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Mediterranean and Nordic diet scores and long-term changes in body weight and waist circumference: results from a large cohort study

Yingjun Li[1,2†], Nina Roswall[2,3†], Peter Ström[2], Sven Sandin[2], Hans-Olov Adami[2,4] and Elisabete Weiderpass[2,5,6,7]*

[1]*Department of Epidemiology and Health Statistics, School of Public Health, Zhejiang University, 310058 Hangzhou, People's Republic of China*
[2]*Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, 171 77 Stockholm, Sweden*
[3]*Danish Cancer Society Research Center, 2100 Copenhagen, Denmark*
[4]*Department of Epidemiology, Harvard T. H. Chan School of Public Health, Boston, MA 02115, USA*
[5]*Department of Community Medicine, Faculty of Health Sciences, University of Tromsø, The Arctic University of Norway, 9037 Tromsø, Norway*
[6]*Genetic Epidemiology Group, Folkhälsan Research Center, 00290 Helsinki, Finland*
[7]*The Cancer Registry of Norway, 0304 Oslo, Norway*

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Abstract

Dietary patterns, which represent a broader picture of food and nutrient consumption, have gained increasing interest over the last decades. In a cohort design, we followed 27 544 women aged 29–49 years from baseline in 1991–1992. We collected data from an FFQ at baseline and body weight (BW) and waist circumference (WC) data both at baseline and at follow-up in 2003. We calculated the Mediterranean diet score (MDS, ranging from 0 to 9) and the Nordic diet score (NDS, ranging from 0 to 6). We used linear regression to examine the association between MDS and NDS (exposures) with subsequent BW change (ΔBW) and WC change (ΔWC) (outcomes) both continuously and categorically. Higher adherence to the MDS or NDS was not associated with ΔBW. The multivariable population average increment in BW was 0·03 kg (95 % CI −0·03, 0·09) per 1-point increase in MDS and 0·04 kg (95 % CI −0·02, 0·10) per 1-point increase in NDS. In addition, higher adherence to the MDS was not associated with ΔWC, with the multivariable population average increment per 1-point increase in MDS being 0·05 cm (95 % CI −0·03, 0·13). Higher adherence to the NDS was not significantly associated with gain in WC when adjusted for concurrent ΔBW. In conclusion, a higher adherence to the MDS or NDS was not associated with changes in average BW or WC in the present cohort followed for 12 years.

Key words: Mediterranean diet score: Nordic diet score: Body weight change: Waist circumference change: Cohort studies

The rising prevalence of overweight and obesity has been described as a global pandemic(1). In 2010, overweight and obesity were estimated to cause 3·4 million deaths, and account for 4 % of years of life lost and 4 % of disability-adjusted life-years worldwide(2). Over the last decades, in parallel to the growing amount of research focusing on the correlation between diet and obesity, the scientific community has taken an increasing interest in dietary patterns. Such patterns represent a broader picture of food and nutrient consumption and might be more predictive of disease risk than are individual foods or nutrients(3). For several decades, observational and experimental studies have suggested a beneficial effect of the Mediterranean diet on obesity, despite some inconsistency(4–8).

Recently, a healthy Nordic diet has gained interest. Locally produced items included in this diet are whole grains (rye, oats), cabbage, root vegetables, apples/pears, fish and berries(9,10). Adherence to a healthy Nordic diet has been associated with a decrease in body weight (BW) in a 6-week intervention trial including eighty-six mildly hypercholesterolaemic subjects(11). In another 26-week intervention trial(12), an inverse association of change in BW and waist circumference (WC) with Nordic diet was observed among 147 obese subjects but vanished after 12 months of follow-up(13). An intervention study on 166 obese subjects found no effect of Nordic diet on BW over an 18–24-week period(14).

Based on this background, the present study aimed: (1) to test prospectively the association of adherence to the

Abbreviations: ΔBW, BW change; ΔWC, WC change; BW, body weight; MDS, Mediterranean diet score; NDS, Nordic diet score; WC, waist circumference.

* **Corresponding author:** Professor E. Weiderpass, fax +358 919125727, email elisabete.weiderpass@ki.se

† These authors contributed equally to the project and share first authorship.

