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Original Research

Fear of hypoglycaemia and self-management in type 1 diabetes

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ABSTRACT

Aims: We studied the association between fear of hypoglycaemia (FoH) and various diabetes self-management practices.
Methods: Data from 798 individuals with type 1 diabetes participating in the FinnDiane Study were included. Self-reported questionnaires were used to assess FoH and self-management practices (e.g. dietary intake, insulin administration, physical activity). For glycaemic control, we used both the latest HbA_{1c} measurements and the serial HbA_{1c} measurements from the medical files. Factor analysis was used to reveal underlying constructs within the food frequency section of the diet questionnaire.
Results: In all, 44% and 63% of men and women reported FoH, respectively. In men, FoH was associated with higher mean serial HbA_{1c} levels, higher number of reported self-monitoring of blood glucose (SMBG), higher carbohydrate intake, and lower scores in the "high-fat" factor. In women, FoH was associated with a higher number of reported SMBGs and higher energy intake. No difference was observed in physical activity and insulin administration.
Conclusions: FoH has various implications for the self-management of diabetes. More studies are however needed to assess on one hand the association between FoH and diabetes self-management, and on the other hand, FoH and its long term consequences, such as the emergence of diabetic complications and mortality.

Introduction

Good glycaemic control is a prerequisite for reducing the risk of late complications in type 1 diabetes. Normalising blood glucose is, however, challenging due to the potential risk of hypoglycaemia. Hypoglycaemia is, indeed, a common adverse event associated with insulin treatment [1], and a three-fold increase in the occurrence of hypoglycaemic episodes, with intensifying insulin management, was observed in the Diabetes Control and Complications Trial [2].

Hypoglycaemias are categorised as "mild" and "severe" based on the individual's ability to self-treat oneself. During severe episodes, external assistance is required for recovery. Estimates of the frequencies of hypoglycaemias vary depending on the level of hypoglycaemia and the population in question. Roughly, two episodes of mild hypoglycaemias per week, have been reported in type 1 diabetes [3], and in a population-based study, 82% of individuals with type 1 diabetes reported having experienced at least one hypoglycaemic event over the course of one month [1]. With regards to the severe hypoglycaemias, an overall rate of 1.3 episodes per patient-year was observed in an unselected population of individuals with type 1 diabetes [4]. However, with increasing disease duration, the frequency of episodes seems to increase, as over 3 episodes per patient-year were observed among individuals with diabetes duration over 15 years [5].

The symptoms of hypoglycaemia, such as shaking, impaired vision, anxiousness and sweating may be inconvenient and unpleasant. It is, however, the life threatening nature of the severe hypoglycaemias, which are particularly worrisome to many individuals with insulin-treated diabetes. Fear of hypoglycaemia (FoH) appears to be common [6]. Amongst others, factors such as trait anxiety and frequency of experienced severe hypoglycaemic episodes have been associated with FoH [7,8].

There are various self-management strategies that individuals with FoH use to cope with their fear. One may, for example, administer less insulin than required [9] or restrain from physical activity [10]. Alternatively, one could increase the amount of food

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eaten or eat more carbohydrate-rich food stuffs in order to avoid hypoglycaemia [11]. Despite these actions that all aim at keeping the blood glucose concentrations at higher levels, there does not seem to be a clear association between FoH and HbA_{1c} [8,12–14].

The aim of the current study was to evaluate the association between self-reported FoH and various diabetes self-management practices, including self-monitoring of blood glucose (SMBG), food intake, and leisure-time physical activity (LTPA), in a large and well characterised population of patients with type 1 diabetes. Moreover, the association between FoH and HbA_{1c} was studied.

Methods

Study subjects

Study subjects were participants in the Finnish Diabetic Nephropathy (FinnDiane) Study. From this study of people with type 1 diabetes, we included all who had filled in both the diabetes questionnaire and the diet questionnaire. Thus, for the current cross-sectional analyses, we included data from a total of 798 individuals. The Ethics Committee of the Hospital District of Helsinki and Uusimaa approved the study protocol. Signed informed consent was obtained from all participants prior to study inclusion.

