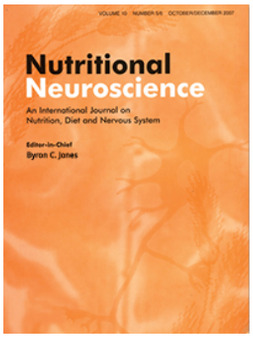

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Adherence to dietary guidelines is associated with better physical and mental quality of life: results from a cross-sectional survey among 728 Dutch MS patients

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ABSTRACT

Background: A healthy diet has been associated with less symptoms or progression of disease in multiple sclerosis (MS). However, whether specific diets are needed, or general healthy diet recommendations are sufficient is unknown.

Objective: To investigate the association between diet quality, use of diets, and quality of life (QoL) in men and women with MS.

Methods: Diet quality was measured with the Dutch Healthy Diet-index, which measures adherence to the Dutch Guidelines for a Healthy Diet. QoL was assessed with the MSQoL-54 questionnaire. A total of 728 people were included (623 women, 105 men). Multiple linear regression, stratified for gender, was used to analyse the data.

Results: In women with MS, an association was found between diet quality and both physical and mental QoL after adjusting for several confounders (Physical Health Composite Score (β=0.410; P=0.001); Mental Health Composite Score (β=0.462; P=0.002)). Similar results were less pronounced in men. Subjects following a specific diet had higher diet quality and QoL than subjects not following a diet.

Conclusion: Adherence to the Dutch dietary guidelines is associated with better physical and mental QoL, especially in women. Following an MS-specific diet may help to adhere to these guidelines.

KEYWORDS
Multiple sclerosis; diet; quality of life; nutrition; dietary guidelines; MS-specific diet; mental health; lifestyle

Introduction

Multiple sclerosis (MS) is a chronic inflammatory autoimmune disease of the central nervous system. With a prevalence of 100 per 100,000 in Europe [1], MS is the most common demyelinating disease in high-income countries and one of the leading causes of disability in young adults [2,3]. Onset of disease is on average around 30 years of age [4] and MS occurs mostly in women, with a female-to-male ratio of 1.4–2.3 [5].

MS has a major impact on quality of life (QoL) [6], due to various common physical symptoms such as vision problems, spasticity, weakness and fatigue and psychological symptoms, like cognitive impairment and mood disorders [6]. For now, the goal of disease management is to minimise these symptoms and, if possible, improve function [7].

Patients with MS are often proactive and ask for guidance from their physician on modifiable lifestyle-factors that may slow MS disease progression [8]. Modifying lifestyle-factors may be important since it is known that vascular comorbidity, whether present at symptom onset, diagnosis, or later in the disease course, is associated with a substantially increased risk of disability progression in MS [9]. Questions about exercise and supplements are common, but most questions from patients are about their diet [8]. Although there is limited scientific evidence supporting the use of specific diets in the management of MS, there is a wide variety of 'MS cookbooks' and Web-based dietary advice [8,10]. These advices are mostly based on individual experiences and have not been scientifically tested [10].

There is, however, some scientific evidence that certain dietary patterns may be beneficial for patients with MS. One of these diets is the Mediterranean diet, which has been shown to reduce inflammatory markers in other autoimmune diseases and cardiovascular diseases

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and might therefore be interesting for MS patients [11]. Various MS-specific diets have been proposed as well. These diets include the Swank diet, the Jelinek diet and the modified Palaeolithic Wahls diet [12]. All diets include a high intake of fruits, vegetables and whole grains [11]. Alcohol consumptions is restricted in these diets [11]. Some evidence for reduction in complaints when using these diets has been published [11]. For example, a pilot study showed that a Palaeolithic diet may reduce perceived fatigue and increased mental and physical quality of life [13]. In a recent trial, a ketogenic diet and a Palaeolithic diet were compared [14]. This trial showed that participants consuming a ketogenic diet achieved nutritional ketosis, however, it was not associated with significant clinical improvements in fatigue and QoL, whereas the modified Palaeolithic diet was associated with significant clinical improvements [14]. Although some studies are available, the results are still inconclusive, and no diet has been shown to be superior to others [11]. One of the main limitations of the studies is a small sample size.

