·2	18·4	18·0	17·7	16·3	15·0	13·9	12·5	<0·0001
PUFA	5·6	1·9–15·6	4·4	5·2	5·9	6·0	6·1	6·2	6·5	<0·0001
Fish and shellfish (g/week)	254	0–2104	143	170	231	330	359	446	525	<0·0001
Dietary fibre (g/MJ)	2·2	0·5–7·4	1·7	1·9	2·0	2·3	2·7	2·8	2·9	<0·0001
Fruit and vegetables (g/d)	349	1–1871	237	273	306	387	496	546	593	<0·0001
Sucrose	8·5	0·7–36·8	13·5	10·8	8·9	8·4	8·1	7·9	7·3	<0·0001

DQI-SNR, diet quality index based on the Swedish nutrition recommendations 2005; IQR, interquartile range.
†Expressed as non-alcohol energy percentage (%E) unless otherwise noted.
‡Adjusted for age and season.
§Adjusted for age, season and total energy intake.

Table 5 Adjusted† mean macronutrient intakes (%E) by categories of DQI-SNR score among men (*n* 4525) and women (*n* 8491) of the Malmö Diet and Cancer cohort

	DQI-SNR score			
Nutrient	Low (0 or 1 point)	Medium (2 or 3 points)	High (4–6 points)	*P* for trend‡
MEN				
Total fat	39·5	40·1	35·9	<0·0001
MUFA	13·6	14·1	12·8	<0·0001
n-6 fatty acids	4·2	5·1	5·1	<0·0001
n-3 fatty acids	0·8	1·0	1·1	<0·0001
Total carbohydrates	45·9	44·2	47·3	<0·0001
Protein	14·5	15·7	16·8	<0·0001
Alcohol	3·6	4·6	4·1	<0·0001
WOMEN				
Total fat	38·6	38·8	35·3	<0·0001
MUFA	13·2	13·4	12·3	<0·0001
n-6 fatty acids	4·1	4·8	4·9	<0·0001
n-3 fatty acids	0·8	1·0	1·0	<0·0001
Total carbohydrates	46·3	45·0	47·6	<0·0001
Protein	15·1	16·2	17·1	<0·0001
Alcohol	2·5	3·0	2·9	<0·0001

%E, percentage of energy; DQI-SNR, diet quality index based on the Swedish nutrition recommendations 2005.
†Adjusted for age, total energy intake and season.
‡*P* for trend was determined using the DQI-SNR score in its continuous form and represents the *P* value associated with the linear regression coefficient for the DQI-SNR score for continuous nutrient variables.

intakes across continuous total index score <0·0001) and lower intakes of butter, high-fat dairy and meat, soft drinks, cakes and biscuits, and sweets and chocolate (all $P<0·0001$). Men and women with a high DQI-SNR score were also more likely to reach the recommended intake levels for most micronutrients (Figs 2(a) and 2(b), respectively). However, although significantly higher intakes of vitamin D and folate (P for trend <0.0001) were found for participants with a high score, most of the study population was below the recommended intake level for both vitamin D (82 %) and folate (98 %). In addition, most participants (close to 100 %) reached the recommended intake level for retinol equivalents, riboflavin, niacin equivalents, vitamin B_6, vitamin B_{12} and P.

Tables 6a and 6b show how selected characteristics of participating men and women are related to DQI-SNR score. Individuals with higher DQI-SNR score were more likely to be older, more physically active during leisure-time and at work, non-smokers, have a higher educational level and socio-economic status, and have changed their food habits in the past. Among women, energy misreporting was also associated with a higher score. In addition, a high score was associated with diabetes diagnosis and a previous cardiovascular event.

Discussion

The present study describes the development of a diet quality index based on the SNR 2005 and the SDG. Such an index could potentially assume several different designs. We designed the DQI-SNR to assess the key dietary factors that are thought to be related to development of chronic disease, under the prerequisite that these would jointly reflect overall diet quality.

