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Participation in structured diabetes mellitus self-management education program and association with lifestyle behavior: results from a population-based study

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ABSTRACT

Objective Whether participation in structured diabetes self-management education programs (DSME) for participants with diabetes mellitus is associated with a healthy lifestyle in routine care apart from randomized-controlled studies remains unclear and is this studies' research question.

Research design and methods We identified 1300 persons with diabetes mellitus drawn from the cross-sectional population-based analysis German Health Update 2014/2015 (GEDA 2014/2015), which integrated the modules of the European Health Interview Survey (EHIS) wave 2. Of those, 816 were ever-DSME participants and 484 never-participants. We conducted multivariable weighted logistic regression analyses for lifestyle differences comparing ever-DSME and never-DSME participants. Lifestyle was defined by physical activity (PA), current smoking, fruit/vegetable consumption and body mass index (BMI). Age, sex, socioeconomic status, living together, limitation due to health problems for at least for 6 months, self-efficacy and attention to one's health were included as confounders in the regression models.

Results Ever-DSME participants engaged significantly more often in cycling at least 1 day per week (OR 1.62, 95% CI: 1.15–2.30) and performed significantly more often aerobic endurance training of 150 min per week (including walking: OR 1.42, 95% CI: 1.03–1.94, without walking: OR 1.48, 95% CI: 1.08–2.03) compared with never-DSME participants. Ever-DSME participants were significantly more often ex-smoker compared with never-DSME participants (OR 1.39, 95% CI: 1.03–1.88). DSME attendance was not significantly associated with current smoking, BMI and fruit or vegetable consumption.

Conclusion DSME participation is associated with a moderately healthier lifestyle particularly for PA even in routine healthcare. Study results emphasize the importance of a broadly dissemination of DSME access for nationwide diabetes healthcare. Future studies should adjust for DSME participation when investigating lifestyle in persons with diabetes.

Significance of this study

What is already known about this subject?

- Randomized controlled trials focusing on diabetes self-management education (DSME) programs showed beneficial effects on healthier lifestyle in very controlled settings leading to a nationwide implementation of DSME in Germany.
- Data on DSME association with lifestyle in routine care in population-based studies after nationwide implementation are rare.

What are the new findings?

- DSME participation is associated with a moderate healthier lifestyle and particularly more physical active lifestyle even in routine care settings in a nationwide population-based cross-sectional population-based study.
- DSME participation was associated with more frequent cycling and aerobic exercise of more than 150 min per week compared with never-DSME participation.
- DSME participation may be associated with increased smoking cessation compared with never-DSME participation.

How might these results change the focus of research or clinical practice?

- Study results emphasize the importance of nationwide DSME access for every person with diabetes mellitus (diabetes) to support an optimal diabetes healthcare.
- Study results should encourage clinicians to motivate patients to participate in DSME programs.
- Studies investigating lifestyle in persons with diabetes should adjust for DSME participation in addition to sociodemographic and other confounders

BACKGROUND

Diabetes mellitus (diabetes) is a global major public health concern.[1 2] It is estimated that 425 million people worldwide and 58 million people in Europe aged 20–79 years have diabetes, among them about 90% with type 2 diabetes.[3] In Europe, 477 000 deaths are attributed to diabetes among people aged

20–79 years, this corresponds to 9% of all-cause mortality.[3] Given the increasing incidence of type 2 diabetes with age and the aging population in the western world, the number of people with diabetes can be expected to grow even further in the future.[2 4] Diabetes is a chronic disease, which has considerable effects on affected person's daily life.[5] If not well managed, diabetes can lead to severe morbidity: Macrovascular complications are coronary heart disease, cerebrovascular and peripheral vascular contributing to cardiovascular mortality.[1] Furthermore, microvascular complications can occur as retinopathy, nephropathy and neuropathy. Thus, diabetes is an important risk factor for blindness, kidney failure and lower limb amputation resulting in a substantial individual and healthcare burden.[1 2] To prevent those diabetes-related complications, a near-normal blood glucose should be maintained.[6] This requires the implementation of lifestyle modifications and, if necessary, the adherence to a drug therapy for patients with diabetes.[6] Lifestyle modifications include healthy eating, increased physical activity (PA) and sustainable weight loss. It is therefore crucial, that patients learn self-management techniques in order to take personal responsibility for the management of their illness in daily life.[6] Thus, national and international guidelines and experts panels recommend participation in an structured patient self-management education programs for each patient with diabetes, the so-called Diabetes Self-Management Education programs (DSME) at least once in lifetime to increase patient empowerment and performance of self care.[6 7] In those DSME, patients acquire knowledge on healthy lifestyle and the importance of reduction of cardiovascular risk factors (eg, smoking cessation and weight loss). In Germany, DSME are provided as formal group-based programs combining structured group-based education with care for individual patient's needs and help for practical diabetes-related problems.[6] International literature has shown good evidence for effectiveness of DSME. In randomized controlled trials (RCTs), DSME participation is associated with decreased levels of blood glucose, glycolyzed hemoglobin A,[8] blood pressure[9 10] and increased foot care.[11] In addition, favorable results of DSME on healthy lifestyle behavior as PA, nutrition and body mass index (BMI) have been shown in some RCT.[9 11 12] In Germany, DSME are therefore covered by national insurance companies and installed nationwide in predominantly outpatient care in addition to pre-existing inpatient DSME. However, given the controlled settings and specific patient groups in RCTs, results of those international studies could not be easily transferred to effects of DSME in nationwide routine healthcare. In this context, population-based studies on possible DSME effects on lifestyle behavior are useful but rare.

