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Original Article

Do eating behaviors in the general population account for country variance in glycemic control among adolescents with diabetes: the Hvidoere Study Group and the Health Behaviour in School-Aged Children study

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Background: The Hvidoere Study Group (HSG) has demonstrated major differences in glycemic control between pediatric diabetes centers which remain largely unexplained. This study investigates whether these differences are partly attributable to healthy eating norms in the background population.
Methods: The study involved adolescents from 18 countries from (i) the Health Behaviour in School-Aged Children study (HBSC) and (ii) the HSG. There were 94 387 participants from representative HBSC samples of 11-, 13- and 15-yr-olds and 1483 11- to 15-yr-old adolescents with diabetes from the HSG. The frequency of intake of fruit, vegetables, sweets, sugary soft drinks, and daily breakfast was compared between the two groups. The glycemic control of the adolescents in the HSG cohort was determined by measuring glycated hemoglobin (HbA1c).
Results: Across countries in the HSBC survey, there was substantial variation in prevalence of healthy eating behavior and even greater variation between adolescents from the HSG centers. In all countries more adolescents with diabetes reported healthy eating behavior compared to national norms. In individuals healthy eating behavior had a significant effect on the individual level HbA1c. There was no significant correlation between the frequencies of these healthy eating behaviors at (i) the national level and (ii) diabetes center level and the center mean HbA1c.
Conclusions: Although individual healthy eating behavior is associated with better glycemic control at the individual level, such eating behavior does not explain the center differences in HbA1c. Similarly, the reported healthy eating norm of the background populations does not explain the variation in glycemic control among centers.

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Key words: adolescents – behavior – comparative study – diabetes mellitus type 1 – eating

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Since 1994 the Hvidoere Study Group (HSG), a multicenter international collaborative study group, has conducted studies demonstrating differences in metabolic control between pediatric diabetes centers from 21 countries (1). So far the most influential factors affecting glycemic control in different centers would seem to be target setting for glycated hemoglobin (HbA1c) (2), the individual center's ability to implement particular insulin regimens (3), family dynamic factors (4), and sedentary behavior (5) but these factors do not adequately explain the wide variation in glycemic control across centers.

As diet is one of the corner stones of management in diabetes (6), questions on food intake were asked in the HSG 2005 center differences study and although preliminary analyses appeared to show some significant associations between eating habits and the glycemic control of individuals it did not explain variance in glycemic control across centers (7). This might have been due to the different cultural background eating habits in the various countries. Therefore to facilitate national comparisons, the specific dietary questions which were included in the HSG 2005 study were derived from the Health Behaviour in School-Age Children (HBSC) study (8, 9). In the HBSC the data represent an indication of healthy eating norms of the country (10). HBSC is a WHO collaborative cross-national survey carried out every 4 yr since 1983 in 41 countries from Europe and North America, investigating health and health-related behavior among nationally representative random samples of adolescents in the school setting.

Therefore this study investigates whether eating habits in adolescents with type 1 diabetes (T1DM) in the HSG centers differ from their healthy peers in the HBSC study, using the same measures in the two international populations. It also examines whether the variation in glycemic control between HSG centers is influenced by healthy eating norms, using eating behavior in the background population (HBSC populations) as the indicator of healthy eating norms.

Methods

Adolescents from a general population

The HBSC is a standardized, international World Health Organization collaborative study with repeated cross-sectional surveys administered in the school setting among students aged 11, 13, and 15 years from 41 countries and regions. (For more information, see http://www.hbsc.org). Each national study includes students from a representative random sample of schools and has adapted the international standard English version of the questionnaire, with independent forward and backward translations, conducted at the international coordinating center. Because the study is anonymous, we are unable to analyze the characteristics of non-participants. In this study, we use data from 2005/2006 and only include data from the 18 HBSC countries that were also represented in HSG.

Adolescents with diabetes

The HSG center differences study 2005 was an observational multicenter, cross-sectional study. The setting of the study was 21 pediatric diabetes departments from 19 countries in Europe, Japan, Australia, and North America (3). Adolescents (aged 11–18 yr; diabetes duration (6.1 ± 3.5 yr)) were invited consecutively to participate. Only data from countries which participated in both the HSG study in 2005 and HBSC 2005/2006 ($n = 18$) and only children within the HBSC age range (11–15 years of age) were included in this study.