Clinical methods

During the study visits, participants' height and weight were measured in light clothing. Based on these measurements, body mass index was calculated. Following a 10-minute rest, blood pressure was measured in the sitting position. The measurement was repeated with a minimum of 2 minutes' interval, and the mean of the two measurements were used in the analyses. Blood samples were collected and HbA_{1c} was determined locally by standardised assays. In addition, data on all HbA_{1c} measurements conducted at the participating centres were collected from the patients' medical files. The serial HbA_{1c} data collected from these medical files and from the measurements conducted at the study visits (on average 26.6 ± 16.9 measurements per patient) were used to calculate the mean serial HbA_{1c} and the coefficient of variation for these HbA_{1c} values. The coefficient of variation was considered a measure of HbA_{1c} variability. Only those participants with a minimum of three HbA_{1c} measurements were included in the analyses of HbA_{1c} variability (n = 733). Serum lipid and lipoprotein concentrations were measured as previously described [15]. The daily insulin dose was self-reported. Based on these reports and the measured weight, insulin dose per body weight (IU/kg) was calculated.

Urinary albumin excretion rate (AER) in at least two out of three timed 24-hour or overnight urine collections was used to assess participants' renal status. The following classifications were made: normal albumin excretion rate (AER <20 μg/min or <30 mg/24 h), microalbuminuria (AER ≥20 and <200 μg/min or ≥30 and <300 mg/24 h), macroalbuminuria (AER ≥200 μg/min or ≥300 mg/24 h), and end-stage renal disease (ESRD) (in dialysis or with kidney transplant). Diabetic nephropathy was defined as macroalbuminuria or ESRD. Retinal laser-treatment (data obtained from the medical records) was used as an indication of severe retinopathy. Data on smoking and social class (grouped as unskilled/skilled blue-collar, lower/upper white-collar, farmers, and others) were self-reported. Unskilled blue-collar workers were classified as having a low socioeconomic status (SES).

Questionnaires

The diabetes questionnaire was used to collect data on various diabetes specific issues of clinical importance. The diabetes questionnaire is a self-reported structured form, designed to collect data on patients' perceptions of their disease. The questionnaire was designed by a panel of experienced diabetes specialists. Based on years of clinical work, these specialists aimed at formulating a questionnaire that would shed light on the patients' subjective view of their disease. Thus, by design, the questionnaire is subjective in nature. Two questions from this questionnaire were used to approximate FoH: 1. Are you afraid of hypoglycaemia? 2. Has fear of hypoglycaemia led you to eat just in case. FoH was assumed if a positive reply was given to both of these questions.

Dietary intake was measured by two separate methods, as previously described [16]. In short, participants (n = 798) filled in a diet questionnaire that was designed to capture information on their habitual dietary intake. As part of this diet questionnaire, a 19-item food frequency questionnaire (FFQ) was also completed. In this FFQ, the frequency of consuming the most common food items in Finland were queried. Thus, participants reported the frequency of consuming fish dishes, meat dishes, poultry, sausages and cold cuts, eggs, legumes, fresh vegetables, cooked vegetables, potatoes, pasta and rice, fruits and berries, high-fat cheese, low-fat cheese, yoghurt, ice cream, soft drinks, pastries, sweets, and fried and grilled foods using a seven scale responses. Upon returning the diet questionnaire, patients were allocated a 3-day exercise and food record (two weekdays and one weekend day). In this record, data on food consumption, physical activity, insulin use, and SMBG were reported. In order to capture some seasonal variation in the dietary intake, the 3-day recording was repeated in 2–3 months. In the current analyses, individuals who filled in the record for a minimum of three days (n = 615) were included. AivoDiet software (version 2.0.0.1, AIVO, Turku, Finland), based on the Finnish National Food Composition Database (Fineli) [17], was used to calculate the mean daily energy and nutrient intakes reported in the records.

From the same record, the number of reported blood glucose measurements per journal day, the mean value of the reported blood glucose measurements, and the number of days with reported blood glucose values <3.5 mmol/l (cut off level previously used by Leese et al. [18]) per journal day were calculated. Additionally, the mean reported insulin dose divided by body weight was calculated. Finally, we calculated the daily metabolic equivalent of task hour (METh), which reflects the energy cost of LTPA. The METh was calculated by multiplying the duration of the activity, reported in the record, by the activity- and intensity-specific metabolic equivalent.