Therefore, it is the aim of our study to investigate whether ever-participation in a DSME for participants with diabetes is associated with a healthier lifestyle behavior defined by increased PA behaviors (eg, routine daily activity and time spent in endurance or strength training, respectively), healthier eating behavior (reflected by daily fruit or vegetable consumption), smoking cessation and lower BMI compared with never-DSME participants in a real-world setting.

METHODS

Study population

We used data of the nationwide population-based German Health Update (GEDA) 2014/2015 European Health Interview Survey (EHIS) wave 2 survey, conducted on behalf of the German Federal Ministry of Health by the Robert Koch Institute between November 2014 and July 2015 via self-administered questionnaires provided either as online or paper-based version (response rate: 26.9%).[13] Our study population included adults with a permanent residence in Germany living in private households, who gave their informed consent.[13] Details of participant sampling, recruitment, questionnaire design and collected data are published elsewhere.[13 14] The study protocol was inspected and approved by the "Federal Commissioner for Data Protection and Freedom of Information in Germany." Written informed consent was obtained from all participants. Participants were informed about the goals and contents of the study, about privacy and data protection proceedings and their voluntary participation. The overall survey sample included 24 016 participants.[13 15] Of these, 3292 were excluded for missing values, further 217 for being currently pregnant and three for having gestational diabetes (online supplementary table S1). Thus, the final study population comprised 20 504 participants aged 19–99 years.

Assessment of lifestyle variables

Details of lifestyle variable assessment and categorization are shown in online supplementary table S3. Briefly, PA was obtained by the following self-reported items: (i) time spent in everyday life walking, (ii) days per week using bicycle in everyday life, (iii) days per week doing sports and (iv) time spent in endurance or strength training, respectively. BMI was calculated as the ratio of body weight to height squared and categorized according to WHO classification.[16] Smoking behavior (smoking) was analyzed as current smoker, ex-smoker and former smoker. Fruit and vegetable consumptions were obtained by asking for the frequency of consumption and number of portions of "fruits, including freshly squeezed fruit juices" and "vegetables or salad, including freshly squeezed vegetable juices" excluding potatoes and categorized each into daily versus less than daily consumption.

Assessment of diabetes and DSME

Participants were asked "During the past 12 months, have you had any of the following diseases or conditions?" with an attached list of diseases including "diabetes (not including gestational diabetes)." Respondents answering with "yes" were classified as having diabetes. Those, who answered with "yes," but reported a pregnancy at the time

of diagnosis and time of diagnosis and survey time was less than 2 years ago were categorized as having gestational diabetes and excluded from analyses. Furthermore, participants were asked, if they have ever participated in an DSME (yes/no). Those who answered "yes" were classified as ever-DSME participants, the others as never-DSME participants.

Statistical analysis

For descriptive statistics, we used unweighted absolute and weighted relative frequencies as well as weighted means and SD to analyze characteristics of the study sample regarding diabetes and DSME participation. For adjusted analyses, we performed weighted logistic regression analyses comparing the two exposures: (i) participants with diabetes versus participants without diabetes and (ii) for those with diabetes ever-DSME versus never-DSME participants for the outcomes PA, smoking, BMI and consumption of fruits/vegetables. For PA and consumption of fruit/vegetables binary weighted-logistic regression analyses; for smoking and BMI weighted multinomial logistic regression analyses were performed. We included the following variables as potential confounders in the model: age, sex, limitation due to health problems for at least 6 months, occupational status according to Labour Force Concept,[17] socioeconomic status based on the socioeconomic status score,[18] living situation, self-efficacy based on the ASKU Index[19] and how much participants do generally pay attention to their health (details of assessment and categorization tables 1–3 and online supplementary table S3). All results of the weighted logistic regression analyses were adjusted for above described confounders.

