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Flourishing mental health and lifestyle behaviours in adults with Type 1 and Type 2 Diabetes Mellitus: results from the Diabetes MILES – The Netherlands Study

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ABSTRACT

Objective: To examine the associations between mental health and lifestyle in adults with type 1 and type 2 diabetes mellitus (T1DM and T2DM).

Methods: Online survey data from the cross-sectional Diabetes MILES – The Netherlands Study was analysed, including 270 adults with T1DM and 325 with T2DM. Mental health status (flourishing, moderate and languishing) in relation to diet, physical activity, alcohol consumption and smoking was analysed with ANCOVA and logistic regressions (adjusted for confounders).

Results: 47% of T1DM-, and 55% of T2DM participants reported flourishing mental health. Due to an insufficient number, participants with languishing mental health were excluded. In T2DM, participants with flourishing mental health had more optimal diet quality (mean ± SEM: 70 ± 1 vs 68 ± 1 diet quality score, $p = 0.015$), and physical activity levels (mean ± SEM: 3484 ± 269 vs 2404 ± 273 MET minutes/week, $p = 0.001$) than those with moderate mental health, but did not differ with respect to alcohol consumption and smoking. In T1DM, no significant associations were found.

Conclusion: Only in T2DM, people with flourishing mental health had more optimal lifestyle behaviours compared to people with moderate mental health. Further research is needed to determine if mental health is more important for specific lifestyle behaviours, and if the mental health effect differs across diabetes types.

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1. Introduction

The global burden of diabetes mellitus is high: in 2019, the prevalence was approximately 463 million, and it is estimated that this will rise up to 700 million by 2045 [1,2]. Lifestyle behaviours, such as a balanced diet and regular physical activity, are important for both type 1 and type 2 diabetes mellitus (T1DM and T2DM), because they lower the risk of long-term vascular complications [3]. The success of current lifestyle improving approaches has been variable, and sustained long-term improvements remain difficult to achieve [4,5,6]. For sustainable lifestyle changes, it is inevitable to pay attention to contextual factors that influence lifestyle behaviours in everyday life [7,8]. An important factor in this is mental health.

Mental *ill*-health (e.g. anxiety, depressive and psychiatric disorders) is an important risk factor for developing diabetes [9,10]. There is a large body of research that has demonstrated that mental ill-health among people with diabetes increases changes of an unhealthy lifestyle [11], cardiovascular complications [12], and all-cause mortality [13]. Associations between mental ill-health and glycated haemoglobin (HbA_{1c}) seem bi-directional: depressive symptoms have been associated with developing suboptimal HbA1c, and suboptimal HbA1c has been associated with an increased risk of developing depression [14].

Most research on diabetes and lifestyle behaviours focussed on mental ill-health rather than mental health per se [15]. Mental health is not simply the absence of negative mental states. The WHO defines mental health as a multidimensional concept: '*a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community*' [16]. This definition is in line with theoretical frameworks such as positive psychology and salutogenesis that focus on factors that improve and create health well-being [17,18].

Yet, there is an increasing interest in how positive mental health can contribute to lifestyle and vice versa [19,20,21]. Especially since positive mental health and lifestyle seem bi-directionally related as well: maintaining a healthy lifestyle improves mental well-being [22], and more optimal mental health increases changes towards a healthy lifestyle [23]. There are several concepts available that have been used to measure positive mental health (e.g. positive affect, well-being, self-efficacy, empowerment, optimism) [19]. Indeed, a meta-analysis of 26 studies found that well-being was associated with lower rates of mortality in populations with and without medical conditions, independent of traditional risk factors [24]. In T1DM and T2DM, mental health (measured by, among other concepts, positive affect, and well-being) was associated with reduced mortality, more self-care activities and more optimal HbA_{1c} [19,25]. Simultaneously, psychological interventions were able to improve mental wellbeing and HbA_{1c} [26,27].

However, these concepts for mental health are closely related to, but not synonymous with mental health. They merely related to one aspect of mental health: either the *hedonic* (feelings of happiness) or the *eudaimonic (*individual functioning) aspect. Yet, the WHO definition of mental health comprises both hedonic and eudaimonic aspects. To the best of our knowledge, one study so far used a measure for mental health that included both hedonic and eudaimonic aspects among people with diabetes [28]. This study showed that a state of flourishing mental health (i.e. optimal positive mental health) was associated with more exercise, better self-rated health, fewer comorbidities, less functional-disability and lower likelihood of smoking [28]. However, this study neither investigated diet, nor adjusted analyses for potential confounders, nor investigated the results for T1DM and T2DM separately.