Statistical analyses

Descriptive statistics are reported as percentages for categorical data, median (interquartile range) for non-normally distributed continuous data, and mean ± standard deviation (SD) for normally distributed continuous data. The respective group comparisons were performed with chi-squared test, Mann–Whitney U-test, and independent-sample t-test. Exploratory factor analysis (maximal likelihood and varimax rotation) was conducted to reveal underlying constructs within the FFQ of the diet questionnaire. In the analysis, the number of factors identified was based on eigenvalues >1.0, and items with factor loading $|\geq 0.20|$ with a particular factor, were included. The factor score was the sum of the scores for all items associated with that particular factor multiplied by its corresponding factor loading. The obtained scores were used as dependent variables in the analyses. Forward stepwise logistic regression analyses were used to assess factors independently associated with FoH. For the model, all items that were statistically significant ($p < 0.05$) or borderline significant ($p < 0.08$) in the bivariate analyses were included. All data were analysed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp, Armonk, NY, USA).

Table 1
Patient characteristics divided by gender and fear of hypoglycaemia status

	Men			Women		
	FoH, yes n = 154 (43.9%)	FoH, no n = 197 (56.1%)	p	FoH, yes n = 283 (63.3%)	FoH, no n = 164 (36.7%)	p
Background data						
Age, years	48.6 ± 13.3	51.4 ± 13.0	0.054	47.2 ± 13.6	48.4 ± 12.2	0.347
Diabetes duration, years	30.8 ± 14.1	31.0 ± 13.2	0.890	31.2 ± 13.3	30.9 ± 13.4	0.832
Current smoking, %	14.9	14.4	0.999	12.0	11.9	<0.999
Low SES, %	14.6	14.7	0.999	9.9	14.6	0.228
Retinopathy, %	43.4	47.4	0.514	36.2	34.6	0.758
Diabetic nephropathy, %	26.7	29.4	0.767	13.4	12.8	0.999
BMI, kg/m^2	26 (23–28)	26 (24–28)	0.814	24 (22–28)	25 (23–28)	0.339
Total cholesterol, mmol/l	4.2 (3.8–4.8)	4.4 (3.9–5.1)	0.224	4.5 (4.0–5.2)	4.7 (4.3–5.2)	0.166
HDL cholesterol, mmol/l	1.4 (1.2–1.6)	1.4 (1.1–1.6)	0.683	1.7 (1.4–2.0)	1.8 (1.5–2.2)	0.080
Triglycerides, mmol/l	1.1 (0.8–1.4)	1.1 (0.8–1.5)	0.675	0.9 (0.6–1.2)	0.9 (0.7–1.1)	0.910
Systolic blood pressure, mmHg	141 (132–153)	142 (133–155)	0.382	134 (122–148)	132 (120–146)	0.454
Diastolic blood pressure, mmHg	79 ± 11	80 ± 9	0.321	77 ± 10	76 ± 9	0.473
Insulin and HbA_{1c} data						
Insulin dose, IU/kg	0.58 (0.46–0.73)	0.61 (0.48–0.76)	0.223	0.53 (0.44–0.69)	0.56 (0.45–0.75)	0.557
Insulin pump, %	7.5	10.4	0.510	17.4	12.9	0.300
Latest HbA_{1c}, %	8.1 (7.4–8.6)	8.0 (7.2–8.8)	0.827	8.2 (7.5–9.1)	8.1 (7.2–9.0)	0.489
HbA_{1c}, mmol/mol	65 (57–71)	64 (55–73)		66.1 (59–76)	65 (55–75)	
Mean* HbA_{1c}, %	8.3 (7.6–9.1)	8.0 (7.4–8.9)	0.015	8.3 (7.6–9.0)	8.3 (7.4–9.1)	0.934
HbA_{1c}, mmol/mol	67 (60–76)	64 (57–74)		67 (60–75)	67 (57–76)	
Coefficient of variation for HbA_{1c}*	7.8 (5.8–11.0)	7.7 (5.9–11.0)	0.546	8.1 (6.1–11.4)	8.2 (6.6–10.6)	0.717

Data are presented as median (interquartile range) for continuous non-normally distributed variables, mean ± SD for continuous normally distributed variables, and frequency (%) for categorical variables. FoH, fear of hypoglycaemia; Low SES, low socioeconomic status (unskilled blue collar workers); IU, international units. *Calculated from the serial HbA_{1c} measurements.