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Mediterranean diet with BW change (ΔBW) and WC change (ΔWC); (2) to test prospectively the association of adherence to the healthy Nordic diet with ΔBW and ΔWC; and (3) to compare the association of the two dietary patterns with ΔBW and ΔWC in the Swedish Women's Lifestyle and Health (WLH) cohort over a 12-year period, 1991–2003. Most importantly, the primary aim of this study was to address long-term changes in anthropometric measures in a generally healthy population, whereas most existing studies focused on the changes following short-term dietary interventions in high-risk groups.

Methods

Study population

The study cohort and data collection have been described in detail previously[15]. In brief, the source population of this study was women aged 29–49 years and residing in the Uppsala Health Care Region in Sweden between 1991 and 1992. A random sample of 96 000 women were asked to fill in a mailed baseline questionnaire on diet, lifestyle and socio-economic factors, including BW and WC. Of those invited, 49 259 (51 %) returned the baseline questionnaire.

In 2003, a follow-up questionnaire was sent to women who were still alive to update information on BW and WC as well as lifestyle changes. A total of 34 402 women returned the follow-up questionnaire. Thus, all the information on diet, lifestyle, socio-economic factors and anthropometric measures were self-reported.

We excluded 6454 (13·1 %) of the women: 2634 with a diagnosis of cancer, CVD, or diabetes before baseline or during the follow-up period; 1098 who died or emigrated between baseline and follow-up; 966 with an energy intake outside the 1st (1840 kJ/d) and 99th (12 232 kJ/d) percentiles; and 1756 who were pregnant at baseline or during follow-up. Furthermore, 13 394 and 20 857 subjects lacked the information on BW and WC, respectively, in the follow-up questionnaire. In all, 1867 and 1274 subjects with missing values on other included variables were excluded from the data set of ΔBW and ΔWC, respectively. The remaining 27 544 and 20 674 women were included in the final analyses for ΔBW and ΔWC, respectively.

The study was approved by the regional Ethical Committee at Uppsala University and the Ethical Committee at Karolinska Institutet, Stockholm, Sweden.

Dietary assessment

The baseline questionnaire included a validated FFQ that assessed the frequency and quantity of approximately eighty food items and beverages consumed during the 6 months preceding study recruitment[16]. Reported consumption of foods and beverages was then translated into nutrient and energy intakes, using the Swedish National Food Administration database[17].

Mediterranean diet score

This study used the previously developed Mediterranean diet score (MDS), which includes nine components that are characteristic of the Mediterranean diet[18]. We calculated the median consumption of each component in the WLH cohort and constructed an MDS for each participant based on her consumption of each component compared with that of the overall cohort. We treated components differently according to whether they are traditionally consumed more or less in Mediterranean countries. We assigned components that are more frequently consumed, such as vegetables, fruits/nuts, legumes, cereals, fish/seafood and a high ratio of unsaturated fat:SFA, a value of 1 if a participant's consumption was above the cohort median for that component and a value of 0 if it was otherwise. For components that are less frequently consumed in Mediterranean countries (i.e. dairy and meat products), we assigned a value of 1 if a participant's consumption was below the cohort median and 0 if it was otherwise. For alcohol, a value of 1 was given to subjects with moderate consumption (5–25 g/d) and a value of 0 if it was otherwise. We then summed the values for all components (equal to either 0 or 1) to obtain a participant's MDS. The score varied between 0 and 9; the higher the score, the closer the adherence to a Mediterranean dietary pattern. We considered the following three adherence groups: low adherers (those scoring 0–3 points), medium adherers (those scoring 4–5 points) and high adherers (those scoring 6–9 points).

Nordic diet score

The Nordic diet score (NDS), originally developed and tested by Olsen *et al.*[9], is based on traditional Nordic foods chosen *a priori* on the basis of expected health benefits. The food items had to grow naturally in the Nordic countries, had to be an essential part of the Nordic diet and had to have information available from the FFQ. This resulted in the inclusion of six food groups: whole grain bread, oatmeal, apples/pears, cabbage, root vegetables and fish/shellfish[19]. We calculated median consumption of each food group and constructed the NDS for each participant based on the consumption of each food group compared with the median consumption of all study participants. One point was given for above-median intake and 0 points for below-median intake for each item. For whole grain bread and oatmeal, the median intake was 0 as >50 % of the cohort did not consume these two components (Table 1). Thus, 1 point instead was given to all participants with any intake of whole grain bread (44·2 %) and oatmeal (41·1 %). A score of 0 or 1 was given to each participant for each of the six dietary components in the index, thus each participant could score between 0 (poorest adherence) and 6 points (best adherence). We considered the following three adherence groups: low adherers (those scoring 0–1 point), medium adherers (those scoring 2–3 points) and high adherers (those scoring 4–6 points).