A total of 263 students from HBSC who lacked age information and 1 patient from HSG without information on gender were excluded from the study leaving a population of 94 387 participants from the general population (HBSC) and 1483 from the diabetes centers (HSG). Table 1 shows the number of participants from the 18 countries in the HBSC that were common in both studies and from the 18 centers included from HSG.

Both studies were performed according to the criteria of the Helsinki II Declaration and were abiding by national ethical requirements in all countries.

Measures

The HSG Case Report Form (CRF) included information on gender, age, height, weight, duration of diabetes, number of severe hypoglycemic events, and diabetic ketoacidosis (DKA). Information regarding insulin treatment and concomitant medical conditions was obtained. A capillary blood sample for HbA1c was provided by participants and analyzed at Steno Diabetes Centre, Gentofte, Denmark, using the Tosoh method (normal range 4.4–6.3% and an inter-assay SD of 0.15%) as described elsewhere (3). Language difficulties causing communication problems and

Table 1. Number of boys and girls included in the HBSC and the Hvidoere study from 18 countries with comparable data

	HBSC study general population		Hvidoere Study (HSG) adolescents with diabetes	
Country	Boys	Girls	Boys	Girls
Belgium	2313	2163	60	51
Canada	2769	3090	36	39
Denmark	2757	2984	34	37
England	2318	2464	36	39
Finland	2510	2739	44	37
Germany	3668	3606	74	66
Ireland	2451	2389	34	26
Israel	2424	3262	54	50
Italy	1998	1953	64	63
Grand Duchy of Luxembourg	2162	2138	25	21
Republic of Macedonia	2629	2652	37	34
the Netherlands	2114	2114	18	19
Norway	2438	2273	25	31
Scotland	3063	3127	39	37
Spain	4368	4523	25	30
Sweden	2192	2223	32	32
Switzerland	2257	2364	60	43
USA	1857	2035	62	69
Total	46 288	48 099	759	724

co-morbid conditions specified as coeliac disease, thyroid disease, asthma, epilepsy, or others were documented. In the HBSC study, age and gender were self-reported by the students.

In both studies diet was assessed by questions from HBSC survey 2001 (11). The questionnaires included five comparable food frequency questions on diet related behavior:

How many days a week do you usually eat or drink: fruits/vegetables/sweets/sugar containing soft drinks? The possible responses being: never/less than once a week/once a week/2–4 days a week/5–6 days a week/once a day every day/more than once a day every day.

Breakfast consumption was ascertained by asking: How often do you usually have breakfast during weekdays? Possible responses being: never/1 day/2 days/3 days/4 days/5 days (10).

The variables were dichotomized as follows: fruit [every day (1) vs. less (0)], vegetables [every day (1) vs. less (0)], sweets [once a week or less (1) vs. more often (0)], sugary soft drinks [less than once a week (1) vs. more often (0)], breakfast [five weekdays (1) vs. less (0)]. An index of healthy eating behavior was constructed combining all five variables (range: 0–5) for use in individual level regressions. Further, a dichotomized version of the index variable was constructed defining healthy eating behavior indicated by 4 or 5 points for use in country level proportions and logistic regressions. Sensitivity analyses including other cut-points did not alter the conclusion.

Statistical analysis

The HSG participants were divided into three age groups to match the HBSC 11-, 13-, and 15-yr groups (10.5–12.5 yr/12.6–14.5 yr/14.6–16.5 yr). A weighting variable was calculated for each age group at each study-country-gender level to enable age group standardization in the analyses. All analyses were done for boys and girls separately.

We included both individual and country level information in the analyses.

Logistic regression analyses using individual level data was applied to compare eating behaviors between the two study groups (see Table 2).

Spearman correlation analyses were used to calculate associations between HBSC country level data on prevalence of each healthy eating behavior and HSG diabetes center level mean HbA1c.

Multilevel regression analysis was carried out to assess to what extent the diabetes center variation in HbA1c is explained by the individuals' healthy eating behavior and by the HBSC country level of healthy eating behavior. Intraclass correlation (ICC) as a measure of similarity within centers was calculated as the variance at the center level divided by the total variance. Throughout the study, we used 95% confidence intervals as the level of statistical significance.