Next to this, information about the differences between patients following a diet and not following a diet and their diet quality and QoL is scarce. Moreover, most of the dietary studies in MS have been performed in the United States of America [12], and it would be interesting to see if similar results would be found in a European population. This cross-sectional study aims to investigate the association between diet quality and QoL in Dutch patients with MS and furthermore looks at the role of MS-specific diet use in this association.

Methods

Participants recruitment

Subjects were recruited from the volunteer database of the National Multiple Sclerosis Foundation, Rotterdam, The Netherlands and via social media, posters/flyers, MS nurses, and MS centres. An online survey was conducted between May 2017 and February 2018 and filled out by 745 respondents. For this survey, the online programme LimeSurvey™ was used. Eligibility was checked with the first three screening questions about age (18 years or older), diagnosis (by a neurologist) and for women pregnancy or lactation (these were excluded). Respondents who did not meet the criteria were automatically sent to the end of the questionnaire.

Participant characteristics

Via an online survey, the following sociodemographic characteristics were asked: age, sex, country of birth, education level, and living situation (number of persons in household). Questions about clinical characteristics were included, involving information about height, weight, comorbidities, smoking status, years of complaints of MS, age at MS diagnosis, type of MS, exacerbations, and progression of MS. Questions about treatment including current use of medication, exercise supervised by a professional, exercise not supervised, diet supervised by a professional, diet not supervised, and use of complementary and alternative medication.

Body mass index (BMI, kg/m2) was calculated as weight (in kg) divided by body height (in m) squared. Underweight, normal weight, overweight and obesity were classified using BMI cut-off points classified by the WHO: < 18.5 kg/m2 is underweight, 18.5–24.9 kg/m2 is normal weight, ≥25 kg/m2 is overweight and ≥ 30 kg/m2 is obesity [15].

Diet quality

Diet quality was measured with the Dutch Healthy Diet index (DHD-Index), a dietary quality score which includes eight diet components representing the Dutch Guidelines for a Healthy Diet [16]. For each component, the score ranges between zero and ten, resulting in a total score between zero (no adherence) and 80 (complete adherence). The eight components are vegetable, fruit, fibre, fish, saturated fat, trans fat, salt and alcohol. Threshold values (minimum score) and cut-off values (maximum score) of each diet component are shown in Table 1. Scores were calculated according to the method described by van Lee et al. [16]. The DHD-Index is a short version of an FFQ and takes around 10 min to complete [16]. The DHD-index is a validated questionnaire and shown to be capable of ranking participants according to their adherence to the Dutch Guidelines for a Healthy Diet [16]. The score reflects variation in diet components, and was originally based on two 24-hour recalls [16].

Quality of life

QoL was measured using an MS-specific questionnaire, called the Multiple Sclerosis Quality of Life-54 (MSQoL-54) [17]. It is based on the 36-items Short Form Health Survey with eighteen additional MS-specific items. The MSQoL-54 provides two scores: the Physical Health Composite Score (PHCS) and the Mental Health Composite Score (MHCS), both ranging from 0 to 100. The PHCS is a score based on the categories physical function, health perceptions, energy/fatigue, physical limitation, pain, sexual function, social function and health distress. The MHCS includes the categories health

Table 1. Diet components and Dutch dietary guidelines of the Dutch Healthy Diet index and their threshold values (minimum score) and cut-off values (maximum score).