In a sensitivity analysis, we addressed the influence of time after diagnosis of diabetes to estimate whether DSME effects on lifestyle could be established in a short period of time. Therefore, we divided the overall sample in two subgroups at the cut-off of 2 years from being first diagnosed with diabetes until survey participation (less than 2 years group (≤2Y) vs more than 2 years group (>2Y)). We recalculated the weighted logistic regression analyses for each group separately. We tested for significant differences in effect sizes of DSME between both groups using the method of overlapping CIs and the corresponding test for interactions in logistic regression models.[20 21] All analyses were performed by STATA V.15.0[22] including a weighting factor as described in detail previously.[13 15]

RESULTS

Participants with and without diabetes

Of the 20 504 eligible participants, 1300 (6.7%) participants had diabetes. In descriptive analysis, participants with diabetes were significantly more often male and older than participants without diabetes. They had a significantly lower socioeconomic status and were significantly more likely to live in a partnership (table 1). Participants with diabetes experienced a significantly higher limitation due to health problems for at least 6 months, had a significantly lower self-efficacy but paid significantly more attention to their health compared with participants without diabetes (table 1). In descriptive analysis, participants with diabetes were more likely to consume fruits and vegetables at least once a day, to walk at least 30 min per day and to be ex-smokers. They engaged significantly less often in all other observed activities and were significantly more often overweight or obese than participants without diabetes (table 1). In adjusted logistic regression analysis, differences in health behaviors between participants with and without diabetes remained significant, except for walking in routine daily life and vegetable consumption (table 2).

Ever-DSME and never-DSME-participants

Of all 1300 participants with diabetes, 816 (62.7%) were ever-DSME participants compared with 484 (37.3%) never-DSME participants. Ever-DSME participants were significantly younger than never-DSME participants, had stronger self-efficacy beliefs, but showed no other statistically significant differences in sociodemographic characteristics. In descriptive analyses, ever-DSME participants engaged significantly more often in the observed PA, except for walking at least 30 min in routine daily life, and days doing sports. Ever-participants were significantly more often ex-smokers and less often never-smokers compared with never-participants. In adjusted logistic regression analyses, differences in PA behavior between ever-DSME and never-DSME participants remained significant for cycling for at least once a week (table 2; OR 1.62, 95% CI: 1.15–2.30) and followed the WHO recommendations for aerobe PA of more than 150 min per week with or without walking (OR 1.42, 95% CI: 1.03–1.94; OR 1.48, 95% CI: 1.08–2.03). The association between DSME participation and increased endurance strength training missed significance level in adjusted logistic regression analyses. Ever-participants of DSME remained significantly more often smoking quitters compared with never-participants (OR 1.39, 95% CI: 1.03 to 1.88) in adjusted logistic regression analyses. There were no statistically significant differences between ever-DSME and never-DSME participants with regard to overweight and obesity, current nicotine, vegetable and fruit consumption in descriptive and adjusted weighted logistic regression analyses.

In our sensitivity analyses, we took time after diabetes diagnosis into account. In the >2Y group, DSME participation was significantly associated with aerobic PA of more than 150 min per week and being an ex-smoker than in the ≤2Y group. However, OR's CIs between the ≤2Y and >2Y group overlapped. This shows that there was no significant difference between both groups concerning the effect of time after diabetes diagnosis on lifestyle factors. This was supported by the analysis of interaction effects between DSME participation and time after diabetes diagnosis on lifestyle variables (table 3, online supplementary table S2).

Table 1 Characteristics of the study sample and subgroups according to diabetes history or participation in a DSME program