Results

The study comprised HBSC representative samples of students from 18 countries ($N_{HBSC} = 94\,387$;

Table 2. Indicators of healthy eating habits among samples of adolescents in the general population (HBSC) and adolescents with diabetes (HSG) in 18 countries. Age standardized prevalence (%) and odds ratios (95% CI) for boys and girls

Country	Fruit every day			Vegetables every day			Sweets once a week or less			Sugary soft drinks less than once a week			Breakfast every weekday			At least four of five healthy habits		
	HBSC	HSG	OR (95% CI)	HBSC	HSG	OR (95% CI)	HBSC	HSG	OR (95% CI)	HBSC	HSG	OR (95% CI)	HBSC	HSG	OR (95% CI)	HBSC	HSG	OR (95% CI)
For Boys																		
Belgium	41.83	45.93	1.2 (0.7–2.0)	41.47	50.05	1.4 (0.8–2.4)	31.52	48.50	2.0 (1.2–3.4)	23.38	66.74	6.6 (3.8–11.3)	66.89	73.52	1.4 (0.8–2.5)	12.37	32.03	3.3 (1.9–5.8)
Canada	34.54	35.24	1.0 (0.5–2.1)	37.17	30.32	0.7 (0.4–1.5)	31.85	48.57	2.0 (1.0–3.9)	23.70	65.40	6.1 (3.0–12.2)	66.89	90.79	4.9 (16–15.2)	12.43	18.73	1.6 (0.7–3.8)
Denmark	34.77	30.34	0.8 (0.4–1.7)	32.15	46.50	1.8 (0.9–3.6)	38.84	34.70	0.8 (0.4–1.7)	19.95	92.99	53.2 (14.2–199.3)	75.18	74.10	0.9 (0.4–2.0)	12.73	22.91	2.0 (0.9–4.6)
England	37.97	25.32	0.6 (0.3–1.2)	38.17	25.63	0.6 (0.3–1.2)	22.99	51.27	3.5 (1.8–6.8)	20.22	63.25	6.8 (3.4–13.5)	69.75	84.84	2.4 (1.0–6.1)	10.83	21.03	2.2 (1.0–4.9)
Finland	18.75	13.89	0.7 (0.3–1.7)	20.75	11.11	0.5 (0.2–1.2)	45.08	37.50	0.7 (0.4–1.4)	22.13	75.00	10.6 (5.3–21.0)	66.83	89.58	4.3 (1.6–11.2)	7.94	11.81	1.6 (0.6–3.9)
Germany	29.88	42.69	1.7 (1.1–2.8)	18.41	31.02	2.0 (1.2–3.3)	30.19	19.70	0.6 (0.3–1.0)	30.00	69.33	5.3 (3.2–8.7)	67.25	79.45	1.9 (1.1–3.3)	7.19	16.22	2.5 (1.3–4.7)
Ireland	31.84	42.76	1.6 (0.8–3.2)	36.04	44.84	1.4 (0.7–2.9)	19.23	54.55	5.0 (2.5–10.0)	19.28	86.12	26.0 (9.8–69.0)	72.60	90.77	3.7 (1.2–11.9)	7.97	51.51	12.3 (6.2–24.4)
Israel	37.93	34.62	0.9 (0.5–1.5)	37.25	44.94	1.4 (0.8–2.4)	27.92	27.38	1.0 (0.5–1.8)	13.23	72.89	17.6 (9.6–32.5)	45.14	74.59	3.6 (1.9–6.6)	4.49	26.53	7.7 (4.1–14.5)
Italy	41.18	47.44	1.3 (0.8–2.1)	23.01	34.36	1.8 (1.0–3.0)	27.11	53.15	3.1 (1.8–5.0)	15.78	47.18	4.8 (2.9–7.9)	71.24	72.71	1.1 (0.6–1.9)	6.58	20.30	3.6 (1.9–6.8)
Grand Duchy of Luxembourg	31.23	31.06	1.0 (0.4–2.3)	24.78	17.17	0.6 (0.2–1.8)	33.78	59.09	2.8 (1.3–6.3)	21.16	79.55	14.5 (5.5–38.5)	59.26	65.15	1.3 (0.6–2.9)	7.44	25.25	4.2 (1.7–10.5)