Diet component (per day)	Dutch Guidelines for a Healthy Diet	Minimum score (=0)	Maximum score (=10)
1. Vegetables	Eat 150–200 grams of vegetables.	0 g	≥ 200 g
2. Fruit + fruit juices[1]	Eat 200 grams of fruit a day.	0 g	≥ 200 g
3. Fibre	Eat 30–40 grams a day of dietary fibre, especially from sources such as fruit, vegetables and whole-grain cereal products.	0 g/4.2 MJ	≥ 14 g/4.2 MJ
4. Fish[2]	Eat two portions of fish a week, at least one of which should be oily fish.	0 mg EPA = DHA	≥ 450 mg EPA + DHA
5. Saturated fatty acids	Limit saturated fatty acid consumption to less than 10 percent of energy intake.	≥ 15 en %	< 10 en %
6. Trans fatty acids	Limit mono trans-fatty acid consumption to less than 1 percent of energy intake.	≥1 en %	< 1 en %
7. Sodium	Limit consumption of table salt to 6 grams a day.	≥ 2520 mg	< 1680 mg
8. Alcohol	If alcohol is consumed at all, male intake should be limited to two Dutch units (20 gram ethanol) a day and female intake to one.	Male: ≥ 6 drinks Female: ≥ 4 drinks	Male: ≤ 2 drinks Female: ≤1 drink

EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid; en %: energy %; [1]A maximum of 100 g of fruit juice containing vitamin C and folate could be included. [2]Fish intake was estimated based on dietary fish fatty acids (EPA + DHA) and fish oil capsules.

distress, overall QoL, emotional well-being, role of limitations and cognitive function [17]. Scores were calculated based on the method described by Vickrey et al. [17]. Overall wellbeing was based on one of the questions within the MSQoL-54 questionnaire. 'Overall, how would you rate your own quality-of-life?'. This question could be rated by a score between 1 and 10.

Following a diet

Patients were asked whether they were following a diet or had made dietary changes for disease management. If patients were following a diet they were asked to choose that diet from the list, that was most closely to the diet they were following. Possible diet options were a 'low carbohydrate diet', 'high carbohydrate diet', 'high fibre diet', 'gluten free diet', 'sugar free diet', 'vegan diet', 'vegetarian diet', 'Atkins diet', 'Jelinek diet' and 'Paleo diet'. They also had the option to fill in 'others'. Only diets that were reported by a minimum of 20 patients are reported.

Data analysis

Data were analysed by using IBM SPSS Statistics version [22]. Normally distributed variables are presented as mean ± standard deviation (SD) and skewed variables as median with interquartile range (IQR). For categorical variables cases (n) and percentages (%) are presented. For continuous data an independent samples t-test was used. If data were nominal, a Chi-square test was performed. Data that were not normally distributed or measured on an ordinal scale were analysed using the Mann–Whitney U test. Significance was set to $p<0.05$. Based on experience and literature, differences in baseline characteristics between men and women were expected in diet quality scores but also in disease characteristics: men are more often diagnosed with progressive types of MS than women [18]. For these reasons, data were stratified for gender.

Sex-specific tertiles of the DHD-Index score were made, based on previous research [16]. These tertiles were used to check if all components of the DHD-Index contributed equally across the DHD-Index. Next to this, possible trends in lifestyle factors across the DHD-Index could be checked by using tertiles. Differences between groups were tested using a one-way ANOVA when normally distributed, not normally distributed variables were analysed using the Kruskal Wallis test. For the categorical variables the chi-square test was used to analyse the trend.

Differences between diet quality, mental QoL and physical QoL between patients following a diet or one of the specific diets was tested with an independent sample t-test. Following a diet was tested against not following a diet. Following one of the specific diets was tested against not following that specific diet. For example people following a 'High in fibre diet' were tested against all patients not following a 'High in fibre diet'.

Multiple linear regression was used to analyse the possible association between diet quality and QoL. Covariates which were considered to be confounders were age, gender, type of MS, duration of disease, body mass index (BMI), past and current smoking, level of education and physical activity. In the final model, only covariates that changed the crude model with more than 10% were included.

Ethical aspects

The study protocol was presented to the Medical Research Ethics Committee Brabant, Tilburg, the Netherlands, this committee declared that this study did not come within the scope of the Medical Research Involving Human Subjects Act (WMO) and therefore needed

no approval. The study was performed in agreement with the Declaration of Helsinki and the WMO. After having completed informed consent online, the patients received a personal code and logged on to the website.