Results

Of the 798 participants, 492 (61.7%) were self-reportedly afraid of hypoglycaemias (question 1), and 566 (70.9%) reported eating "just in case" because of their fear of hypoglycaemias (question 2). A total of 437 (55%) individuals replied positively to both of these questions and were thus categorised as having FoH. As women reported FoH more frequently than men (63% vs. 44%, Table 1), we decided to conduct separate analyses for men and women. In men, with and without FoH, serial HbA_{1c} measurements were based on 25.1 ± 17.4 and 23.9 ± 14.4 individual measurements ($p = 0.896$). The respective figures for women were 28.0 ± 17.7 and 28.9 ± 17.6 ($p = 0.637$).

There was a tendency for men with FoH to be younger than men without FoH ($p = 0.054$, Table 1). No other differences in the background data between the FoH groups were observed. In men, the mean serial HbA_{1c} level was modestly higher amongst those with FoH. No differences were observed between the FoH groups in the amount of daily insulin dose per body weight, the frequency of insulin pump use, the latest HbA_{1c} values, and the HbA_{1c} variability of the serial measurements.

A total of 252 men and 363 women filled in the exercise and food record (Table 2). FoH was observed in 108 (43%) and 225 (62%) of these respective participants. Compared to those without FoH, both men and women with FoH reported more frequent SMBG. These

Table 2
Blood glucose monitoring, leisure-time physical activity, and dietary intake in the groups divided by gender and fear of hypoglycaemia status

	Men			Women		
	FoH, yes n = 108 (42.9%)	FoH, no n = 144 (57.1%)	p	FoH, yes n = 225 (62.0%)	FoH, no n = 138 (38.0%)	p
Reported SMBG/day, n	3.6 ± 1.8	3.2 ± 1.8	0.063	3.9 ± 1.9	3.5 ± 1.7	0.025
Hypoglycaemia* measurements per number of journal days, n	0.2 (0.0–0.5)	0.2 (0.0–0.5)	0.372	0.3 (0.0–0.5)	0.2 (0.0–0.5)	0.538
Mean of reported BG values, mmol/l	8.1 (7.1–9.5)	7.6 (6.5–8.9)	0.041	8.2 (7.0–9.4)	7.8 (6.8–9.7)	0.485
METh per number of journal days	4.3 (2.5–8.4)	5.0 (2.4–8.6)	0.901	5.3 (3.2–8.3)	4.5 (2.7–8.0)	0.242
Dietary intake						
Energy, MJ	8.8 ± 2.5	8.3 ± 2.4	0.118	7.1 (6.1–8.1)	6.7 (5.8–7.7)	0.059
Carbohydrate, E%	43.9 ± 6.5	43.4 ± 7.5	0.568	44.9 ± 6.4	44.0 ± 7.8	0.221
Carbohydrate, g	233 (172–282)	208 (160–256)	0.068	188 (155–226)	174 (146–216)	0.065
Fat, E%	35.2 (30.9–39.0)	36.4 (30.3–39.9)	0.372	34.8 ± 6.1	35.3 ± 6.5	0.545
Fat, g	77 (61–101)	75 (60–97)	0.360	65 ± 21	67 ± 22	0.244
Protein, E%	16.3 (14.8–18.7)	16.7 (15.0–18.3)	0.728	16.2 (14.3–18.5)	17.2 (15.0–18.9)	0.024
Protein, g	83 (68–102)	79 (64–100)	0.175	69 (60–81)	68 (59–79)	0.475
Protein, g/kg	1.11 ± 0.33	0.96 ± 0.26	0.001	1.05 (0.84–1.26)	0.98 (0.82–1.16)	0.071
Alcohol, E%	0.96 (0–2.70)	1.18 (0–3.94)	0.880	0.53 (0–2.99)	0.05 (0–2.54)	0.360
Alcohol, g	2.56 (0–8.75)	3.59 (0–9.99)	0.700	1.52 (0–7.28)	0.12 (0–5.85)	0.365
Sucrose, g	34.0 (22.2–54.5)	24.8 (16.2–41.0)	0.169	32.0 (20.6–45.0)	28.5 (17.6–45.3)	0.100
Fibre, g	23.2 (17.6–30.2)	21.6 (16.1–26.2)	0.192	22.4 (17.3–28.3)	20.9 (16.9–25.5)	0.209