Republic of Macedonia	37.17	49.02	1.6 (0.8–3.1)	31.21	22.88	0.7 (0.3–1.4)	23.09	45.75	2.8 (1.5–5.4)	15.72	82.35	25.0 (10.7–58.6)	62.48	88.24	4.5 (1.7–12.3)	4.78	26.14	7.0 (3.3–15.0)
the Netherlands	26.88	25.00	0.9 (0.3–2.6)	36.58	22.22	0.5 (0.2–1.5)	20.95	19.44	0.9 (0.3–2.9)	10.02	50.00	9.0 (3.5–22.9)	82.97	94.44	3.5 (0.5–26.2)	5.06	18.06	4.1 (1.2–13.9)
Norway	35.99	55.36	2.2 (1.0–4.9)	26.63	64.05	4.9 (2.2–11.2)	47.38	64.40	2.0 (0.9–4.6)	16.05	83.33	26.2 (9.1–75.3)	73.99	84.17	1.9 (0.6–5.5)	13.01	44.05	5.3 (2.4–11.7)
Scotland	35.43	40.15	1.2 (0.6–2.3)	32.57	23.35	0.6 (0.3–1.3)	17.94	38.66	2.9 (1.5–5.5)	19.36	76.36	13.4 (6.4–28.3)	66.17	97.92	24.0 (2.7–216.4)	8.85	19.64	2.5 (1.1–5.6)
Spain	30.36	44.55	1.8 (0.8–4.1)	16.12	6.36	0.4 (0.1–1.8)	43.39	87.58	9.2 (2.8–30.2)	19.28	93.64	61.6 (12.3–307.3)	78.76	96.67	8.1 (1.5–43.5)	7.91	28.79	4.7 (2.0–11.3)
Sweden	28.16	53.08	2.9 (1.4–5.8)	30.36	55.07	2.8 (1.4–5.7)	43.06	48.11	1.2 (0.6–2.5)	20.25	89.53	33.7 (10.8–104.9)	76.73	100.0	Not applicable	11.76	47.95	6.9 (3.4–14.0)
Switzerland	35.60	52.71	2.0 (1.2–3.4)	34.56	47.16	1.7 (1.0–2.8)	31.98	23.81	0.7 (0.4–1.2)	24.31	62.63	5.2 (3.1–8.9)	57.82	85.98	4.5 (2.1–9.3)	10.33	32.03	4.1 (2.3–7.2)
USA	37.85	36.67	1.0 (0.6–1.6)	33.47	43.34	1.5 (0.9–2.5)	34.66	44.27	1.5 (0.9–2.5)	18.34	67.70	9.3 (5.4–16.1)	54.43	79.37	3.2 (1.7–6.0)	9.09	25.00	3.4 (1.8–6.1)
Total	33.45	39.97	1.3 (1.1–1.5)	29.70	35.78	1.3 (1.1–1.5)	32.04	42.25	1.6 (1.3–1.8)	19.92	71.50	10.1 (8.6–11.8)	68.00	83.08	2.3 (1.9–2.8)	8.90	26.15	3.6 (3.1–4.3)
For Girls																		
Belgium	47.12	58.76	1.6 (0.9–2.8)	54.24	61.97	1.4 (0.8–2.4)	30.73	47.86	2.1 (1.2–3.6)	33.96	71.79	4.9 (2.7–9.2)	62.83	61.15	0.9 (0.5–1.6)	18.98	39.99	2.8 (1.6–5.0)
Canada	44.02	38.33	0.8 (0.4–1.5)	45.02	38.33	0.8 (0.4–1.5)	31.86	59.44	3.1 (1.6–6.0)	36.22	59.44	2.6 (1.4–4.9)	55.74	80.00	3.2 (1.4–7.0)	17.58	31.67	2.2 (1.1–4.3)
Denmark	47.61	40.74	0.8 (0.4–1.5)	40.82	61.81	2.3 (1.2–4.6)	41.49	36.57	0.8 (0.4–1.6)	33.36	95.14	39.1 (8.7–175.1)	68.00	92.59	5.9 (1.7–20.2)	19.31	41.67	3.0 (1.5–5.8)
England	47.85	39.90	0.7 (0.4–1.4)	45.48	41.92	0.9 (0.5–1.6)	25.22	29.80	1.3 (0.6–2.5)	30.74	58.59	3.2 (1.7–6.1)	57.90	82.32	3.4 (1.5–7.7)	16.84	25.76	1.7 (0.8–3.5)
Finland	27.53	36.70	1.5 (0.8–3.0)	29.95	46.70	2.1 (1.1–3.9)	44.08	30.98	0.6 (0.3–1.1)	37.57	77.39	5.7 (2.6–12.3)	62.76	87.08	4.0 (1.5–10.5)	13.90	26.17	2.2 (1.0–4.6)