Since the relationships between mental health and lifestyle in diabetes has been insufficiently investigated so far, this study examines the relationships between mental health –ranging from languishing to moderate to flourishing mental health– and lifestyle behaviours (diet, physical activity, alcohol consumption and smoking) using the data from the Diabetes MILES-the Netherlands (Diabetes MILES-NL). The effect of mental health was investigated separately for T1DM and T2DM, because these are different conditions which potentially yield different conclusions. It was hypothesised that for both T1DM and T2DM, flourishing mental health would be associated with more optimal lifestyle behaviours compared to languishing and moderate mental health.

2. Methods

2.1. Study design and procedure

Data from the Diabetes MILES-NL study was used, which was a national cross-sectional study conducted in 2011 using an online survey to investigate psychosocial aspects in people with diabetes. The rationale and methods of the entire study were described elsewhere [29]. The Psychological Research Ethics Committee of Tilburg University approved both the Diabetes MILES-NL study (EC-2011 5), and the current secondary analysis (RP-2019).

The online survey consisted of a core questionnaire (questions on demographics, clinical variables, and lifestyle behaviours) and five modules with additional questionnaires, each with its own topic (self-care, depression, mindfulness and positive mental health, sleep, and relations to others). After finishing the core questionnaire, participants were randomly offered one of the five modules. The current study focussed on data from the core questionnaire and module 3: mindfulness and positive mental health.

2.2. Participants

Participants were recruited via Dutch health websites and media channels of national diabetes organisations. Inclusion criteria were 1) adults (>18 years old) and 2) any type of (self-reported) diabetes diagnosis. It was indicated that participation was voluntary, and data would be analysed anonymously. Participants signed a digital informed consent before participation. In total, 3301 participants finished the core questionnaire and one of the five modules, with 684 participants being allocated to module 3. The current study included the 595 participants who completed the both the core questionnaire and module 3 (Fig. A.1).

2.3. Variables

2.3.1. Mental health

Mental health was assessed with the Mental Health Continuum - Short Form (MHC-SF). The MHC-SF has been validated among Dutch adults, has high internal reliability, good test-retest reliability and good convergent validity [30]. The MHC-SF consists of two subscales: emotional and psychological well-being. The emotional subscale relates to the hedonic (feelings of happiness) aspect of well-being and consists of three items (happiness, interest and life satisfaction). The psychological subscale relates to eudaimonic (optimal functioning) aspect of well-being and consists of six items (self-acceptance, mastery, positive relations, personal growth, autonomy and purpose in life). Per item, the participants indicated how often they had experienced each feeling over the past month by using a 6-point Likert scale. The scores were divided into three categories based on existing guidelines for categorising mental health as measured by the MHC-SF: 1) languishing mental health, 2) moderate mental health and 3) flourishing mental health [31]. Please note that flourishing mental health is different from the term 'flourishing' as used in the positive psychology model of Seligman [18]. Participants were categorised as having languishing mental health when they indicated a score of zero or one on at least one of the items of emotional well-being, and at least four items of psychological well-being. Participants were categorised as having flourishing mental health when they indicated a score of four or five on at least one of the items of emotional well-being, and at least four items of psychological well-being. The participants who could not be categorised as either flourishing or languishing mental health were categorised as having moderate mental health. Previously, flourishing mental was associated

with more physical activity, better sleep, less stress, lower likelihood of smoking, better self-rated health, fewer co-morbidities, and less functional disability [28,32].

2.3.2. Lifestyle behaviours

2.3.2.1. Diet. Diet was assessed using a 38-item food frequency questionnaire [29], in which participants indicated how many days per week they consumed certain foods with use of a four-point Likert-scale ('0 days per week', '1–3 days per week', '4–5 days per week' and '6–7 days per week'). Unfortunately, questions regarding portion sizes were not included. Therefore, we estimated the portion sizes for each item to calculate the consumed quantity of food products in grams per day. First, we linked a product code based on the Dutch National Food Composition Database (NEVO, online version 2019/6.0) to each item, followed by the average portion size based on the Dutch National Food Consumption Survey (DNFCS 2012–2014) [33] and the portion-size online tool (National Institute for Public Health and the Environment, version 2017/1.1). Total consumed quantity (g/d) was calculated, by multiplying the frequency of consumption by the estimated portion sizes.

Diet quality and the intake of specific food components was calculated using the Dutch Healthy Diet index (DHD-index): an index that enables ranking participants based on the extent to which they follow the Dutch dietary guidelines of 2006 [34]. The DHD-index originally consisted of ten components, of which eight were included in the current study (the components physical activity and acidic drinks and foods were not included, because physical activity was measured separately, and there was insufficient information collected on acidic drinks and foods). Each component was scored on a scale ranging from 0 (not following of the dietary guidelines) to 10 (complete following of dietary guidelines), eventually providing a total score between 0 and 80.