Results

Characteristics of study population

A total of 745 subjects started the screening questionnaire. Seventeen were excluded: fifteen because they did not fulfil the inclusion criteria, two based on implausible values for height or weight. Baseline characteristics of the remaining 728 subjects, 623 women and 105 men, are shown in Table 2. Men had an average age of 53 years, women 45 years. In both genders, almost half of the subjects had a high education level and the majority of subjects had a healthy BMI. Over 80% of the subjects were not current smokers. Only one out of five subjects met the physical activity guideline of 30 min per day for 5 days per week. In many subjects, MS-related complaints started more than ten years ago followed by a diagnosis some years later. Women were diagnosed more often with the relapsing-remitting type of MS, where men more often had a progressive type of MS.

Table 2. Sociodemographic and clinical characteristics of 728 research subjects diagnosed with MS, stratified by gender.

Characteristics	Men	Women	*P*-values difference men and women
N	105	623	
Sociodemographic			
Age (years), mean ± SD	52.6 ± 9.9	45.4 ± 11.2	0.000
Country of birth,[1] n (%)			0.464
The Netherlands	99 (94.3)	591 (94.9)	
Western country	3 (2.9)	25 (4.0)	
Non-Western country	3 (2.9)	7 (1.1)	
Living situation			0.464
Alone	15 (14.3)	107 (17.2)	
Together	90 (85.7)	516 (82.8)	
Level of education[2], n (%)			
Low	22 (21.0)	114 (18.3)	0.519
Medium	33 (31.4)	201 (32.3)	
High	50 (47.6)	308 (49.4)	
BMI, n (%)			0.781
Underweight	1 (1.0)	9 (1.4)	
Normal weight	56 (53.3)	329 (52.8)	
Overweight	31 (29.5)	156 (25.0)	
Obese	15 (14.3)	126 (20.2)	
Smoking status, n (%)			
Current	10 (9.5)	73 (11.7)	0.514
Past	58 (55.2)	241 (38.7)	0.002
Never	37 (35.2)	309 (49.6)	0.001
Physical activity (≥30 min/day)[3], n (%)			0.136
<5 times per week	88 (83.8)	485 (77.8)	
≥5 times per week	17 (16.2)	138 (22.2)	
Clinical			
Start of complaints			0.054
<1 year ago	2 (1.9)	13 (2.1)	
1-3 years ago	3 (2.9)	62 (10.0)	
3-5 years ago	15 (14.3)	85 (13.6)	
5-10 years ago	27 (25.7)	167 (26.8)	
>10 years ago	25 (55.0)	296 (47.5)	
MS type, n (%)			0.038
CIS	2 (1.9)	9 (1.4)	
Benign	10 (9.5)	60 (9.6)	
Relapsing-remitting	35 (33.3)	380 (61.0)	
Primary progressive	30 (28.6)	46 (7.4)	
Secondary progressive	24 (22.9)	112 (18.0)	
Unknown	4 (3.8)	16 (2.6)	
Current use drugs, n (%)			0.087
Yes	47 (44.8)	335 (53.8)	
No	58 (55.2)	288 (46.2)	

MS: Multiple Sclerosis; SD: Standard Deviation; BMI: Body Mass Index; CIS: Clinically Isolated Syndrome; [1]Country of birth: based on definitions made by Statistic Netherlands (CBS: Centraal Bureau Statistiek) [2]Level of education: based on the standard classification of education in the Netherlands made by Statistic Netherlands [3]Physical activity: groups based on the guidelines for physical activity in the Netherlands made by the Dutch Health Organisation (Gezondheidsraad).

Diet quality

Women had a DHD-Index of 57.9, which was 2.9 points higher than the DHD-Index of men (p=0.005) (Table 3). Their higher score was mainly due to a higher score for the diet components vegetable, fibre and salt, meaning a higher or more frequent intake of vegetables and fibre and a lower intake of salt. In both men and women, significant trends from lowest to highest tertile of the DHD-Index were seen for all diet components ($p \leq 0.002$) (Supplemental Tables I and II), but especially for the components vegetables, fruits, fish and saturated fat. High adherence to trans-fat and alcohol guidelines was seen in all tertiles. In women, smaller differences between the tertiles were seen for salt than for men.