Variables		Participants without diabetes		Participants with diabetes		p value*	Never-DSME participants		Ever-DSME participants		p value†
		N/M±SD‡	%§	N/M±SD‡	%§		N/M±SD‡	%¶	N/M±SD‡	%¶	
N		19204	93.3§	1300	6.7§		484	37.3¶	816	62.7¶	
Sex	Male	8588	49.4	767	57.4	<0.001	280	53.7	487	59.6	0.093
	Female	10616	50.6	533	42.6		204	46.3	329	40.4	
Age (years)		47.3±17.0		64.9±13.5		<0.001	67.4±13.1		63.5±13.5		<0.001
SES score ((min) 3 to 21 (max))		12.8±4.0		11.5±4.0		<0.001	11.6±4.1		11.4±3.9		0.713
Living together with spouse or as couple	Yes	13030	67.2	951	71.6	0.006	350	69.4	601	72.8	0.293
Limitation due to health problems for at least 6 months	High	808	4.8	225	18.4	<0.001	75	16.3	150	19.6	0.140
	Moderate	2923	15.7	442	33.9		164	31.9	278	35.0	
	None	15473	79.5	633	47.7		245	51.8	388	45.4	
Occupational status	Employed person	12869	67.1	404	30.3	<0.001	133	27.1	271	32.2	0.365
	Unemployed person	442	2.6	26	2.5		9	2.4	17	2.5	
	Retired/unable	5893	30.3	870	67.3		342	70.6	528	65.3	
Self-efficacy beliefs (ASKU; min: 1 to max: 5)		4.2±0.7		3.9±0.9		<0.001	3.9±1.0		4.0±0.9		0.009
How much participants generally pay attention to their health (min: 1 to max: 5)		3.5±0.7		3.53±0.8		0.010	3.5±0.8		3.6±0.8		0.303
Fruit intake	Less than daily	10299	56.4	540	42.3	<0.001	195	42.4	345	42.3	0.969
	At least once daily	8905	43.6	760	57.7		289	57.6	471	57.7	
Vegetable intake	Less than daily	12739	68.9	815	63.8	0.001	292	62.1	523	64.8	0.414
	At least once daily	6465	31.1	485	36.2		192	37.9	293	35.2	
Walking (min/day)	<30	12884	67.2	846	62.9	0.009	321	65.6	525	61.4	0.236
	≥30	6320	32.8	454	37.1		163	34.4	291	38.6	
Cycling (days/week)	<1	12898	69.4	980	77.4	<0.001	385	82.9	595	74.2	<0.001
	≥1	6306	30.6	320	22.6		99	17.1	221	25.8	
Doing sports (days/week)	<1	6442	36.3	649	51.0	<0.001	257	54.8	392	48.8	0.116
	1	2568	12.6	144	11.6		56	12.4	88	11.1	
	≥2	10194	51.1	507	37.3		171	32.7	336	40.1	

Continued

Table 1 Continued

Variables		Participants without diabetes N/M±SD‡	%§	Participants with diabetes N/M±SD‡	%§	p value*	Never-DSME participants N/M±SD‡	%¶	Ever-DSME participants N/M±SD‡	%¶	p value†
Endurance training ≥150 min/week and strength training twice/week	Yes	4689	23.6	193	13.5	<0.001	60	10.2	133	15.5	0.014
≥150 min. aerobic PA/week including walking	Yes	12149	61.2	655	48.9	<0.001	224	42.8	431	52.5	0.013
≥150 min. aerobic PA/week without walking	Yes	9399	47.0	455	33.2	<0.001	148	27.2	307	36.7	0.004
Tobacco use	Smoker	4526	25.3	211	16.9	<0.001	74	15.2	137	17.9	0.013
	Ex-smoker	5635	29.2	592	43.2		212	38.6	380	45.9	
	Never-smoker	9043	45.5	497	39.9		198	46.1	299	36.2	
BMI	Normal	9856	49.1	231	17.2	<0.001	82	18.1	149	16.6	0.256
	Overweight	6523	35.0	511	40.6		206	43.3	305	39.0	
	Obese	2825	15.9	558	42.2		196	38.6	362	44.4	
Time since diabetes mellitus-diagnosis	≤2 years	–	–	233	16.8		131	24.1	102	12.4	<0.001
	>2 years	–	–	1044	83.2		345	75.9	699	87.6	

This table shows absolute frequencies and estimated prevalences in per cent based on weight factors. The tests for significance take weight factors into account. N for time since diagnosis of diabetes mellitus varies from overall N for ever-DSME participants or never-DSME participants due to missing values for this variable. BMI was categorized according to WHO categorization as normal (<25 kg/m²), overweight (25-<30 kg/m²) and obese (≥30 kg/m²).[16]
*Indicates test for significance between participants with and without diabetes.
†Indicates test for significance between patients with diabetes with versus without DSME participation.
‡We show unweighted absolute frequencies.
§Percentages are calculated with reference to overall cohort including weight factors except for variable N.
¶Percentages are calculated with reference to ever-DSME participants or never-DSME participants, respectively. Calculation includes weight factors except for variable N.
ASKU, Index of self-efficacy; BMI, body mass index; diabetes, diabetes mellitus; DSME, diabetes self-management education; N, number; PA, physical activity; SES, socioeconomic status.