For the categorical analyses, the diet quality scores were categorised into tertiles, with higher scores indicating a more optimal diet quality (i.e. low: a score up to 64.76; intermediate: a score between 64.76 and 71.98; and high: a score above 71.08).

Because more research became available on dietary patterns and chronic diseases, the Dutch dietary guidelines have been updated in 2015, which led to an updated DHD-index: the Dutch Healthy Eating 2015 index (DHD15-index) [35]. The data was collected in 2011 and analysed in 2021. Hence, all analyses that focused on diet were performed twice: based on the guidelines of 2006 (i.e. DHD-index), and based on the guidelines of 2015 (i.e. DHD15-index). The main difference between the guidelines of 2006 and 2015 is that the guidelines of 2006 were based on nutrients, and the guidelines of 2015 are based on foods. Other differences are: the addition of three new guidelines (for legumes, nuts, and tea), the guideline for fish/polyunsaturated acids is less stringent, and the guidelines for fruits, vegetables, and alcohol consumption are more strict (see Table A.1 for a comparison). The results based on the guidelines of 2006 are displayed in the main tables, because this was the advice the participants were receiving at time of inclusion in this study. The results based on the guidelines of 2015 are displayed in the appendices.

2.3.2.2. Physical activity. Physical activity was assessed with the validated International Physical Activity Questionnaire short form (IPAQ) [36], in which participants self-reported the frequency and the duration of vigorous and moderate activities, and of walking and sitting (additional items). The answers were used to calculate the Metabolic Equivalent of Task (MET) minutes over the previous week. For the continuous analyses, the total amount of vigorous, moderate and walking MET-minutes per week was used. For the categorical analyses, physical activity was separated into three categories based on existing IPAQ scoring criteria [37]: low, intermediate and high physical activity.

2.3.2.3. Alcohol consumption. Alcohol consumption was assessed by a singular item in which participants had to self-report the number of units of alcoholic drinks per week (0, 1–7, 8–14, 15–21, 22–28, 29–25 or 36 or more alcoholic drinks per week) [29]. We estimated the grams per day based on the assumption that one alcoholic beverage contains 10 g of alcohol. Categorised measures of alcohol intake were also calculated, based on the Dutch dietary guidelines of both 2006 and 2015 [35,34]. Hence, alcohol consumption was categorised as 'low' if consumption was according to either the guidelines of 2006 or 2015, respectively, and as 'high' if consumption was not according to the guideline of either 2006 or 2015, respectively (Table A.1).

2.3.2.4. Smoking. Smoking was assessed with use of a self-reported singular item in which participants indicated the frequency of their smoking behaviour (daily, weekly, once in a while, never, or unknown) [29]. In the analyses, the answers were dichotomized (i.e. daily smoking or not).

2.3.3. Demographic and clinical characteristics

The following demographic variables were included: sex (male/female), age (years), marital status (having a partner yes/no), ethnicity (Dutch or ethnic minority), education (based on the highest completed education, subdivided in low/middle/high; based on the criteria of Statistics Netherlands [38]), current employment (paid employment yes/no). Clinical characteristics included were: diabetes type, diabetes duration (years), diabetes treatment regimen (insulin injections, insulin pump, GLP injections, oral medication, or lifestyle), most recent HbA_{1c} (mmol/mol, or ticking the box "I don't know"; HbA_{1c}% was calculated by the following formula: % = 0.0915*mmol/mol + 2.15), BMI (kg/m^2), the number of comorbidities (the sum of indicated comorbidities), and the number of hospitalisations (the sum over the past 12 months).

2.4. Statistical analysis

The demographic and clinical characteristics of the total sample, and the sample stratified by diabetes type and mental health category were calculated and tabulated as mean and standard deviation (mean ± SD) or as percentage ((%)N). Differences in demographics and clinical factors between moderate and flourishing mental health were tested with chi-square tests (categorical variables), and Mann-Whitney *U* tests (continuous variables). Missing values for age ($n = 9$), current employment ($n = 1$), and BMI ($n = 9$) were imputed with use of multiple imputation.