One drawback of dietary indices is that it is possible only to compare individuals with high and low scores[10]. A large proportion of the study population was given an intermediate score (i.e. 2 or 3 points) and these individuals could have very different diets. However, intakes of the DQI-SNR components showed significant trends across total score demonstrating the index's capability of separating individuals based on intakes of the selected index components. Results also showed that index score was associated with intakes of several foods groups. Notably, a high score was associated with a diet in accordance with the SDG: choosing margarine instead of butter, high-fibre cereals, low-fat dairy and meat products, and consuming larger amounts of fruit and vegetables. Individuals with high scores also seemed to avoid or consume less high-fat dairy, soft drinks, cakes, biscuits, sweets and chocolate. In addition, index score was associated with intake of several macronutrients other than the components. Individuals with high scores seemed to meet the recommendations for vitamins and minerals to a greater extent, notably for vitamin D, vitamin E, ascorbic acid, K, Mg, Fe, Zn and Se. Only a small proportion of the total study population managed to reach recommended intake of vitamin D (18 %) and folate (2 %), which is in accordance with what is previously known about the nutritional status of Swedish populations[33,35,36]. We have also shown that the DQI-SNR score relates as expected to participant characteristics. For example, one would expect that individuals with higher age, non-smokers, high physical activity level and high educational and socio-economic status would

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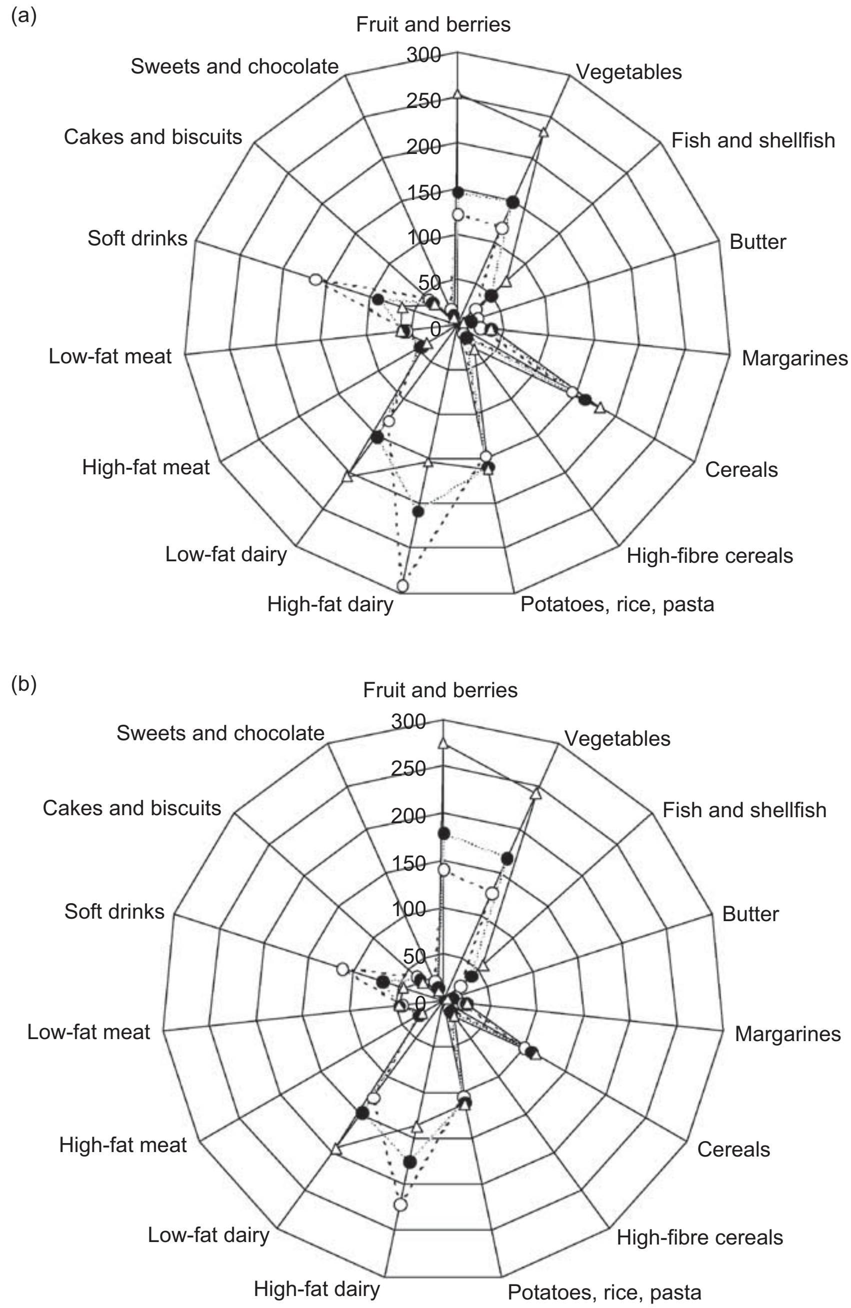