Statistical analyses

Linear regression was used to examine the association between MDS and NDS (exposures) with subsequent ΔBW and ΔWC (outcomes). In the first model, we adjusted for age (years), height (cm) and baseline measure of BW (kg) and WC (cm).

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Table 1. Intake of food groups in the Mediterranean diet score (MDS) and the Nordic diet score (NDS) at baseline (Medians and 10th and 90th percentiles (P))

	Baseline (*n* 27 544)		
	Median	P10	P90
MDS component (g/d)			
Legumes	18	0	42
Vegetables	63	24	124
Cereals	184	101	306
Fish/seafood	23	8	42
Fruits and nuts	139	40	296
Unsaturated fat:SFA	1	1	1
Dairy products	332	33	690
Meat	84	42	137
Alcohol	3	1	8
MDS	4	2	6
NDS component (g/d)			
Whole grain bread	0	0	49
Oatmeal	0	0	70
Apples/pears	35	4	123
Cabbage	8	0	27
Root vegetables	13	3	42
Fish and shellfish	21	7	39
NDS	3	1	5

In a fully adjusted model, we also included smoking status (categorical, never/former/current) as well as cigarettes smoked per d for former and current smokers (categorical, <10/10–14/15–19/≥20), education level (categorical, ≤10/11–13/≥14 years), physical activity (PA) (categorical, very low/low/normal/high/very high) and energy intake (kJ/d) for MDS and smoking status, cigarettes smoked per d for former and current smokers, education level, PA, alcohol consumption (g/d), energy intake and red/processed meat intake (g/d) for NDS.

As almost 30·2 % of the participants failed to return the follow-up questionnaire, a logistic regression model was used to predict the probability of the drop-outs of outcomes by adjusting for other related covariates including diet, lifestyle, socio-economic factors and baseline anthropometric measures. We used the predictors of drop-outs of outcomes as weight in all of the linear regression models to give more weight to subjects who were more likely to drop out, based on her answers in the baseline questionnaire. The weight should be the inverse of the probability of not dropping out. The estimates of adherence to the MDS and NDS were estimated by treating the scores both continuously (per 1-point increment) and categorically (0–3, 4–5, 6–9 points for MDS and 0–1, 2–3, 4–6 points for NDS). Furthermore, to assess associations that were independent of ΔBW, the analysis with ΔWC as outcome was performed both with and without adjustment for concurrent ΔBW[20].

We calculated the changes in BW and WC by adherence group of MDS and NDS and plotted these in box-and-whisker plots, including joined medians to graphically illustrate the development across adherence groups. We further performed stratified analyses by age category (<40/≥40 years) to detect potential effect modification of the association between MDS and NDS with ΔBW and ΔWC.

From a graphical evaluation, the assumptions for the linear regression were considered met. *P* values < 0·05 were regarded as statistically significant. All analyses were performed using SAS software version 9.4 (SAS Institute Inc.).

Results

Baseline characteristics

Table 1 shows the median intakes of food groups of the MDS and NDS, with the 10th and 90th percentiles, for all participants analysed in ΔBW. The median MDS was 4 (10th, 90th percentiles 2, 6) and the median NDS was 3 (10th, 90th percentiles 1, 5).

The baseline distribution of possible confounders for participants with different score categories of MDS and NDS is shown in Table 2. Compared with participants with low scores, participants who scored high on the MDS had a longer education, greater intake of energy, were more physically active and less likely to be smokers. Otherwise, the age, height, BW, WC, ΔBW and ΔWC of participants were similar across adherence groups. The same trend was observed across different score categories of NDS.

Mediterranean diet score and Nordic diet score in relation to body weight change and waist circumference change

MDS and NDS were not associated with ΔBW in any group. When we assessed the score as a linear variable, the multivariable population average increment was 0·03 kg (95 % CI −0·03, 0·09; *P* = 0·19) per 1-point increase in MDS and 0·04 kg (95 % CI −0·02, 0·10; *P* = 0·19) per 1-point increase in NDS. In the categorical analyses, high adherers of MDS and NDS had a multivariable population average increment of 0·14 kg (95 % CI −0·08, 0·36; *P* = 0·20) and 0·18 kg (95 % CI −0·06, 0·42; *P* = 0·15), respectively. In addition, higher adherence to the MDS was not associated with ΔWC, with the multivariable population average increment per 1-point increase being