All main analyses were stratified by diabetes type. In all analyses, mental health was the independent variable, and the lifestyle behaviours (all continuous variables except smoking) were the main dependent variables. The group with languishing mental health was excluded from the final analyses due to a small number of participants ($n = 33$). It was decided not to collapse the languishing and moderate mental health group because it would impair the distinction between mental health and mental ill-health. Therefore, ANCOVA was used to test the differences between flourishing and moderate mental health. Three models were used to adjust for confounders step-by-step. The first model was unadjusted (i.e. the crude model), the second model was adjusted for age and sex, and the final model was additionally adjusted for having a partner (yes/no), BMI, diabetes duration (years), education (low, middle, high), and employment (paid employment yes/no). These confounders are often adjusted for in similar analyses, facilitating comparability of the results [39,40,41]. Outcomes were displayed as adjusted mean and the standard error of the mean (SEM).

Subsequently, multivariate binary and multinomial logistic regression analyses were performed, despite some loss of statistical power, based on categorical measures of the lifestyle behaviours due to three reasons: 1] smoking was a categorical outcome and cannot be analysed with ANCOVA, 2] the odds ratio's (OR) of lifestyle behaviours can be more easily compared to previous literature, and 3] it allows for ranking

people in sequential groups from low-intermediate-high diet quality and physical activity. In more detail, the multinomial logistic regression analyses were performed to investigate the associations between the independent variable mental health and the ordinal dependent variables diet quality and physical activity with three categories ('low', 'intermediate' or 'high'). Because the proportional odds assumption was not met (i.e. the predictors did not have the same effect on the odds of moving to a higher-order category along the scale), multinominal logistic regression (instead of ordinal logistic regression) was performed. Binary logistic regression analyses were performed for the dichotomous dependent variables alcohol consumption and smoking. Moderate mental health and the lowest categories of the lifestyle behaviours were the reference categories. The same three models as in the ANCOVA analyses were used to adjust for confounders. Outcomes are tabulated as OR and 95% Confidence Interval (95%CI).

Effect modification was tested with use of interaction terms. To test whether the associations differed between sex (male vs female), BMI categories (overweight (= BMI >25) yes/no), presence of comorbidities (yes/no), having a partner (yes/no), and educational level (low/middle/high), interaction terms were added to each final model separately to test for interaction. The models were also tested for multicollinearity by evaluating the Variance Inflation Factors (VIF). Data was analysed using IBM SPSS Statistics 25. *p*-values of 0.05 were considered statistically significant.

3. Results

3.1. Sample characteristics

Table 1 shows the demographic, clinical and behavioural characteristics for the total sample, and stratified by diabetes type and mental health category. Of the 595 participants, 45% had T1DM and 55% T2DM. Regarding T1DM, more female participants (51%) had flourishing mental health. Participants with T1DM and flourishing mental health had a higher intake of fruits and grains compared to moderate mental health (Table A.2 and A.3). Regarding T2DM, more male participants had flourishing mental health (58%). Participants with T2DM with flourishing mental health were also more likely to have a partner (Table 1), and had a higher intake of nuts compared to moderate mental health (Table A.3).

3.2. Associations between mental health and the lifestyle behaviours

Tables 2 and 3 show the associations between mental health and the lifestyle behaviours based on ANCOVA and the logistic regression analyses, respectively. There were no significant interaction effects between mental health category and sex, BMI, presence of comorbidities, having a partner and education level on lifestyle behaviours. Evaluation of the VIF showed no multicollinearity between the variables in the models.

3.2.1. T1DM

3.2.1.1. Diet quality. The ANCOVA showed that flourishing mental

Table 1
Characteristics of the total sample, and characteristics stratified by diabetes type and mental health category.