Fig. 1 Mean intake (g/d) of different food groups adjusted for energy intake, age and season in categories of DQI-SNR score (- -○- -, low score (0 or 1 point); · · ● · ·, medium score (2 or 3 points); —△—, high score (4–6 points)) among (a) men (*n* 4525) and (b) women (*n* 8491) of the Malmö Diet and Cancer cohort. All *P* for the linear trends of mean intake across total index score (continuous) were <0·0001 (DQI-SNR, diet quality index based on the Swedish nutrition recommendations 2005)

consume a higher-quality diet, as seen with the DQI-SNR. In addition, individuals reporting to have changed their food habits in the past (due to illness or other reason), having diabetes or having a previous cardiovascular event were more likely to have a higher total score. This is most likely a reflection of the fact that individuals who change their diets due to illness rely on the current dietary recommendations[55]. The associations seen with past food habit change and energy misreporting highlight the importance of excluding these individuals from analysis when investigating associations with disease endpoints.

Overall, the results of our study are consistent with the findings of previous studies using other indices in other populations[15,56–58], as well as with other Swedish studies on dietary habits and nutritional status[33,36].

Recently published reviews on diet quality indices highlighted several unresolved methodological issues of the index approach including the selection of components,

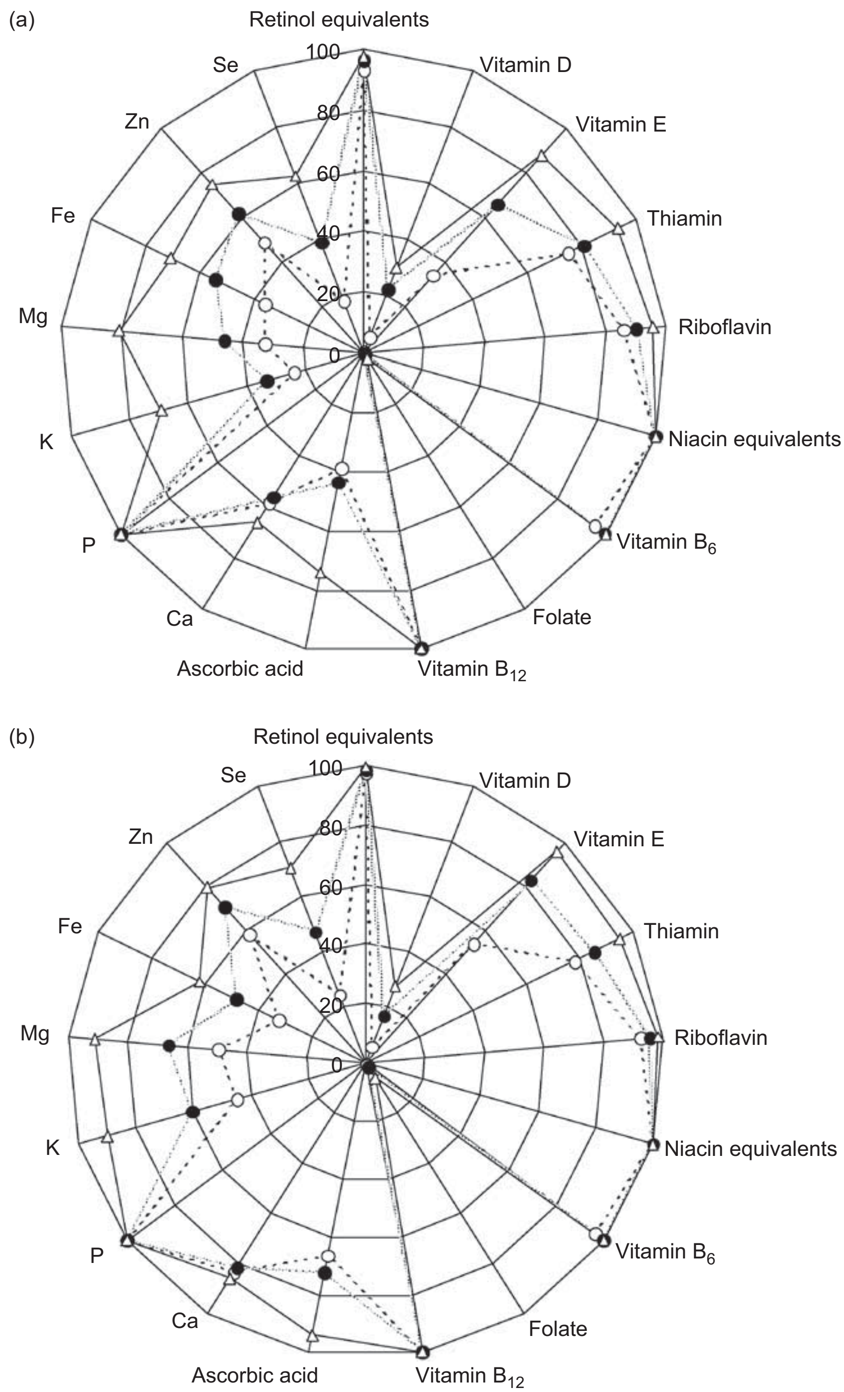

Fig. 2 Adherence (%) to recommended intake level (g/MJ) of selected micronutrients in categories of DQI-SNR score (- -○- -, low score (0 or 1 point); · · ● · ·, medium score (2 or 3 points); —△—, high score (4–6 points)) among (a) men (*n* 4525) and (b) women (*n* 8491) of the Malmö Diet and Cancer cohort (DQI-SNR, diet quality index based on the Swedish nutrition recommendations 2005)

inter-correlation between components, cut-off points and scoring. The subjective decisions made by the researcher regarding these issues may affect the diagnostic capacity of indices[10–12,14].