Germany	41.05	49.77	1.4 (0.9–2.3)	29.02	33.69	1.2 (0.7–2.1)	29.78	28.46	0.9 (0.5–1.6)	40.39	82.50	7.0 (3.7–13.2)	59.38	76.32	2.2 (1.2–3.9)	12.59	29.70	2.9 (1.7–5.0)
Ireland	41.58	25.59	0.5 (0.2–1.2)	45.85	29.46	0.5 (0.2–1.2)	19.64	43.43	3.1 (1.4–6.9)	33.44	81.65	8.9 (3.3–24.0)	64.75	93.27	7.5 (1.6–35.0)	14.91	20.20	1.4 (0.6–3.8)
Israel	44.57	43.40	0.9 (0.5–1.7)	46.27	66.32	2.3 (1.3–4.1)	25.53	30.06	1.3 (0.7–2.3)	16.57	79.90	20.0 (10.0–40.2)	40.16	66.32	2.9 (1.6–5.3)	6.40	36.19	8.3 (4.6–15.0)
Italy	45.36	54.18	1.4 (0.9–2.4)	29.65	35.91	1.3 (0.8–2.2)	28.44	46.24	2.2 (1.3–3.6)	26.65	46.21	2.4 (1.4–3.9)	61.77	75.87	1.9 (1.1–3.5)	9.97	30.23	3.9 (2.2–6.8)
Grand Duchy of Luxembourg	43.17	67.24	2.7 (1.1–6.8)	32.69	48.20	1.9 (0.8–4.5)	31.68	40.55	1.5 (0.6–3.5)	32.62	90.91	20.6 (4.7–91.5)	52.98	77.06	3.0 (1.1–8.3)	11.47	32.76	3.8 (1.5–9.4)
Republic of Macedonia	46.72	29.05	0.5 (0.2–1.0)	40.92	33.81	0.7 (0.4–1.5)	19.90	53.81	4.7 (2.4–9.3)	19.27	90.79	41.3 (12.9–132.6)	64.19	86.35	3.5 (1.3–9.4)	7.35	29.05	5.2 (2.4–11.0)
the Netherlands	37.98	11.11	0.2 (0.0–0.9)	46.63	33.89	0.6 (0.2–1.5)	20.62	25.56	1.3 (0.5–3.7)	16.60	23.33	1.5 (0.5–4.5)	77.14	87.78	2.1 (0.5–8.4)	9.00	2.78	0.3 (0.0–4.5)
Norway	47.11	68.66	2.5 (1.1–5.3)	33.13	78.63	7.4 (3.1–17.6)	46.05	78.63	4.3 (1.8–10.2)	21.37	80.06	14.8 (6.1–35.9)	64.37	76.35	1.8 (0.8–4.1)	17.49	67.52	9.8 (4.6–21.0)
Scotland	42.82	48.71	1.3 (0.7–2.4)	43.16	44.75	1.1 (0.6–2.0)	17.42	43.95	3.7 (1.9–7.2)	30.54	93.46	32.5 (8.8–119.9)	56.90	86.94	5.0 (1.9–13.2)	13.87	34.38	3.3 (1.6–6.5)
Spain	35.80	49.40	1.8 (0.9–3.6)	21.20	34.23	1.9 (0.9–4.1)	40.62	88.39	11.1 (3.6–34.0)	27.13	93.15	36.5 (8.8–150.9)	71.15	95.24	8.1 (1.5–43.5)	11.66	54.17	9.0 (4.3–18.5)
Sweden	35.44	45.71	1.5 (0.8–3.1)	40.16	56.67	1.9 (1.0–3.9)	46.74	55.60	1.4 (0.7–2.9)	32.01	86.79	13.9 (5.0–38.9)	70.50	91.90	4.8 (1.3–17.0)	19.28	46.67	3.7 (1.8–7.4)
Switzerland	46.62	55.56	1.4 (0.8–2.6)	44.46	51.11	1.3 (0.7–2.4)	31.43	41.11	1.5 (0.8–2.8)	32.30	75.93	6.6 (3.3–13.4)	49.81	85.19	5.8 (2.5–13.5)	14.05	34.44	3.2 (1.7–6.1)
USA	40.98	35.40	0.8 (0.5–1.3)	38.33	36.98	0.9 (0.6–1.6)	28.45	52.62	2.8 (1.7–4.5)	27.64	71.35	6.5 (3.8–11.1)	41.46	64.52	2.6 (1.6–4.2)	10.13	20.08	2.2 (1.2–4.1)
Total	42.13	45.26	1.1 (1.0–1.3)	38.48	46.08	1.4 (1.2–1.6)	31.35	45.45	1.8 (1.6–2.1)	29.56	74.95	7.1 (6.0–8.4)	60.24	79.25	2.5 (2.1–3.0)	13.50	33.24	3.2 (2.7–3.7)