	T1- and T2DM (n = 595)	T1DM(n = 270)				T2DM(n = 325)			
		Mental health category				Mental health category			
		Languishing (n = 15)	Moderate (n = 128)	Flourishing (n = 127)	p-value	Languishing (n = 18)	Moderate (n = 130)	Flourishing (n = 177)	p-value
	%(N) ormean ± SD	*%(N) ormean ± SD*	*%(N) ormean ± SD*	*%(N) ormean ± SD*		*%(N) ormean ± SD*	*%(N) ormean ± SD*	*%(N) ormean ± SD*	
Demographics									
Women	52 (307)	27 (4)	67 (86)	51 (65)	**0.009***	50 (9)	53 (69)	42 (74)	**0.050***
Age (y)	55 ± 14	51 ± 12	46 ± 15	49 ± 15	0.104	54 ± 11	61 ± 10	62 ± 9	0.114
Ethnic minority	2 (12)	0 (0)	1 (1)	2 (2)	0.557	0 (0)	4 (5)	2 (4)	0.416
Education level					0.887				0.419
Low	22 (129)	20 (3)	17 (22)	16 (20)		33 (6)	23 (30)	27 (48)	
Middle	34 (201)	47 (7)	28 (36)	31 (39)		39 (7)	35 (45)	38 (67)	
High	45 (265)	33 (5)	55 (70)	54 (68)		28 (5)	42 (55)	35 (62)	
Having a partner	82 (488)	80 (12)	81 (103)	84 (106)	0.534	67 (12)	75 (97)	89 (158)	**0.001***
Paid employment	51 (301)	40 (6)	63 (80)	72 (91)	0.120	44 (8)	36 (47)	39 (69)	0.613
Clinical characteristics									
Diabetes duration (y)	17 ± 13	24 ± 15	24 ± 15	23 ± 15	0.607	8 ± 5	10 ± 8	11 ± 8	0.092
Diabetes treatment					0.091				0.853
Insulin pump	25 (150)	33 (5)	56 (71)	45 (57)		0 (0)	7 (9)	5 (8)	
Insulin injections	47 (278)	67 (10)	45 (57)	55 (70)		56 (10)	42 (54)	44 (77)	
GLP injections	1 (5)	0 (0)	0 (0)	0 (0)		6 (1)	1 (1)	2 (3)	
Oral medication	25 (148)	0 (0)	0 (0)	0 (0)		39 (7)	46 (60)	46 (81)	
Lifestyle only	2 (14)	0 (0)	0 (0)	0 (0)		0 (0)	5 (6)	5 (8)	
HbA1c (mmol/mol)	56 ± 12	55 ± 12	58 ± 12	58 ± 11	0.647	54 ± 13	55 ± 12	53 ± 10	0.119
HbA1c (%)	7.2 ± 1.1	7.2 ± 1.1	7.4 ± 1.1	7.4 ± 1.0		7.1 ± 1.1	7.2 ± 1.1	7.0 ± 1.0	
BMI (kg/m^2)	28 ± 6	26 ± 12	25 ± 5	26 ± 5	0.791	33 ± 7	30 ± 6	29 ± 5	0.216
BMI ≥25	62 (366)	27 (4)	42 (54)	43 (54)	0.957	89 (16)	80 (104)	76 (134)	0.373
Co-morbidities ≥1	78 (465)	93 (14)	71 (91)	71 (90)	0.968	78 (14)	84 (109)	83 (147)	0.853
Hospitalisations ≥1	18 (104)	20 (3)	18 (23)	17 (21)	0.740	17 (3)	19 (25)	16 (29)	0.517

Outcomes are displayed as percentage ((%)*N*) or as mean and standard deviation (mean ± SD) (chi-square tests for categorical variables and Mann-Whitney *U* tests for continuous variables).

* Statistically significant ($p \leq 0.05$).

Table 2
Associations between flourishing and moderate mental health (independent variable) based on the continuous variables of the lifestyle behaviours (dependent variables) (ANCOVA).

	T1DM ($n = 255$)			T2DM ($n = 307$)		
	Mental health category		*p*-value	*Mental health category*		*p*-value
	Moderate ($n = 128$)	Flourishing ($n = 127$)		Moderate ($n = 130$)	Flourishing ($n = 177$)	
	mean±SEM[a]	*mean±SEM*[a]		*mean±SEM*[a]	*mean±SEM*[a]	
Diet quality *(score)*						
Model 1	66 ± 1	68 ± 1	**0.047**[*]	67 ± 1	69 ± 1	**0.026**[*]
Model 2	66 ± 1	68 ± 1	0.064	67 ± 1	69 ± 1	**0.041**[*]
Model 3	66 ± 1	68 ± 1	0.053	68 ± 1	70 ± 1	**0.016**[*]
Physical activity *(MET-minutes/week)*						
Model 1	3195 ± 268	3483 ± 269	0.449	2291 ± 247	3451 ± 211	**<0.001**[*]
Model 2	3300 ± 276	3496 ± 270	0.611	2270 ± 245	3442 ± 212	**<0.001**[*]
Model 3	3730 ± 324	3880 ± 335	0.695	2380 ± 280	3472 ± 272	**0.001**[*]
Alcohol *(g/day)*						
Model 1	11 ± 1	11 ± 1	0.850	10 ± 1	9 ± 1	0.624
Model 2	12 ± 1	11 ± 1	0.605	10 ± 1	9 ± 1	0.370
Model 3	9 ± 1	8 ± 1	0.510	9 ± 1	7 ± 1	0.318

Model 1: crude model; model 2: adjusted for age and sex; model 3: additionally adjusted for having a partner (yes/no), BMI, diabetes duration (years), education level (low, middle or high), and employment (paid employment yes/no).
[*] Statistically significant ($p \leq 0.05$).
[a] Outcomes are displayed as estimated marginal mean with standard error of the mean (SEM).

Table 3
The associations between flourishing and moderate mental health (independent variable) based on the categorical measures of the lifestyle behaviours (dependent variables) (binary and multinomial logistic regression analyses).