Women in the highest tertiles of the DHD-Index were more highly educated (p=0.002), had a normal

Table 3. Nutritional characteristics of 728 research subjects diagnosed with MS, stratified by gender.

Characteristics	men	women	*P*-values difference men and women
N	105	623	
Diet quality			
DHD-Index Total[1], mean ± SD	55.0 ± 11.7	57.9 ± 9.6	0.005
Vegetable	6.0 ± 3.0	7.0 ± 2.9	0.001
Fruit	6.8 ± 3.4	7.4 ± 3.0	0.094
Fibre	6.2 ± 2.1	6.6 ± 2.2	0.035
Fish	2.7 ± 3.7	2.1 ± 3.2	0.768
Saturated fat	8.0 ± 3.5	7.7 ± 3.4	0.560
Trans fat	9.3 ± 0.2	9.6 ± 0.8	0.336
Salt	7.0 ± 2.5	8.5 ± 1.4	0.000
Alcohol	9.0 ± 2.7	9.0 ± 2.5	0.941
Currently on a diet, n (%)	27 (25.7)	233 (37.4)	0.014
Willing to change diet, n (%)	98 (93.3)	591 (94.9)	0.520

MS: Multiple Sclerosis; SD: Standard Deviation; DHD-Index: Dutch Healthy Diet-Index **1** Per diet component the score ranges between zero and ten, resulting in a total score between zero (no adherence) and 80 (complete adherence).

Table 4. Association between DHD-index and Physical Health Composite Score or Mental Health Composite Score.

	Sample size	Crude model (β [1]± SE)		Fully adjusted model (β[1] ± SE)	
Type of score					
PHCS					
Men	105	0.351 ± 0.18	$p = 0.056$	0.233 ± 0.19	$p = 0.256$
Women	623	0.498 ± 0.12	$p = 0.000$	0.410 ± 0.12	$p = 0.001$
MHCS					
Men	105	0.511 ± 0.26	$p = 0.051$	0.419 ± 0.27	$p = 0.126$
Women	623	0.548 ± 0.14	$p = 0.000$	0.462 ± 0.15	$p = 0.002$

Note: Adjusted for age, level of education, smoking, physical activity and BMI. Stratification for gender.

DHD-Index: Dutch Healthy Diet-Index; BMI: Body Mass Index; **1** ß indicates change in PHCS or MHCS for one point change in DHD-Index; PHCS: Physical Health Composite Score; MHCS: Mental Health Composite Score

BMI ($p<0.001$), were not smoking ($p<0.001$) and met the guideline for physical activity ($p=0.004$) more frequently compared to people in the lowest tertiles of the DHD-Index (Supplemental Table III). No differences were seen for age and type of MS. In men, no significant differences in characteristics were found across tertiles of the DHD-Index, except for age ($p=0.038$) (Supplemental Table IV).

Wellbeing

Overall wellbeing was graded with a 6.8 out of 10 in men and 7.0 out of 10 in women. Mental Health Composite Scores (MHCS) of the MSQoL-54 questionnaire were higher than the Physical Health Composite Scores (PHCS), 67.2 (men) and 69.0 (women) vs 53.8 (men) and 56.6 (women) respectively. Although women had slightly higher scores, these differences were not significant.

Association diet quality and QoL

The DHD-Index score significantly predicted physical and mental QoL in univariate analysis in women: PHCS ($\beta=0.498$; $p<0.001$); MHCS ($\beta=0.548$; $p<0.001$). After adjusting for the confounders age, level of education, smoking, physical activity and BMI the association remained significant (Table 4). In univariate analysis in men, positive associations were seen as well, however not significant: PHCS ($\beta=0.351$; $p=0.056$); MHCS ($\beta=0.511$; $p=0.051$). This trend was weakened after adjusting for the confounders.

Specific diets for disease management

More than a third of the respondents indicated to follow a diet, which was most often restricted in carbohydrates (Table 5). Remarkably, followers of a diet had a 7-point higher DHD-index compared to patients not following a diet ($p<0.001$). Patients following a diet were more often female, higher educated, non-smokers and more physically active. The Jelinek diet, which is specific for MS patients, was mentioned by less than 5% of respondents, but had the highest score on diet quality: on average more than 10 points higher than patients not following a diet. The highest mental QoL was found in patients following a 'high fibre diet', whereas people following a 'vegetarian diet' had the highest physical QoL.