Table 2. Changes in baseline characteristics and anthropometric measures from 1991 to 2003 among the participants in the Women's Lifestyle and Health cohort by adherence to the Mediterranean diet score (MDS; 0–3, 4–5 and 6–9 points) and Nordic diet score (NDS; 0–1, 2–3 and 4–6 points)
(Number and percentage; medians and 10th and 90th percentiles (P))

			MDS						NDS					
	All		0–3		4–5		6–9		0–1		2–3		4–6	
Characteristics	Median	P10, P90	Median	P10, P90	Median	P10, P90	Median	P10, P90	Median	P10, P90	Median	P10, P90	Median	P10, P90
n	27 544		9434		11 757		6353		5425		12 602		9517	
%			34·3		42·7		23·1		19·7		45·8		34·6	
Age (years)	40	32, 47	40	32, 47	40	32, 47	41	33, 47	40	32, 47	40	32, 47	40	32, 47
Height (cm)	166	159, 173	166	159, 173	166	159, 173	166	159, 173	166	158, 173	166	159, 173	166	159, 173
Weight (kg)	63·0	53·0, 78·0	63·0	53·0, 78·0	63·0	54·0, 78·0	63·0	54·0, 77·0	62·0	52·0, 76·0	63·0	54·0, 78·0	63·0	54·0, 78·0
BMI (kg/m^2)	23·0	20·0, 27·5	23·0	20·0, 27·5	23·0	20·0, 28·0	22·5	20·0, 27·5	22·5	19·5, 27·5	22·5	20·0, 27·5	23·0	20·0, 28·0
WC (cm)	75·0	68·0, 88·0	75·0	68·0, 88·0	75·0	68·0, 88·0	75·0	67·0, 87·0	75·0	67·0, 88·0	75·0	68·0, 88·0	75·0	68·0, 88·0
ΔBW (kg)	5·0	−1·0, 13·0	5·0	−1·0, 13·0	5·0	−1·0, 13·0	5·0	−1·0, 12·0	5·0	−2·0, 13·0	5·0	−1·0, 13·0	5·0	−1·0, 13·0
ΔWC (cm)	7·0	−1·0, 17·0	7·0	−1·0, 17·0	7·0	−1·0, 17·0	7·0	−1·0, 16·0	7·0	−1·0, 17·0	7·0	−1·0, 17·0	7·0	−1·0, 16·0
Education (%)														
≤10 years	27·8		32·6		26·2		23·6		33·6		29·1		22·6	
11–13 years	39·3		41·0		39·1		37·0		40·4		39·0		39·0	
≥14 years	33·0		26·4		34·7		39·5		26·0		31·9		38·4	
Smoking status (%)														
Never	42·3		39·6		44·1		43·1		35·8		41·2		47·5	
Former	30·5		28·0		30·2		34·8		28·0		30·3		32·3	
Current	27·2		32·4		25·7		22·1		36·2		28·5		20·2	
PA (%)														
Very low	3·6		5·0		3·1		2·2		6·3		3·6		2·0	
Low	10·8		12·2		10·7		8·7		12·7		11·3		9·0	
Normal	58·8		60·3		58·5		56·9		57·9		59·4		58·4	
High	18·1		15·4		18·7		21·2		15·5		17·4		20·6	
Very high	8·8		7·1		8·9		11·0		7·6		8·4		9·9	
Energy intake (kJ/d)	6419·2	4276·22, 9029·3	6034·6	3933·8, 8589·2	6503·1	4343·1, 9177·0	6849·5	4799·5, 9260·1	5488·0	3463·3, 7947·1	6289·4	4308·2, 8720·3	7125·7	5080·7, 9630·1

WC, waist circumference; ΔBW, body weight change; ΔWC, waist circumference change; PA, physical activity.