			T1DM ($n = 255$)	T2DM ($n = 307$)
			Flourishing vs. Moderate Mental Health	Flourishing vs. Moderate Mental Health
			OR(95%CI)[a]	*OR(95%CI)*[a]
Diet Quality *(score)*	Model 1	*Low*	1.0 (reference)	1.0 (reference)
		Intermediate	0.8 (0.4–1.4)	1.4 (0.8–2.4)
		High	1.6 (0.9–2.8)	1.5 (0.9–2.7)
	Model 2	*Low*	1.0 (reference)	1.0 (reference)
		Intermediate	0.8 (0.4–1.4)	1.3 (0.7–2.2)
		High	1.5 (0.8–2.8)	1.5 (0.8–2.7)
	Model 3	*Low*	1.0 (reference)	1.0 (reference)
		Intermediate	0.7 (0.4–1.4)	1.3 (0.7–2.3)
		High	1.6 (0.9–3.1)	1.5 (0.8–2.8)
Physical Activity *(MET-minutes/ week)*	Model 1	*Low*	1.0 (reference)	1.0 (reference)
		Intermediate	0.9 (0.4–2.0)	1.0 (0.6–1.9)
		High	1.1 (0.5–2.5)	1.9 (0.998–3.7)[b]
	Model 2	*Low*	1.0 (reference)	1.0 (reference)
		Intermediate	0.9 (0.4–2.1)	1.0 (0.6–1.9)
		High	1.1 (0.5–2.5)	1.9 (0.995–3.7)[b]
	Model 3	*Low*	1.0 (reference)	1.0 (reference)
		Intermediate	1.0 (0.5–1.9)	1.0 (0.5–2.0)
		High	1.7 (0.9–3.5)	1.8 (0.9–3.6)
Alcohol consumption *(g/day)*	Model 1	*Low*	1.0 (reference)	1.0 (reference)
		High	1.1 (0.5–2.1)	0.9 (0.4–1.8)
	Model 2	*Low*	1.0 (reference)	1.0 (reference)
		High	1.1 (0.6–2.3)	0.9 (0.4–1.9)
	Model 3	*Low*	1.0 (reference)	1.0 (reference)
		High	1.2 (0.6–2.5)	0.9 (0.4–1.9)
Smoking *(smoking* vs *non- smoking)*	Model 1	*Low*	1.0 (reference)	1.0 (reference)
		High	0.7 (0.3–1.9)	0.7 (0.3–1.6)
	Model 2	*Low*	1.0 (reference)	1.0 (reference)
		High	0.6 (0.2–1.7)	0.8 (0.3–1.7)
	Model 3	*Low*	1.0 (reference)	1.0 (reference)
		High	0.6 (0.2–1.9)	0.7 (0.3–1.7)

Model 1: crude model; model 2: Adjusted for age and sex; model 3: additionally adjusted for having a partner (yes/no), BMI, diabetes duration (years), education level (low, middle or high), and employment (paid employment yes/no).
[a] Outcomes are displayed as odds ratio (OR) and 95% confidence interval (95%CI).
[b] A larger amount of decimals is displayed to prevent wrong interpretation of results.

health was significantly associated with a higher total diet quality score compared to moderate mental health in the crude model (mean ± SEM: 68 ± 1 vs 66 ± 1, $p = 0.047$), but this association was attenuated in model 2 (Table 2). When repeating the ANCOVA for diet quality with the 2015 dietary guidelines, flourishing mental health was not associated with higher diet quality compared to moderate mental health in any of the models (Table A.4). The logistic regression showed that people with flourishing mental health had a 1.6 times higher odds (95%CI: 0.9–3.1) to have high diet quality compared to people with moderate mental health in the final model, albeit this was not significant (Table 3 and Table A.5).

3.2.1.2. Physical activity. No significant associations were found in any of the analyses (Tables 2 and 3).

3.2.1.3. Alcohol consumption. No significant associations were found in any of the analyses (Tables 2 and 3 and Table A.5).

3.2.1.4. Smoking. No significant association was found (Table 3).

3.2.2. T2DM

3.2.2.1. Diet quality. The ANCOVA showed that flourishing mental health was significantly associated with a higher diet quality score (mean ± SEM: 70 ± 1 vs 68 ± 1, $p = 0.016$) compared to moderate mental health in the final model (Table 2). The logistic regression confirmed this relationship with ORs of 1.5 (95%CI: 0.8–2.8) for higher diet quality in the final model, albeit not statistically significant (Table 3). When repeating the ANCOVA for diet quality with the 2015 dietary guidelines, flourishing mental health was also significantly associated with higher diet quality compared to moderate mental health in the final model (mean ± SEM: 87 ± 1 vs 83 ± 1, $p = 0.006$; Table A.4). When using the 2015 dietary guidelines, people with flourishing mental health had a 2.1 higher odds (95%CI: 1.1–3.9) to have high diet quality compared to moderate mental health in the final model (Table A.5).