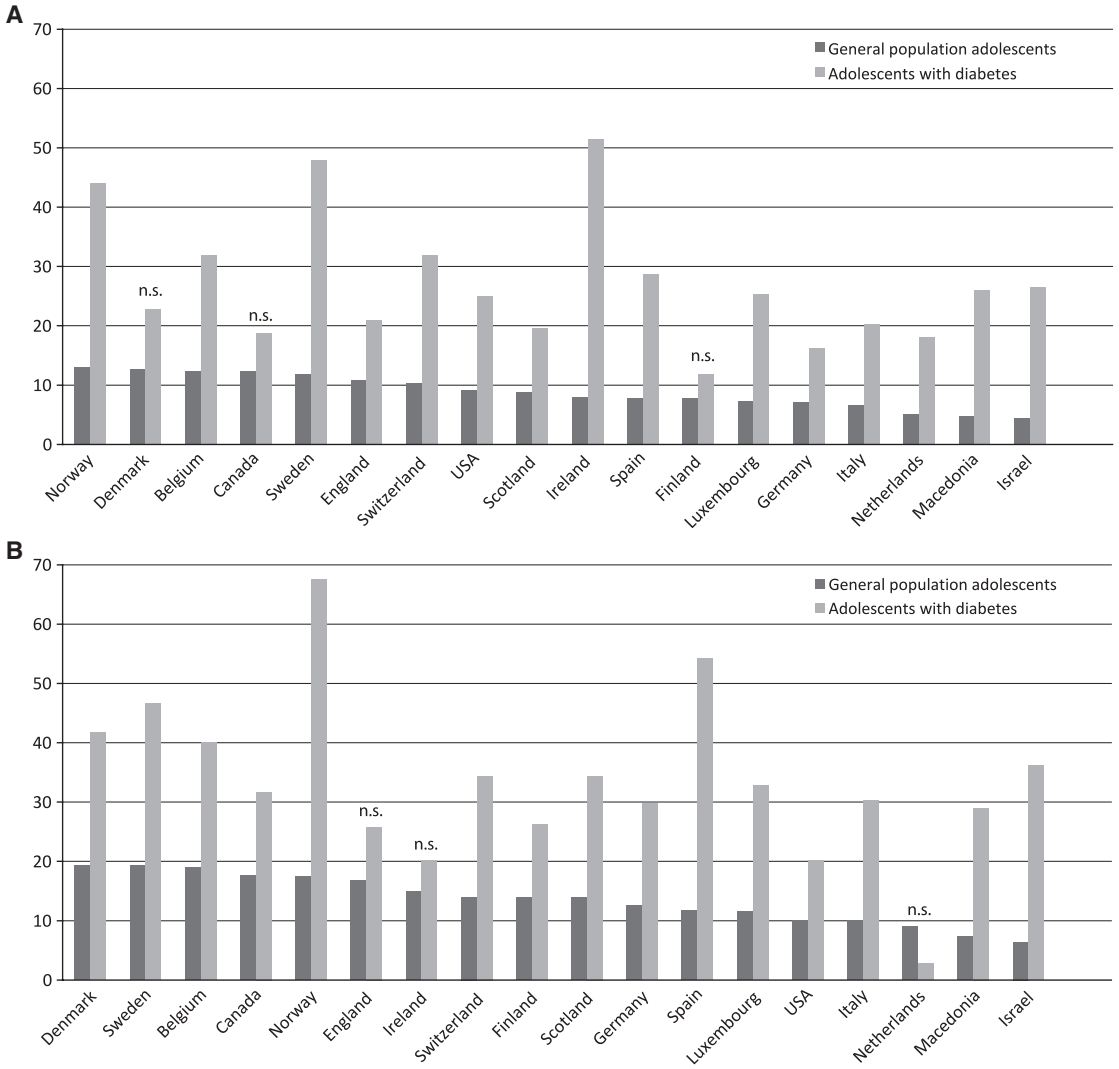

Fig. 1. (A) Proportion of 11- to 15-yr-old boys with at least four of five healthy eating habits by country. (B) Proportion of 11- to 15-yr-old girls with at least four of five healthy eating habits by country. n.s.: non-significant ($p < 0.05$).

N between 3892 from USA and 8891 from Spain) and adolescents with diabetes from HSG centers in the same 18 countries ($N_{HSG} = 1483$; N between 37 from the Netherlands and 140 from Germany) (Table 1).

Figure 1A, B shows the proportion of 11 to 15-yr-old boys and girls with at least four of five healthy eating behaviors. These are illustrated by ranking the 18 national background levels from the HBSC study, from highest to lowest, and comparing them with the 18 diabetes centers. These analyses showed that more adolescents with diabetes had healthy eating behavior in all centers in both boys and girls, with the exception of girls in the Netherlands. The result for Dutch girls was not significant, and this was also the case for differences in prevalence of healthy eating between the normal population and the diabetic children in five other situations: for boys in Denmark, Canada, and Finland and for girls in England and Ireland (Table 2).

The figures also illustrate both the variation between different countries in the prevalence of healthy eating behaviors in the background HBSC populations ($range_{boys}$: 4.5% in Israel to 13.0% in Norway; $range_{girls}$: 6.4% in Israel to 19.3% in Denmark) and the even larger variation between the participants with diabetes from different HSG centers ($range_{boys}$: 11.8% in Finland to 51.5% in Ireland; $range_{girls}$: 2.8% in the Netherlands to 67.5% in Norway).

When looking at each of the food intake behaviors separately, the difference in prevalence was largest and most consistent in the use of sugar containing soft drinks (Table 2). In all countries, prevalence of use of soft drinks was significantly lower among adolescents with diabetes compared to the general population. For instance, in Spain 93.6% of boys with diabetes reported having sugary soft drinks less than once a week, compared to 19.3% of boys in the HBSC population. Also most HBSC countries showed a significantly lower

proportion of adolescents having an intake of sweets once or less per week. In almost all countries, prevalence of daily breakfast was higher for adolescents with diabetes compared to the general population. However, for both fruit and vegetable intake, several countries showed lower daily intake among the adolescents with diabetes than among the general population, varying to some extent between males and females.