An important limitation of dietary indices is when some of the index items show high inter-correlation, which can result in some aspects of diet contributing greater weight to the overall index score[10,11]. What level of correlation is acceptable, however, is highly subjective and there are no methodological papers discussing this issue. The inter-correlation between components of the DQI-SNR was low, apart from a negative correlation between dietary fibre intake and SFA ($r = -0{\cdot}54$) and a positive correlation between dietary fibre and fruit and vegetables ($r = 0{\cdot}63$). The correlation between dietary fibre and SFA is an example of an overlap in dietary behaviours that is inherent in the

Table 6a Anthropometric, lifestyle and socio-economic factors, and disease history by categories of DQI-SNR score among men (*n* 4525) of the Malmö Diet and Cancer cohort

	DQI-SNR score			
	Low (0 or 1 point)	Medium (2 or 3 points)	High (4–6 points)	*P* for trend†
No. of participants	774	2800	951	
Age (years)	61·5	61·8	62·3	<0·0001
BMI (kg/m^2)	25·9	26·5	26·7	<0·0001‡
Waist circumference (cm)	92·9	94·4	93·9	0·155‡
Waist-to-hip ratio	0·94	0·95	0·94	0·642‡
High leisure-time physical activity (%)	29·5	32·9	37·1	<0·0001
Sedentary work (%)	39·3	48·0	50·2	<0·0001
Current smokers (%)	34·4	24·5	14·2	<0·0001
Moderate/high alcohol consumption (%)	20·7	31·2	25·2	0·089
Past food habit change (%)	16·3	19·8	34·7	<0·0001
Energy misreporters (%)	13·4	14·6	14·8	0·991
High educational level (%)	27·5	34·0	40·6	<0·0001
High socio-economic status (%)	41·3	46·7	49·7	<0·0001
Blood pressure >140/90 mmHg (%)	27·4	27·4	28·2	0·576§
Previous cardiovascular event (%)	4·8	6·7	9·4	0·001§
Diabetes diagnosis (%)	1·8	4·3	9·3	<0·0001§

DQI-SNR, diet quality index based on the Swedish nutrition recommendations 2005.
†*P* for trend was determined using the DQI-SNR score in its continuous form and represents the *P* value associated with the linear regression coefficient for the DQI-SNR score for continuous variables (age, BMI, waist, waist-to-hip ratio) and the logistic regression coefficient for the DQI-SNR score for dichotomous variables (high leisure-time physical activity, sedentary work, current smokers, moderate/high alcohol consumption, past food habit change, energy misreporting, high educational level, high socio-economic status, blood pressure, previous cardiovascular event and diabetes diagnosis). Analysis adjusted for age (except for mean age across score) and total energy intake, unless otherwise noted.
‡Adjusted for age, total energy intake and leisure-time physical activity.
§Adjusted for age, total energy intake, leisure-time physical activity and BMI.