Table 2 Association between lifestyle variables and diabetes or ever-participation in DSME, respectively, estimated by logistic regression analyses

		Participants with diabetes (ref. participants without diabetes)	DSME-ever participants (ref: DSME-never participants)
		OR* (95% CI)*	OR* (95% CI)*
Fruit intake	At least once daily (ref: less than once daily)	1.25 (1.08 to 1.45)†	1.15 (0.87 to 1.53)†
Vegetable intake	At least once daily (ref: less than once daily)	1.13 (0.97 to 1.30)†	0.97 (0.73 to 1.30)†
Physical activity	Walking ≥30 min/day (ref:<30 min/day)	1.01 (0.87 to 1.17)†	1.19 (0.88 to 1.30)†
	Cycling ≥1 day/week (ref:<1 day/week)	0.70 (0.59 to 0.84)†	1.62 (1.15 to 2.30)†
	Doing sports in general ≥1 day/week (ref:<1 day/week)	0.74 (0.63 to 0.86)†	1.16 (0.86 to 1.57)†
	Doing sports in general ≥2 day/week (ref:<2 day/week)	0.71 (0.62 to 0.82)†	1.25 (0.90 to 1.73)
	Endurance training ≥150 min/week & strength training twice/week (ref: no)	0.59 (0.49 to 0.72)†	1.41 (0.95 to 2.08)†
	≥150 min aerobic PA/week including walking (ref.: less)	0.69 (0.60 to 0.80)†	1.42 (1.03 to 1.94)†
	≥150 min aerobic PA/week without walking (ref: less)	0.65 (0.56 to 0.76)†	1.48 (1.08 to 2.03)†
Tobacco use	Smoking (ref. never-smoking)	1.00 (0.81 to 1.23)‡	1.32 (0.87 to 2.00)‡
	Ex-smokers (ref. never-smokers)	1.28 (1.09 to 1.50)‡	1.39 (1.03 to 1.88)‡
BMI	Overweight (ref. normal)	2.09 (1.67 to 2.60)‡	0.97 (0.65 to 1.45)‡
	Obesity (ref. normal)	4.92 (3.95 to 6.12)‡	1.17 (0.79 to 1.74)‡

This table shows results of logistic regression analyses, dependent variables were lifestyle variables (fruit and vegetable intake, physical activity variables, smoking, BMI); DSME participation and diabetes as independent variables.
*All results are adjusted for age, sex, socioeconomic status, living together in marriage/as an unmarried couple or alone, limitation due to health problems for at least 6 months, occupational status, AKSU Index of self-efficacy and attentiveness to own health. Age, socioeconomic status [3 to 21], self-efficacy [1 to 5] and how much participants pay attention to their health [1 to 5] were included as continuous variables in the model. Categorial variables included in the model were: Sex (male/female), limitation due health problems for at least 6 months (high limitation/moderate limitation/none), occupational status [employed/unemployed/ retired or unable to work], living situation (as married or unmarried couple/ living alone] and how much participants do generally pay attention to their health [not at all/not so much/moderate/much/very much).
†Results were calculated using weighted multinomial logistic regression analyses, BMI categorization was according to WHO categorization[16] as normal (<25 kg/m²), overweight (25-<30 kg/m²) and obese (≥30 kg/m²).
‡Results were calculated using binary weighted-logistic regression analyses.
BMI, body mass index; diabetes, diabetes mellitus; DSME, diabetes self-management education; PA, physical activity; SES, socioeconomic status.

DISCUSSION

In this cross-sectional nationwide population-based study, participants with diabetes who attended an DSME engaged significantly more often in cycling and aerobic PA more than 150 min per week. Furthermore, DSME participants were significantly more often smoking quitters than persons who never participated in a DSME. The present study showed that DSME participation was associated with modestly healthier lifestyle in a routine healthcare setting even in a general adult population. It underlines the importance of access to DSME for all people with diabetes to support a high quality of diabetes care.

Comparison with other studies

In international literature, RCT and cohort studies underlined the effectiveness of DSME. Most RCT showed an increase in patient's PA,[11 23 24] a healthier nutrition[11 25] and increased smoking cessation [24] for DSME participation. In agreement with some of these studies,[9 12 23 24] we showed that DSME participation is associated with significantly increased PA for some activities. This effect was observable even in routine healthcare conditions. Study participants with diabetes engaged significantly less in PA compared with participants without diabetes. Here, DSME participants seemed to profit from DSME with respect to increased frequency of cycling and time spent for aerobic sportive activity. Participants with diabetes were more often ex-smokers and less often current smokers compared with participants without diabetes.