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Table 3. Association of Mediterranean diet score (MDS)* and Nordic diet score (NDS)† with changes in body weight (ΔBW, kg) and in waist circumference (ΔWC, cm) from 1991 to 2003
(Medians and 10th and 90th percentiles (P); *β* coefficients and 95 % confidence intervals)

	Average change		Model 1			Model 2		
	Median	P10, P90	*β*	95 % CI	*P*	*β*	95 % CI	*P*
ΔBW (*n* 27 544)								
MDS per 1-point increase	5	−1·0, 13·0	−0·01	−0·05, 0·03	0·75	0·03	−0·03, 0·09	0·19
MDS category								
0–3	5	−1·0, 13·0	0	Ref.	–	0	Ref.	–
4–5	5	−1·0, 13·0	0·04	−0·14, 0·22	0·70	0·14	−0·04, 0·32	0·15
6–9	5	−1·0, 12·0	−0·03	−0·25, 0·19	0·81	0·14	−0·08, 0·36	0·20
NDS per 1-point increase	5	−1·0, 13·0	−0·02	−0·08, 0·04	0·54	0·04	−0·02, 0·10	0·19
NDS category								
0–1	5	−2·0, 13·0	0	Ref.	–	0	Ref.	–
2–3	5	−1·0, 13·0	0·01	−0·21, 0·23	0·95	0·11	−0·11, 0·33	0·34
4–6	5	−1·0, 13·0	−0·03	−0·27, 0·21	0·76	0·18	−0·06, 0·42	0·15
ΔWC (*n* 20 674)								
MDS per 1-point increase	7	−1·0, 17·0	−0·05	−0·13, 0·03	0·21	0·05	−0·03, 0·13	0·24
MDS category								
0–3	7	−1·0, 17·0	0	Ref.	–	0	Ref.	–
4–5	7	−1·0, 17·0	−0·01	−0·30, 0·28	0·94	0·24	−0·05, 0·53	0·12
6–9	7	−1·0, 16·0	−0·26	−0·61, 0·09	0·14	0·13	−0·22, 0·48	0·47
NDS per 1-point increase	7	−1·0, 17·0	−0·05	−0·13, 0·03	0·26	0·10	0·00, 0·20	0·04
NDS category								
0–1	7	−1·0, 17·0	0	Ref.	–	0	Ref.	–
2–3	7	−1·0, 17·0	−0·04	−0·39, 0·31	0·82	0·24	−0·13, 0·61	0·19
4–6	7	−1·0, 16·0	−0·19	−0·56, 0·18	0·31	0·38	−0·01, 0·77	0·06
WC change$_{\Delta BW}$ (*n* 20 564)								
MDS per 1-point increase	7	−1·0, 17·0	−0·05	−0·13, 0·03	0·13	0·02	−0·06, 0·10	0·56
MDS category								
0–3	7	−1·0, 17·0	0	Ref.	–	0	Ref.	–
4–5	7	−1·0, 17·0	−0·08	−0·33, 0·17	0·57	0·11	−0·16, 0·38	0·40
6–9	7	−1·0, 16·0	−0·31	−0·62, 0·00	0·05	−0·01	−0·32, 0·30	0·94
NDS per 1-point increase	7	−1·0, 17·0	−0·05	−0·13, 0·03	0·17	0·06	−0·02, 0·14	0·16
NDS category								
0–1	7	−1·0, 17·0	0	Ref.	–	0	Ref.	–
2–3	7	−1·0, 17·0	−0·08	−0·39, 0·23	0·63	0·13	−0·18, 0·44	0·42
4–6	7	−1·0, 16·0	−0·22	−0·55, 0·11	0·20	0·21	−0·14, 0·56	0·23

β, Average change per 1-point increase in diet score; Ref., referent values; WC change$_{\Delta BW}$, further adjusted for concurrent ΔBW.
* For MDS: model 1, adjusted for age, height and baseline outcome; model 2, model 1 plus smoking habits, education, physical activity (PA) and energy intake.
† For NDS: model 1, adjusted for age, height and baseline outcome; model 2, model 1 plus smoking habits, education, PA, alcohol consumption, red/processed meat and energy intake.

0·05 cm (95 % CI −0·03, 0·13; $P=0·24$) and high adherers having an increment of 0·13 cm (95 % CI −0·22, 0·48; $P=0·47$) in the categorical analyses. Higher adherence to the NDS was associated with ΔWC, with the multivariable population average increment per 1-point increase in NDS being 0·10 cm (95 % CI 0·00, 0·20; $P=0·04$). However, the association became not statistically significant when adjusted for concurrent ΔBW. In the categorical analyses of ΔWC, the multivariable population average increment was 0·38 cm (95 % CI −0·01, 0·77; $P=0·06$) for high adherers of NDS (Table 3).

We further divided the changes of BW and WC (outcomes) into two categories: substantial change (≥90 % change); and normal change (<90 % change). A logistic regression model was used to evaluate the association between diet scores and substantial changes in BW and WC. However, no significant association was found in fully adjusted models for MDS and NDS (results not shown). We also conducted a sensitivity analysis in the data set, which included subjects with a diagnosis of cancer, CVD, or diabetes before baseline or during the follow-up period and subjects who were pregnant at baseline or during the follow-up; the results were similar to the complete data set (results not shown).