Discussion

Better adherence to dietary guidelines, measured as a higher score on the DHD-Index, was associated with better physical and mental QoL in women with MS after adjusting for multiple confounders. These results were less pronounced in men. Vegetables, fruits, fish and saturated fat were the main discriminating factors in the DHD-index, whereas trans-fat and alcohol were quite similar across all levels of the index in both sexes. Patients following a specific diet for the management of MS had higher diet quality and higher QoL than patients not following a specific diet.

Our findings in this sample of the Dutch population of MS patients confirm those of an international cross-

Table 5. Specific diets for managing MS and their diet quality, Physical Health Composite Score and Mental Health Composite Score.

Type of diet	N	Mean DHD-Index	*p*-values	PHCS	*p*-values	MHCS	*p*-values
No diet	468	55.0 ± 9.8	-	54.6 ± 17.1	-	68.2 ± 17.2	-
Following a diet[1]	260	62.0 ± 8.5	**<0.001**	59.1 ± 16.4	**0.001**	69.8 ± 17.0	0.230
Sugar free diet[2]	86	63.1 ± 6.8	**<0.001**	60.5 ± 15.3	**0.014**	72.3 ± 15.0	**0.038**
Low carbohydrate diet[2]	85	61.5 ± 8.2	**<0.001**	58.2 ± 14.9	0.215	68.2 ± 16.6	0.769
High fibre diet[2]	48	65.0 ± 8.3	**<0.001**	54.0 ± 15.7	0.347	74.5 ± 14.2	**0.006**
Paleo diet[2]	40	60.1 ± 8.1	**0.050**	60.3 ± 15.7	0.117	71.3 ± 15.0	0.327
Jelinek diet[2]	32	65.3 ± 8.2	**<0.001**	62.1 ± 16.9	**0.045**	67.6 ± 20.6	0.708
Gluten free diet[2]	31	62.9 ± 8.6	**0.002**	59.9 ± 15.1	0.222	69.3 ± 13.5	0.850
Vegetarian diet[2]	23	62.8 ± 8.6	**0.009**	65.7 ± 16.7	**0.007**	68.8 ± 17.8	0.982

[1]Following a diet is tested against not following a diet.
[2]Specific diet is tested against not following that specific diet.
MS: Multiple Sclerosis; DHD-Index: Dutch Healthy Diet-Index; PHCS: Physical Health Composite Score; MHCS: Mental Health Composite Score.

sectional study, in which diets that were characterised by ample amounts of vegetables, fruits, fibre and healthy fats were associated with better physical and mental health [19]. Similar positive associations were found between intake of fruits and vegetables and disability and symptom severity in a survey including almost 7000 MS patients in the U.S.A. [12].

The large sample size is a strength of our study. In addition, our findings in Dutch patients are comparable to those of other studies and clinically relevant. In other studies using the MSQOL-54, a 5-point change was considered to be clinically relevant for patients with MS [20]. The association in our study implies that for a 5-point change in the MSQol-54, a change of 10–12 point on the DHD-Index is needed. Presuming a causal relationship, this change in DHD-Index is feasible, since it can be achieved by improving on at least two diet component (e.g. stop drinking alcohol and start eating fish or eat more fruit and vegetables).

Our study population is skewed towards a higher educated population with a healthy lifestyle, which makes our findings less generalisable. However, other studies in patients with MS showed similar characteristics for their patients group, when looking at education levels, smoking status and physical activity [20]. When comparing the participants to studies in the healthy Dutch population, comparable results are seen as well. This is reflected in the findings that diet quality scores in the population with MS resemble the diet quality scores of the healthy Dutch population (mean DHD-Index healthy population 59.2 ± 11.2; MS population 57.5 ± 9.9) [16].