Correlation analyses at the country level showed that prevalence of healthy eating behaviors (healthy eating norms) in the general HBSC population of adolescents was not significantly correlated with mean HbA1c from the corresponding HSG centers of adolescents with diabetes (data not shown). One nearly significant exception was for low intake of soft drinks among HBSC boys ($r = 0.46$, $p = 0.054$).

To account for healthy eating behaviors at the individual level, multilevel regression analysis was conducted among the HSG adolescents with HbA1c as outcome. This analysis confirmed the substantial variation between countries: 13–14% of the total variation in individual HbA1c could be ascribed to differences between centers (ICC, 0.13 for boys and 0.14 for girls). When the individual level index of healthy eating behavior was entered into the model, a significant effect on the individual level HbA1c was shown ($p_{boys} < 0.0001$, $p_{girls} < 0.01$), but this did not change differences between the centers (the variation at the center level).

Introducing healthy eating norm of the country into the model (proportion of adolescents in the general HBSC population reporting healthy eating behavior) did not contribute to explaining the variation between centers any further.

Discussion

This study compared healthy eating behaviors in two populations; adolescents with diabetes from 18 international diabetes centers (the HSG cohort), and large adolescent school cohorts from the same countries (the HBSC cohort). The results show that adolescents with diabetes in all the diabetes centers reported healthier eating behavior than the comparative general population of young people, especially concerning lower intake of sweets and sugar containing soft drinks, and more frequent daily intake of breakfast. Both the national HBSC cohorts indicating norms of the country, and the diabetes centers showed substantial variability in healthy eating behaviors, which was even more marked in the diabetes populations. Country level analysis of intake of individual food types among the general adolescent population as well as among the adolescents with diabetes failed to show significant correlations with the mean HbA1c of the diabetes centers.