Food components in Mediterranean diet score and Nordic diet score in relation to body weight change and waist circumference change

When examining the association between the nine individual food components of the MDS and ΔBW and ΔWC, we found a statistically significant increase in BW and WC with higher intake of vegetables ($P<0·001$ for both ΔBW and ΔWC), unsaturated fat: SFA ($P<0·001$ for both ΔBW and ΔWC) and dairy product intake ($P<0·001$ for ΔBW and $P=0·04$ for ΔWC). A higher meat intake was associated with a gain in WC (*β* 0·38; 95 % CI 0·11, 0·65; $P=0·01$) but not BW (*β* 0·09; 95 % CI −0·09, 0·27; $P=0·34$) (Table 4). At the same time, no statistically significant associations were observed when we examined the association of six individual food components of the NDS with ΔBW. Higher intake of cabbage was significantly associated with an increment in WC (*β* 0·31; 95 % CI 0·04, 0·58; $P=0·03$) (Table 5).

Analysis stratified by age

No statistically significant interaction was observed between MDS and age ($P_{interaction}=0·75$ in ΔBW; $P_{interaction}=0·57$ in ΔWC).

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Table 4. Association of the intakes of food components in the Mediterranean diet score with changes in body weight (ΔBW, kg) and in waist circumference (ΔWC, cm) from 1991 to 2003 (*β* Coefficients and 95 % confidence intervals)

	ΔBW (*n* 27 544)						ΔWC (*n* 20 674)					
	Model 1*			Model 2†			Model 1*			Model 2†		
	β	95 % CI	*P*	*β*	95 % CI	*P*	*β*	95 % CI	*P*	*β*	95 % CI	*P*
Legumes												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	−0·0	−0·16, 0·16	0·97	−0·01	−0·17, 0·15	0·87	−0·20	−0·45, 0·05	0·13	−0·17	−0·44, 0·10	0·20
Vegetables												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	0·19	0·03, 0·35	0·02	0·27	0·09, 0·45	<0·001	0·20	−0·05, 0·45	0·13	0·44	0·17, 0·71	<0·001
Cereals												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	−0·28	−0·44, −0·12	<0·001	−0·19	−0·39, 0·01	0·07	−0·63	−0·88, −0·38	<0·001	−0·25	−0·58, 0·08	0·13
Fish/seafood												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	0·06	−0·10, 0·22	0·49	0·05	−0·13, 0·23	0·58	−0·06	−0·31, 0·19	0·67	−0·0	−0·27, 0·27	1·00
Fruits												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	−0·04	−0·20, 0·12	0·58	0·01	−0·17, 0·19	0·86	−0·33	−0·58, −0·08	0·01	−0·12	−0·39, 0·15	0·39
Unsaturated fat:SFA												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	0·36	0·20, 0·52	<0·001	0·36	0·18, 0·54	<0·001	0·72	0·47, 0·97	<0·001	0·66	0·39, 0·93	<0·001
Dairy products												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	0·15	−0·01, 0·31	0·07	0·31	0·13, 0·49	<0·001	−0·04	−0·29, 0·21	0·78	0·30	0·03, 0·57	0·04
Meat												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	0·11	−0·05, 0·27	0·17	0·09	−0·09, 0·27	0·34	0·31	0·06, 0·56	0·02	0·38	0·11, 0·65	0·01
Alcohol												
<5 or >25 g/d	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
5–25 g/d	−0·16	−0·36, 0·04	0·12	−0·19	−0·39, 0·01	0·07	0·0	−0·31, 0·31	0·99	−0·10	−0·43, 0·23	0·56

β, Average change per 1-point increase in diet score; Ref., referent values.
* Model 1: adjusted for age, height and baseline outcome.
† Model 2: model 1 plus smoking habits, education, physical activity, energy intake and mutually adjusted for the all other food components.