In agreement with pre-existing literature,[11] we observed the highest proportion of ex-smokers in participants with diabetes who ever participated in an DSME. In contrast to international literature, we observed a higher frequency of fruit and vegetable consumption in

Table 3 Association between lifestyle variables and ever-participation in DSME—subgroup analyses for participants with diabetes 2 years and less or more than 2 years after diagnosis, respectively, estimated by logistic regression analyses

		Time after diagnosis ≤2 years N=233	Time after diagnosis >2 years N=1044
		Ever-DSME participants ref: never-DSME participants	Ever-DSME participation ref. never-DSME participation
		OR* (95% CI)*	OR* (95% CI)*
Fruit intake	At least once daily (ref: less than once daily)	1.37 (0.72 to 2.59)†	1.16 (0.83 to 1.62)†
Vegetable intake	At least once daily (ref: less than once daily)	1.07 (0.54 to 2.11)†	0.99 (0.70 to 1.39)†
Physical activity	Walking >30 min/day (ref:<30 min/day)	1.08 (0.54 to 2.17)†	1.30 (0.92 to 1.82)†
	Cycling ≥1 day/week (ref:<1 day/week)	2.55 (1.21 to 5.37)†	1.52 (1.01 to 2.29)†
	Doing sports in general ≥1 day/week (ref:<1 day/week)	1.67 (0.84 to 3.35)†	1.03 (0.73 to 1.45)†
	Doing sports in general ≥2 day/week (ref:<2 day/week)	1.49 (0.79 to 2.82)†	1.20 (0.82 to 1.75)†
	Endurance training ≥150 min/week & strength training twice/week (ref: no)	0.58 (0.21 to 1.56)†	1.50 (0.96 to 2.34)†
	≥150 min aerobic PA/week including walking (ref: less)	1.28 (0.66 to 2.48)†	1.49 (1.04 to 2.12)†
	≥150 min aerobic PA/week without walking (ref: less)	1.23 (0.60 to 2.52)†	1.46 (1.01 to 2.12)†
Tobacco use	Smoking (ref. never-smoking)	2.84 (0.92 to 8.79)‡	1.26 (0.78 to 2.06)‡
	Ex-smokers (ref. never-smokers)	1.17 (0.59 to 2.32)‡	1.71 (1.21 to 2.41)‡
BMI	Overweight (ref. normal)	1.04 (0.39 to 2.79)‡	0.96 (0.61 to 1.51)‡
	Obesity (ref. normal)	1.61 (0.65 to 3.99)‡	1.19 (0.76 to 1.85)‡

This table shows the results of logistic regression analyses. Dependent variables: lifestyle variables (fruit and vegetable intake, physical activity variables, smoking, BMI); DSME-participation and diabetes as independent variables stratified according to time after diabetes diagnosis until survey time into patients ≤2 years after diagnosis (≤2Y group) and >2 years (>2Y group) after diagnosis. In the ≤2Y group were n=102 ever-DSME participants and n=131 ever-DSME participants. In the >2 Y group were n=699 ever-DSME participants and n=345 never-DSME participants. All logistic regressions were calculated for each subgroup separately.

*All results are adjusted for age, sex, socioeconomic status, living together in marriage/as an unmarried couple or alone, limitation health problems for at least 6 months, occupational status, AKSU Index of self-efficacy and attentiveness to own health. Age, socioeconomic status [3 to 21], self-efficacy [1 to 5] and how much participants pay attention to their health [1 to 5] were included as continuous variables in the model. Categorial variables included in the model were: Sex (male/female), limitation due to health problems for at least 6 months (high limitation/moderate limitation/ none), occupational status (employed/unemployed/retired or unable to work), living situation (as married or unmarried couple/living alone) and how much participants do generally pay attention to their health (not at all/not so much/moderate/much/very much). BMI categorization according to WHO categorization as normal (<25 kg/m²), overweight (25-<30 kg/m²) and obese (≥30 kg/m²).[16]

†Results were calculated using binary weighted-logistic regression analyses.

‡Results were calculated using weighted multinomial logistic regression analyses. N of both subgroups=1277.