3.2.2.2. Physical activity. The ANCOVA showed that flourishing mental health was significantly associated with higher physical activity (mean ± SEM: 3472 ± 272 vs 2380 ± 280, $p = 0.001$) compared to moderate mental health in the final model (Table 2). The logistic regression analyses confirmed this relationship with a 1.8 OR (95%CI: 0.9–3.6) for

higher physical activity in the final model, albeit not statistically significant (Table 3).

3.2.2.3. Alcohol consumption. Based on the Dutch alcohol guideline of 2006, mental health was not associated with alcohol consumption (Tables 2 and 3). When using the 2015 alcohol guideline, flourishing mental health was associated with suboptimal following of the guideline in model 2 (OR(95%CI): 1.6(1.008–2.6)), but this association was attenuated in the final model (Table A.5).

3.2.2.4. Smoking. No significant association was found (Table 3).

4. Discussion

This cross-sectional analysis of the Diabetes MILES-NL study showed that people with T2DM with flourishing mental health had a diet more in line with dietary guidelines, and were more physically active compared to those with T2DM and moderate mental health. Regarding physical activity, findings are in line with a recent Canadian cross-sectional study that found that flourishing mental health was positively associated with more physical activity in people with diabetes (T1DM and T2DM together) [28]. Furthermore, several other cross-sectional studies showed that positive mental state constructs (such as positive affect, self-esteem and empowerment) were significantly associated with physical activity in T2DM [42,19,43]. Although the relationship between flourishing mental health and diet has not been previously investigated, previous studies showed that high self-efficacy was significantly associated with a healthier diet in T2DM [42,19,43]. Particularly for diet, it is important to reflect on socioeconomic status (SES). A high-quality diet is generally easier for people with a higher SES [44], while incidence of diabetes is higher among people with a lower SES [45]. Indeed, a previous study demonstrated that flourishing mental health was significantly associated with a higher level of income in people with diabetes [28]. In the present study, the level of income was not measured, but the percentage of highly educated people (45%) was larger than the national average of 32% [46]. Although all analyses were adjusted for education level, this may limit the generalisability to the total Dutch population.

Interestingly, the associations of flourishing mental health with diet and physical activity were not significant in people with T1DM. This was rather unexpected as previous studies demonstrated significant positive associations between self-efficacy and diet, and between self-efficacy and physical activity in T1DM [19,47,48]. Although self-efficacy does not equal mental health, it has been described as an important positive psychological characteristic in diabetes [19]. Further research seems needed to examine if the effect of mental health on lifestyle behaviours differs across diabetes types.

Regarding alcohol consumption, no significant associations were found with mental health in both T1DM and T2DM, which is in line with a Canadian cross-sectional study on flourishing mental health in diabetes [28]. Yet, when applying the Dutch alcohol guideline of 2015, flourishing mental health was significantly associated with suboptimal adherence to the guideline among people with T2DM in the first two models. This is somewhat contradictory with previous research demonstrating that mental ill-health (i.e. depressive and anxiety symptoms) are associated with higher alcohol use among T1DM and the general population [49,50]. During the data-collection (2011), the national alcohol guideline was less restrictive compared to the current guideline, hence, this may explain the suboptimal adherence in people with flourishing mental health. Alternatively, research suggested that people with mental ill-health use alcohol as a coping mechanism for anxiety and depression [49]. Perhaps, people with flourishing mental health use alcohol for other reasons, such as relaxation, social company or celebration. This hypothesis seems supported by a cross-sectional study that demonstrated culture-specific effects of mental health and alcohol consumption: more frequent alcohol consumption predicted more optimal mental health in German, but more suboptimal mental health in Chinese students [51]. More research in different contexts seems needed for a better understanding of mental health in relation to alcohol consumption.

Regarding smoking, the current study did not find significant associations with mental health in both T1DM and T2DM as well. This is in contrast to a Canadian cross-sectional study that found that flourishing mental health was in fact associated with a lower likelihood of smoking among people with diabetes [28]. Other previous studies showed that smoking was a predictor of mental ill-health (e.g. depression, negative affect, anxiety and stressors) [52,53,51]. Possible reasons that the present study did not find an association might be the relatively small percentages of smokers in the sample (8%) compared to the general Dutch population (15%) [54], and that the sample consisted of people with relatively optimal mental health as the group with languishing mental health was excluded from the analyses.