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Table 5. Association of the intakes of food components in the Nordic diet score with changes in body weight (ΔBW, kg) and in waist circumference (ΔWC, cm) from 1991 to 2003 (*β* Coefficients and 95 % confidence intervals)

	ΔBW (*n* 27 544)						ΔWC (*n* 20 674)					
	Model 1*			Model 2†			Model 1*			Model 2†		
	β	95 % CI	*P*	*β*	95 % CI	*P*	*β*	95 % CI	*P*	*β*	95 % CI	*P*
Whole grain bread												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	0·03	–0·13, 0·19	0·69	0·02	–0·14, 0·18	0·85	–0·10	–0·35, 0·15	0·45	–0·11	–0·38, 0·16	0·42
Oatmeal												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	–0·16	–0·32, 0·00	0·05	–0·09	–0·25, 0·07	0·29	–0·15	–0·40, 0·10	0·26	0·06	–0·21, 0·33	0·65
Apples/pears												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	–0·05	–0·21, 0·11	0·53	0·05	–0·11, 0·21	0·54	–0·25	–0·50, 0·00	0·06	0·01	–0·26, 0·28	0·96
Cabbage												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	–0·06	–0·22, 0·10	0·44	–0·03	–0·21, 0·15	0·70	0·13	–0·12, 0·38	0·32	0·31	0·04, 0·58	0·03
Root vegetables												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	0·04	–0·12, 0·20	0·64	0·14	–0·04, 0·32	0·11	–0·02	–0·27, 0·23	0·85	0·15	–0·12, 0·42	0·28
Fish/seafood												
<Median	0	Ref.	–	0	Ref.	–	0	Ref.	–	0	Ref.	–
≥Median	0·05	–0·11, 0·21	0·51	0·12	–0·06, 0·30	0·17	–0·04	–0·29, 0·21	0·74	0·04	–0·23, 0·31	0·75

β, Average change per 1-point increase in diet score; Ref., referent values.
* Model 1: adjusted for age, height and baseline outcome.
† Model 2: model 1 plus smoking habits, education, physical activity, alcohol consumption, red/processed meat, energy intake and mutually adjusted for all the other food components.

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There was also no statistically significant interaction between NDS and age ($P_{\text{interaction}} = 0{\cdot}19$ in ΔBW; $P_{\text{interaction}} = 0{\cdot}42$ in ΔWC). However, we found evidence of a difference between the two age groups in the analyses of ΔWC, with the multivariable population average increment of high adherence to NDS being 0·59 cm (95 % CI 0·02, 1·16; $P = 0{\cdot}04$) among women who were <40 years and 0·22 cm (95 % CI −0·31, 0·75; $P = 0{\cdot}40$) among women at or >40 years (online Supplementary Table S1).

Discussion

In this large prospective study among Swedish women, participants increased their average BW (median ΔBW: 5·0 kg) and WC (median ΔWC: 7·0 cm) over a 12-year period of follow-up – 1991–2003. A higher adherence to the MDS or NDS did not affect long-term changes in average BW or WC. Higher adherence to the Nordic diet was associated with a gain in WC; however, the association became insignificant when adjusted for concurrent ΔBW.

For MDS, a meta-analysis of sixteen randomised controlled trials with 3436 participants reported that a Mediterranean diet could help to reduce BW, especially when it was energy restricted[4]. The randomised controlled trials focused on the short-term effectiveness of MDS on changes in anthropometric measures, often in highly selected individuals. However, in the present population-based cohort, without any intervention and with 12 years of follow-up, the MDS did not show any association with gain in BW or WC. Subjects included in the present cohort were of normal weight and were generally healthy people with a mean BMI of 23·0 kg/m^2. In contrast, the randomised controlled trials enrolled obese or overweight subjects, with mean BMI ranging from 27·9 to 35·0 kg/m^2[21–25], who attempted substantial short-term weight loss on specialised diets, thus limiting the generalisability of the findings to the normal-weight population and to the long-term effects on gradual weight gain.

Previous prospective studies investigating the possible association between the Mediterranean diet and obesity have reported conflicting results. In one study, the authors evaluated 6319 graduates of the University of Pamplona for over 2 years of follow-up, and no association between Mediterranean diet and weight change was found[26]. In addition, in a recent case–cohort study with a 6·8-year follow-up including 11 048 participants from five European countries, a high adherence to the MDS was associated with a lower gain in WC but not in BW[27]. However, the association between Mediterranean diet and weight change was adjusted for total energy intake in one study[26] but not in the other[27]. The present study, which was adjusted for total energy intake, showed no association between the MDS and gain in BW or WC and had a relatively larger population and longer follow-up.