BMI, body mass index; DSME, diabetes self-management education program.

participants with diabetes compared with those without diabetes. Reasons might be an over-reporting of fruit and vegetable consumption particularly in the group of those with diabetes due to possible clinicians' recommendations on dietary changes followed by a higher awareness of healthy diet as influencing factor in diabetes care and socially desirable answering behavior. We could not show any difference in fruit or vegetables intake between ever-DSME and never-DSME participants within the group of participants with diabetes. Although some RCTs[11 12] have shown favorable effects of DSME on healthy eating, others studies showed no significant difference for DSME participants.[26–28] In our overall sample, we could show the well-established association of diabetes and increased BMI, but DSME participation was not associated with a significant lower prevalence of overweight and obesity. On the other hand, the missing significant DSME influence on BMI might also be explained by recruitment effects. Physicians might tend to refer persons with higher cardiovascular risk more likely to participate in a DSME.[29] However, due to lack of data on physician referral habits in our population-based study we could not adjust for this.

Differences of our results to above-cited international literature may be explained by differences in study settings. Most studies on DSME effects on lifestyle factors were RCT and included several DSME repetitions or other exclusive support, for example, via telephone or

additional doctor–/nurse–patient consultations.[10–12 23 24] This does not reflect routine German healthcare. There, German national insurance companies cover DSME participation once after diagnosis only (in few federal states DSME repetition is reimbursed) and afterwards only in cases of specified events as metabolic disorders or if insulin treatment is required. As our study sample is population-based, setting differences to pre-existing RCT literature should be taken into account. Additionally, DSME's design, frequency and repetition intervals vary widely in international literature leading to much heterogeneity.[8]Studies on DSME participation and its effects on healthy lifestyle are rare when it comes to examining these outcomes in every day routine healthcare: A South Korean population-based study showed no significant association between DSME attendance and abstinence of smoking, increased moderate PA or nutrition.[28] In contrast to the Korean study and in agreement with our results, an US-American cohort study for patients of one insurance company reports a moderate increase of aerobic PA after DSME participation.[30] A small German cohort study showed no changes on BMI after DSME participation but did not examine smoking and PA habits.[31] Here, our study adds knowledge to the current literature.

We performed a sensitivity analysis with stratified samples based on a 2-year cut-off according to time after diagnosis. We chose the cut-off of 2 years because persons with diabetes are usually advised to attend a DSME shortly after diagnosis. Furthermore, 2 years seemed a sufficient time to get a placement for DSME and adapt a new lifestyle habit. It showed no statistically significant differences between both groups concerning DSME participation association with our outcomes. One interpretation might be that DSME participation might result in relatively quick changes on participants lifestyle, which is in concordance to international studies. Those studies showed that lifestyle changes could develop in a comparatively short time period between 3 months to 1 year.[9 11 32] Additionally, our dataset does not provide data on time of DSME attendance, although usually persons with diabetes were referred to a DSME shortly after diagnosis. As the sample size in the ≤2 Y group was relatively small, it might be possible that we underestimate differences between those two groups. Therefore, we treat our interpretation cautiously.

Persons with diabetes showed decreased self-efficacy, but ever-DSME participants reported increased self-efficacy beliefs. Given our observational study setting we cannot conclude, whether persons with a high self-efficacy tend to participate more likely in a DSME or DSME participation increases self-efficacy of participants. However, a meta-analysis of 21 studies on this topic showed a significant improvement of self-efficacy after DSME participation after 6 months,[33] indicating that participant' self-efficacy is increased by DSME participation. Increased self-efficacy seems to be significantly associated with a better glycemic control,[34] but more research is needed on how self-efficacy influences glycemic control.

Strengths and limitation

Up to our knowledge, our study is one of the few studies adding knowledge on DSME effects on a variety of lifestyle variables in a real-world setting based on a large nationwide sample drawn from the general population. Studies published on DSME effects so far were predominantly RCT in a specific care setting or specific patient group. Only a few cohort studies on DSME effects in routine care are published.[28 30 35] Of those, only two were a nationwide or federal state wide population-based studies,[28 35] the other was limited to patients of certain insurance programs.[30] Of the two population-based cohort studies on DSME effects, one does not provide data on lifestyle.[35] Lifestyle parameters are not easily available in most routine setting. Claims data, which are often used to describe routine healthcare, do not cover lifestyle data in most cases.[36] Additionally, the GEDA-2014/2015-EHIS study provides a large representative German population-based sample. In comparison with other studies, we provide a more extensive adjustment for potential confounders.