Table 6b Anthropometric, lifestyle and socio-economic factors, and disease history by categories of DQI-SNR score among women (*n* 8491) of the Malmö Diet and Cancer cohort

	DQI-SNR score			
	Low (0 or 1 point)	Medium (2 or 3 points)	High (4–6 points)	*P* for trend†
No. of participants	1552	4713	2201	
Age (years)	57·1	57·3	58·3	<0·0001
BMI (kg/m^2)	25·0	25·5	25·7	<0·0001‡
Waist circumference (cm)	77·4	78·3	78·4	0·004‡
Waist-to-hip ratio	0·80	0·81	0·80	0·579‡
High leisure-time physical activity (%)	29·3	32·2	38·3	<0·0001
Sedentary work (%)	41·7	43·0	42·7	0·484
Current smokers (%)	32·7	25·5	16·0	<0·0001
Moderate/high alcohol consumption (%)	16·0	19·5	16·4	0·123
Past food habit change (%)	16·5	20·7	31·9	<0·0001
Energy misreporters (%)	17·8	19·1	22·7	0·001
High educational level (%)	31·7	33·4	37·9	<0·0001
High socio-economic status (%)	27·9	32·7	35·9	<0·0001
Blood pressure >140/90 mmHg (%)	16·0	16·8	16·2	0·040§
Previous cardiovascular event (%)	1·4	1·5	1·9	0·395§
Diabetes diagnosis (%)	1·2	2·0	4·5	<0·0001§

DQI-SNR, diet quality index based on the Swedish nutrition recommendations 2005.
†*P* for trend was determined using the DQI-SNR score in its continuous form and represents the *P* value associated with the linear regression coefficient for the DQI-SNR score for continuous variables (age, BMI, waist, waist-to-hip ratio) and the logistic regression coefficient for the DQI-SNR score for dichotomous variables (high leisure-time physical activity, sedentary work, current smokers, moderate/high alcohol consumption, past food habit change, energy misreporting, high educational level, high socio-economic status, blood pressure, previous cardiovascular event and diabetes diagnosis). Analysis adjusted for age (except for mean age across score) and total energy intake, unless otherwise noted.
‡Adjusted for age, total energy intake and leisure-time physical activity.
§Adjusted for age, total energy intake, leisure-time physical activity and BMI.

SNR 2005 (i.e. individuals consuming low-fat and high-fibre diets). Since there is no specified recommendation for intake of wholegrain cereals, dietary fibre was included to reflect intake of wholegrain/fibre-rich cereals. However, the high correlation between fibre and fruit and vegetables suggests some degree of overlap which will have to be investigated in future studies using this index. Despite using energy-adjusted components to a great extent, correlation with energy intake remained for some components as well as a very low correlation with total score. As other researchers have noted previously[59,60], this suggests that the energy density method is not sufficient for complete energy adjustment. Therefore, it will be important to adjust for total energy intake in diet–disease analyses using the DQI-SNR.

Another potential limitation is the categorization of food and nutrient intake into dichotomies of 'compliance' and 'non-compliance'. Such categorization can conceal the true variability in the intake data and diminish the range of scores[10,14]. In the present study we opted for simplicity and used simple cut-offs for all components in order to evaluate adherence to the recommended intake levels. However, in order to provide sufficient discriminatory power for the SFA component, we had to add 1 SD of the population mean to the cut-off value. In other study populations researchers should investigate the possibility of using the recommended intake as a cut-off (i.e. $<10\,\%$E). In addition, future studies need to examine the influence of each component as a continuous variable on disease outcome separately in the search for potential cut-offs with improved predictability.

Finally, the dietary assessment method used in the MDC is a diet history method, reflecting usual intake. Although the high relative validity of the method is a great advantage, it is not ideal for evaluating absolute intakes[39]. We therefore used relative intakes of most components, as well as for evaluation of nutrient intakes across total score. However, the fruit and vegetable component as well as the fish and shellfish component were based on absolute intakes (g/d or g/week) and thus the cut-offs for these components may not be appropriate. Previous studies within the MDC cohort have found that fruit and vegetable intake tends to be over-reported[41].

Several dietary indices have previously been constructed. However, the Mediterranean Diet Score and the Healthy Diet Indicator for instance include food groups (e.g. olive oil and legumes) not consumed in large amounts in Swedish diets[22]. Also, no previous score has specifically addressed the Swedish dietary recommendations. In addition, few studies consider inter-correlation between components. For example, the Recommended Food Score developed by Kant *et al.*[26], which has previously been successfully applied in a Swedish cohort[61], includes thirty-six recommended foods whereof a majority is fruit and vegetables, suggesting the possibility that this index is merely a reflection of fruit and vegetable intake rather than overall diet quality.

In conclusion, the results suggest that the DQI-SNR is a useful tool for assessing adherence to the SNR 2005 and the SDG. Future studies need to validate the DQI-SNR in relation to biochemical and clinical indicators of nutritional status, as well as assess its utility in assessing risk of mortality and morbidity. Also, the utility of the index needs to be examined in other population and age groups.

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