Several intervention trials investigated the association between the Nordic diet and changes in anthropometric measures with contradictory results[11–13]. However, these were all intervention studies that targeted obese or otherwise selected subjects and used a specifically constructed diet with strict criteria for compliance. Thus, it is difficult to compare with our findings on the NDS directly, because the NDS was constructed on the basis of the intake distribution in the population (by using median intakes as cut-offs), not by using predefined cut-offs. Moreover, the case–cohort study conducted by Roswall *et al.*[27] also reported no association between NDS and ΔBW and ΔWC, which is consistent with the present study.

When we examined individual food components of MDS, more vegetables, a higher ratio of unsaturated fat:SFA, more dairy products and a higher meat intake were associated with the gain in anthropometric measures. We found no association between the six individual food components of NDS, except that a higher intake of cabbage was associated with gain in WC, which is in accordance with vegetables in the MDS. Epidemiological evidence of a relation between diet and the risk of changes in anthropometric measures is inconsistent. The Diet, Obesity, and Genes study, including 89 432 men and women, reported fruit/vegetable intake to be significantly, albeit weakly inversely related to weight change after 6·5 years of follow-up[28]. In contrast, no statistically significant association was observed between fruit/vegetable consumption and weight gain among 6613 women of the Seguimiento Universidad de Navarra (SUN) study after 5 years of follow-up[29].

In contrast to our results, several dietary interventions have shown that a diet high in MUFA induces a greater weight loss compared with a diet high in SFA. However, it is difficult to predict the long-term metabolic consequences of consuming diets rich in different fats[30]. A systematic review of prospective studies provided evidence of a suggestive but not consistent protective effect of dairy product consumption, particularly of regular-fat varieties, on the risk of overweight and obesity[31]. In the present study, we did not take the fat content in dairy products into account in the calculation of the MDS. It was reported in a prospective cohort investigation that meat intake increased the risk of weight gain[32], which was in accordance with our results.

We found some evidence of a difference between the two age groups in the analyses of the association between NDS and ΔWC. High adherence to NDS was significantly associated with WC gain among women aged <40 years but not among women aged ≥40 years. The skeletal muscle mass is related to metabolic level and weight change[33]. The muscle protein synthetic response to food intake is attenuated in the elderly compared with young women[34,35]. In the Midlife in the United States study with 9·2 years of follow-up, subjects who were older at enrolment had a more stable weight compared with the younger age group[36].

Strengths of the present study include the population-based design, a 12-year follow-up and detailed information on potential confounding variables. Diet was measured using a validated FFQ[16], and it has been shown that these questionnaires provide valid estimates of diet measured using diet scores[37]. The study is limited by the assessment of diet only at baseline, as diet may have changed over the follow-up period. Such changes might bias the estimates towards unity. Moreover, inference of possible causality is unwarranted as it is not possible to determine whether the diet promotes changes in anthropometric measures or whether those with high baseline BW and WC choose to eat a healthy diet. However, subjects

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included in the present cohort were of normal weight and were generally healthy people who were less likely to change their diet. To reduce the risk of reverse causality, we excluded subjects with cancer, CVD, diabetes or who were pregnant at baseline or during follow-up from the analysis, as these conditions may have led to changes in diet.

When diet is assessed through FFQ, measurement error is often substantial, which could also bias risk estimates towards the null[38]. The effect of measurement error is expected to increase with increasing number of measured dietary exposures[38]. This is particularly relevant in the current investigation as several dietary factors make up the exposure of interest (MDS and NDS components) and are also used as adjusting covariates. Moreover, almost 30·2 % of the participants failed to return the follow-up questionnaire, and this may bias a causal association between the dietary pattern and change in BW and WC. However, we used the predictors of drop-outs of outcomes as weight in the linear regression models to control the bias. Finally, in the WLH cohort, all information collected in the questionnaires is self-reported, and the anthropometric information is self-measured, leaving room for potential information bias. Several potential biases, especially measurement error, social-desirability bias and random error, could account for the lack of statistically significant associations between diet scores and changes in anthropometric measures, thus hampering the generalisability to other populations.

In conclusion, higher adherence to the MDS or NDS dietary pattern was not associated with measurable changes in average BW or WC during a 12-year follow-up period. Hence, although these dietary patterns may convey other health benefits, it is unlikely that adherence to either of them in the general population will be an effective tool to maintain a healthy weight or WC.

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There are no conflicts of interest to declare.

Supplementary material

For supplementary material/s referred to in this article, please visit http://dx.doi.org/doi:10.1017/S0007114515003840

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