Our study has several limitations. GEDA 2014/2015-EHIS survey provides cross-sectional data only, so no longitudinal trends could be assessed. All data on health outcomes and examined variables in our analyses are based on self-report. So, they might be affected by recall bias and social desirability. However, literature suggests that self-report assessments of diabetes and our chosen outcomes are in general moderate to very good reliable compared with assessments based on physical examinations or blood samples.[36–41] The GEDA 2014/2015-EHIS questionnaire excludes gestational diabetes for diabetes definition, but does not distinguish between diabetes type 2 or 1. However, given the representative sample and the high prevalence of diabetes type 2 in the German population it can be assumed, that a high percentage of the participants with diabetes suffered from diabetes type 2. Furthermore, data on DSME participation were limited to dichotomous categories as "ever" or "never" participation, respectively. Data on type of DSME, setting, repetetive DSME participation, time duration between diabetes diagnosis and DSME participation, non-completion of DSME or data on inscription of specialized chronic care disease management programs (DMP) for participants with diabetes were not available. Also, frequencies of participant-practice staff or participant-physician contacts were not available in our survey. In German healthcare routine, in average 75% of patients with diabetes are inscribed in a DMP,[42] which includes a free DSME at least once and for relevant therapeutical changes, for example, beginning of insulin therapy. Participation in this DMP might be a confounder as it includes more frequent doctor/practice staff consultation than usual care. Frequent patient–clinician contacts could also enhance a healthy lifestyle habit in patients

with diabetes.[43] Data on DSME participation for patients with DMP reveal high local differences ranging from about 29%[36] up to 71%–89,5% of inscribed patients.[42] However, as no data specifically on DMP diabetes participation were available in the survey GEDA 2014/2015-EHIS, we could not adjust for this potential confounder.

DSME-ever participants were significantly younger than never-participants, but we addressed this difference by adjusting for age and other variables as confounder in our weighted regression models. Furthermore, due to exclusion of participants for missing values for the analyses of our research question, the diabetes prevalence in our analyzed sample differs slightly from the already published 7.7% in the overall GEDA 2014/2015-EHIS sample.[44] Although healthy eating includes various aspects as reduction of, for example, intake of glucose-sweetened soft drinks and low-fibre foods the GEDA-EHIS 2014/2015 survey provided data on fruit and vegetable consumption only. So, therefore our analyses of nutrition were limited to these aspects. Additionally, the GEDA-EHIS 2014/2015 survey did not provide any data on access to localizations for PA or food security, so we could not adjust for those variables.

Importance of DSME to support diabetes therapy

In Germany, DSME are provided as education for small patient groups (often 4–6 participants). Persons with type 2 diabetes receive at least 8 hours DSME in total, split into 4 weekly session for 90 min. Persons with type 1 diabetes receive more extensive DSME distributed over several days.[6] DSME are provided predominantly by DSME-trained nurses in outpatient care, one session has to be provided by a DSME-trained physician. In Germany, DSME can be accessed nationwide and is covered by public health insurance.[6]

Achieving a healthy lifestyle and prevention or reduction of cardiovascular risk factors are key issues to support an optimal therapy of diabetes. Patients with diabetes have to implement the main therapy and in particularly lifestyle aspects in their daily life by themselves. Therefore, their self-treatment behavior is a key influence factor for their diabetes prognosis.[8] Thus, they rely on knowledge and competencies which are trained by DSME. DSME focuses on knowledge and understanding of diabetes, its associated risks and long-term complications. It helps the patient to accept their disease, promotes patient's active role in the therapy process, enhances patient's self-management and self-determination. DSME programs are aimed to encourage the patients to actively achieve a healthy nutrition, stop smoking, and to be more physical active, enhancing relevant diabetes therapy support issues in everyday life.[8] Thus, DSME is an substantial and integral part for the therapy of each person with diabetes.[8] Our analyses add to the pre-existing knowledge mostly based on RCTs, that DSME participation is significantly associated with a more active, healthy lifestyle under real-world conditions.

CONCLUSION

In our representative population-based nationwide study sample, ever-DSME participation was associated with a moderately increased PA. Particularly, DSME attendance was associated with more frequent cycling and aerobic PA of more than 150 min per week compared with never-DSME participation under real-world conditions. A DSME participation may be associated with increased smoking cessation compared with never-DSME participation. This underlines the importance of DSME referral for every person with diabetes to enhance a healthy lifestyle and to support an optimal therapy of their disease. Future research projects should target the effect of repeated DSME participation on participants' lifestyle and if a participation in a chronic care program (eg, DMP diabetes) might influence their diabetes-related health behavior in addition to DSME participation. Furthermore, studies investigating lifestyle in people with diabetes should adjust for DSME participation in addition to sociodemographic and other confounders in their analyses.

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