In our study, different results for men and women were found. Only recently the importance of studying both sexes separately has gained attention in the field of disease susceptibility and progression, in MS as well as other diseases [18]. Women have an increased susceptibility for MS and an increased rate of disability progression than men, suggesting a gender effect in the mechanism of the disease [18]. Indeed, in our study women were diagnosed more often than men with the relapsing-remitting type of MS, where men more often had a progressive type of MS. In addition, although not significant, around 10% more women than men reported the use of medication in our study. A review on medication use in patients with MS found a positive association between medication use and quality of life [21]. Both types of MS and medication may explain the different findings between men and women in our study. Next to this, our findings showed that significantly more men than women had smoked in the past. Since smoking is an evidence-based risk factor for developing the disease, past smoking might also affect further progression in disease. Sex differences, as in any disease, may be related to sex hormones. However, different studies have shown that the worse disease progression of men compared to women, is probably related to other factors than testosterone [18]. Independent studies show that testosterone is protective in men with MS [18]. In developed countries, cooking (including skills, frequency and involvement in time) has been associated with dietary benefits, such as consumption of healthier food groups and better adherence to dietary guidelines [22]. When looking at cooking at home, positive associations have been shown with being female, married, older, greater time availability and more [22]. Therefore, this may be another factor why women have higher diet quality compared to men. Lastly, the smaller sample size for men decreased the chance of finding significant associations. Thus, although it seems plausible that the relation between diet and QoL is different in men and women, this needs more substantiation in studies that include more men.

About a third of the patients reported to follow a diet to manage their disease. Remarkably, these patients on average scored higher on diet quality than patients not following a specific diet. Patients following a 'high-fibre' diet scored high on mental QoL. Recently, the interest in how diet influences brain function via the gut microbiome and the role of a high fibre diet has gained attention [23]. Although more research is needed into these specific pathways, our results support this promising field of interest. Patients following the MS-specific Jelinek diet had the highest diet quality score, which was 10 points higher than patients not following a diet. This diet focusses on high intake of omega-3 fatty acids and low omega-6 fatty acids. Consequently, fish, fruit and vegetable intake are important in this diet, which are categories in line with the DHD-Index. Thus, although health professionals generally do not advocate diets for MS, following any of these popular diets might improve adherence to the Dutch dietary guidelines and should therefore not be discouraged.

Causal inference cannot be made based on cross-sectional studies. It is also possible that poor physical or mental health leads to food choices that result in a poorer diet quality. This reversed causality is considered to be the main limitation of our study. Likewise, it could be conceived that diet quality and QoL are both causally linked to a third factor, like personality traits or financial situation. E.g. financial means may impact access to foods or physical activity, which could have negative impact on QoL. In addition, patients with higher diet scores could be better in self-management. The idea of having control of your own life, could help in the perception of your QoL. This is in line with our observation

that patients who followed a specific diet, had higher QoL scores than patients not following a diet. Fatigue could also be a third factor since it is a frequently reported symptom of MS which may reduce QoL. People who experience more fatigue, could be less capable of preparing fresh meals and therefore have a lower diet quality.

Generalisability of our research results to the whole (Dutch) MS population might be another shortcoming in our study. Selection bias might be present; it is imaginable that people who are already interested in (and complying with) diet and a healthy lifestyle are more likely to fill out a questionnaire on this topic. In our study, patients who followed a diet were more often women, highly educated and physically active, all of which are attributes associated with better diet quality. Conversely, filling out a survey may be burdensome, especially for patients in a further state of the disease or with a lower QoL. It could therefore be possible that such patients decided to not fill in the questionnaire. Although patients were given the option to save the answers and resume at a later moment, this might still play a role in our results.

Conclusion

A statistically significant positive association was found between adherence to the Dutch dietary guidelines and physical and mental QoL in women with MS. These results were less pronounced in men. One third of the patients was following a diet to manage MS, which seemed to help them to better adhere to the dietary guidelines. As this was a cross-sectional study, longitudinal studies and randomised controlled trials are needed to test whether starting an MS-diet or taking measures to better adhere to the general dietary guidelines improves QoL and reduced disease activity and slows disease progression.

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