4.1. Strengths and limitations

This study is one of the first that focused on mental health (rather than mental ill-health) and lifestyle in diabetes, and it is the first study that investigate the association between flourishing mental health and diet. A second strength is that mental health was determined based on two-dimensions (e.g. emotional and psychological mental health), whereas other studies usually use a mental health measure that relates to one of these dimensions [19,21]. Hence, a more comprehensive measure of mental health was used compared to previous studies. A third strength is that the association between mental health and multiple lifestyle behaviours was investigated, rather than focussing on a single behaviour. A final strength is the robustness of results as demonstrated by multiple confounder models, and analyses based on the old and the most recent Dutch dietary guidelines.

A limitation of this study is the cross-sectional design, which means no conclusions on causality or temporality can be made. Hence, it is possible that optimal diet and physical activity levels precede mental health. Randomised controlled trials (RCTs) have shown indeed that a healthy lifestyle can improve mental health [55,56]. RCTs regarding the other direction of the association are relatively scarce [57], but it seems plausible that the relationship is bidirectional [19]. Secondly, the data collection was based on self-reported measures, which might have caused an information bias. However, since the additional categorical analyses yielded similar results as the main analyses, this problem was reduced, because these errors have a smaller effect in categorical analyses where participants are ranked. Thirdly, the measures for assessing SES were quite limited, which may have caused residual confounding. Future studies are highly recommended to included more thorough SES measures. Fourthly, the group of participants with languishing mental health was too small for meaningful analysis. Previous research has shown that mental ill-health was consistently associated with more suboptimal health behaviours [12,13,11]. Hence, it seems likely that languishing mental health would have been associated with more suboptimal lifestyle behaviours compared to moderate and flourishing mental health. A future study with a larger group of people with languishing mental health would be needed to test this hypothesis. To reach sufficient people with languishing mental health, future studies may consider other/additional recruitment strategies.

4.2. Conclusion

This is one of the first studies that investigated a composite measure of positive mental health in relationship to lifestyle behaviours among people with T1DM and T2DM. The present findings support the importance of flourishing mental health for two key cornerstones of diabetes self-management: diet and physical activity. Although no conclusions can be made about causality/temporality, this study,

together with numerous previous studies, has shown that mental health (rather than mental ill-health) plays an important role in healthy lifestyle behaviours among people with diabetes [19,20]. Biologically, flourishing mental health might directly cause favourable physiological effects, such as lowering the cortisol and the inflammatory responses to psychological stressors [19,58,59]. Behaviourally, flourishing mental health may facilitate healthier lifestyle behaviours and treatment adherence, and, thereby, mediate optimal blood glucose levels [19]. As it is likely that flourishing mental health and lifestyle behaviours reinforce each other, it is pivotal to design RCTs evaluating interventions aimed at promoting mental health to accomplish a healthy lifestyle. Especially since most of the (relatively limited available) interventions for improving mental health as a means to a healthier lifestyle are still focussed on coping with mental ill-health (e.g. decreasing perceived barriers, coping with diabetes-related distress and depression) [15,57]. Only a few interventions applied holistic strategies to enhance skills and behavioural processes important for psychological flexibility/mental health explicitly; the so-called third wave behaviour therapies (e.g. acceptance and commitment therapy, mindfulness and self-compassion training) [60]. The use of third wave behavioural therapies for T2DM seems promising so far [15]. Theoretical models such as positive psychology or salutogenesis are useful for designing mental health promoting interventions [15,20,61].

Finally, this study raises the question if positive mental health is more important for specific lifestyle behaviours (i.e. diet and physical activity) compared to others behaviours (i.e. alcohol and smoking), and if the effect of mental health on lifestyle behaviours differs across diabetes types. Although further research is needed, intervention developers may take this in consideration when designing mental health promoting strategies. For clinical practice, it is recommended to think of ways how to include mental health-promoting strategies, such as self-examination or mindfulness, in the primary care setting for T2DM.

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Author contributions

Diabetes MILES-NL is an international collaborative, initiated and conceptualized by Professor FP in the Netherlands. FP, GN, and MB, set up the Diabetes MILES-NL study, acquired funding, and collected the data. The idea for this paper was generated by SSM. Data analysis was conducted by EvB. Interpretation of the data has been done by CMMP, SSM and EvB. The paper was written by CMMP. FP, MH, LV, MB, GN, JMG, and SSM revised the paper for important intellectual content. All authors have read and approved the final article.

Data availability statement

Data sets are available upon reasonable request via contacting the corresponding author.

Declaration of Competing Interest

The authors have no competing interests to report.

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