Multilevel analysis taking the reports of healthy eating behavior by individuals into account showed an association with individual HbA1c but the center differences in glycemic control remained. Moreover, when prevalence of healthy eating behavior in the background national HBSC populations was also taken into account, this did not influence the HSG center differences in glycemic control.

From the diabetes perspective it would seem to be important that the adolescents with diabetes have modified their diet in the direction which is recommended, toward a healthier diet particularly with fewer sugary soft drinks and sweets, and regular breakfasts. The intake of fruit and vegetables was somewhat disappointing being comparable with the intakes of their non-diabetic peers. However all these features varied enormously between countries and at the national level the healthy eating behaviors were not associated with glycemic control as measured by the HbA1c. Nevertheless at the individual level the healthy eating behaviors were correlated with lower HbA1c.

In diabetes, healthy eating practices are advised not only to assist overall glycemic control (HbA1c) but also glycemic variability (12) so a reduction in sugar intake may well be of importance. Also this may have a positive influence on potential long term problems such as weight gain and vascular complications (13). Other eating behaviors such as regulated carbohydrate intake, carbohydrate counting, meal planning and adjustments probably have a greater influence on glycemia than healthy eating patterns as measured in this study (14).

In this study, neither healthy eating behavior within the HSG groups, nor the national levels of healthy eating in the HBSC populations explain the variation between centers in the mean HbA1c. Future studies will have to reconsider other more dynamic factors such as the ability to modify carbohydrate regulation, success with insulin adjustments and psychosocial interactions, which may have more important influences on adherence and metabolic outcome than food intake.

There are important limitations to this study, perhaps the main one being the different manner in which the data was collected from the two study groups. The food intakes reported by the adolescents with diabetes were reported in clinics alongside the parents and in this situation there is likely to have been bias towards reporting what the medical staff had recommended. In contrast the HBSC reports are from adolescents attending schools without the influence of parents or any strong emphasis toward healthy eating behavior. Nevertheless the degree of difference and the consistency between the groups seems to suggest a gratifying attempt by the adolescents with diabetes to acknowledge a healthier eating pattern. Moreover, we cannot claim that the HSG populations

are truly representative. We are comparing individual city diabetes centers with national norms and selected diabetes centers within certain cities may well differ in dietary cultures from national averages.

A further limitation may be that the dietary data are self-reported and only measuring habitual intake. However the same methodologies were used in both data sets, and previous studies have suggested that despite using this approach children could be accurately classified to high or low intakes compared to other more established methods such as 24-h recall or food diaries (15).

Our hypothesis that the cultural norms in national eating habits might influence the major differences in diabetes centers has not been substantiated by the measures used in this study. Nevertheless this study, designed to compare the results from a medical condition like diabetes with the large background data from HBSC, is an original one which may well prove fruitful in other conditions. Alternative approaches would be to include in the HSG center studies some age matched non-diabetic controls, or in the HBSC studies children with specified medical conditions.

Conclusions

We found large variations in healthy eating behaviors between countries and between diabetes centers.

Our study showed that adolescents with diabetes report some healthier eating habits than their peer groups of young people in national cohorts. There is a significant association between individual scores on a healthy eating index and individual glycemic control. While there might be significant benefits to individuals among the adolescents with diabetes, their healthier dietary intake did not explain the international differences in the mean glycemic control of the centers, and our measures of healthy eating norms do not contribute to explain differences any further. It is to be hoped that the healthier eating behaviors reported by the adolescents with diabetes have benefits such as lower glycemic levels, less glycemic variability and longer term prevention of excessive weight gain and vascular complications.

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Appendix

HSG and HBSC study group

HBSC is an international study carried out in collaboration with WHO/EURO. The International Coordinator of the 2005/2006 HBSC study was Candace Currie, University of St Andrews, Scotland; the Data Bank manager was Oddrun Samdal, University of Bergen, Norway. A complete list of the participating researchers can be found on the HBSC Website (http://www.hbsc.org).

The HSG is an international collaboration involving:

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