Data are presented as median (interquartile range) for continuous non-normally distributed variables, and mean ± SD for continuous normally distributed variables. FoH, fear of hypoglycaemia; SMBG, self-monitoring of blood glucose; BG, blood glucose; MET, metabolic equivalent of task; E%, percentage of total energy intake. *Blood glucose values below 3.5 mmol/l.

Table 3
Formed factors in the factor analysis

Factor	Included items from the food frequency questionnaire	Eigenvalue	% of variance
Vegetable	Cooked vegetables, legumes, fresh vegetables	2.16	11.3
Sweet	Sweets and chocolate, sweet pastry, ice cream, soft drinks	1.86	9.8
Snack	Fruits and berries, yoghurt and curd, fresh vegetables, low-fat cheese	1.56	8.2
Modern	Pasta and rice, poultry, meat dishes, fried and grilled foods	1.33	7.0
Traditional	Meat dishes, potatoes, and sausages and cold cuts	1.32	7.0
Fish	Fish dishes	1.07	5.6
High-fat	High-fat cheese, eggs, and low in low-fat cheese	1.03	5.4

modest differences were, however, significant only among women. In men, the mean of the blood glucose values, reported in the journals, was higher amongst individuals with FoH. No differences were observed in the numbers of reported hypoglycaemic blood glucose values and levels of reported LTPA during the journal days. There was a tendency, for both men ($p = 0.068$) and women ($p = 0.065$) with FoH, to eat more carbohydrates (g/day) compared to those without FoH. Moreover, men with FoH consumed more protein per body weight than those without FoH, while women with FoH obtained lower proportion of energy from proteins. Women with FoH also tended to consume more energy than those without FoH ($p = 0.059$).

Seven factors with a high degree of inter-correlation were formed from the FFQ (Table 3). Based on their contents, these clusters were named "vegetable", "sweet", "snack", "modern", "traditional", "fish", and "high-fat". In the bivariate analyses, men with FoH were observed to score lower in the "high-fat" factor, and women with FoH scored higher in the "sweet" factor (Table 4).

Age, mean serial HbA_{1c} level, the number of reported daily SMBGs, and the mean of reported blood glucose values in the journals were entered in the logistic regression model. Additionally, of the dietary variables, energy intake, carbohydrate intake (g/day), protein intake (g/kg), and factors "sweet", "snack", and "high-fat" were also included. In men, higher mean values of serial HbA_{1c} measurements, higher number of reported daily SMBGs, higher carbohydrate intake and lower scores in the "high-fat" factor were all independently associated with FoH (Table 5). In women, higher energy and carbohydrate intakes were independently associated with FoH.

Discussion

Besides the psychological distress associated with fear, the significance of FoH is frequently related to the actions taken to keep the blood glucose at a "safely high" level. Indeed, in the current study, we observed that in men, FoH was independently associated with higher mean serial HbA_{1c} level and higher carbohydrate intakes. Additionally, both men and women with FoH were observed to more frequently monitor their blood glucose levels.

The association between FoH and glycaemic control is not fully established, and lack of such association has been reported in a number of studies [8,11–13,19]. In concordance with these studies, we observed that the latest HbA_{1c} measurement was no different between the two groups. Opposite observations have, however, also been made as Anderbro et al. reported that the aloneness subscale of the Hypoglycaemia Fear Survey was related to higher HbA_{1c} levels [14]. Moreover, individual cases are known to exist where FoH has deleterious effect on glycaemia [20]. Based on the mixed results obtained on this subject, it is likely that the association between FoH and glycaemic control is complex and more studies are needed to adequately reveal issues related to it.

No differences were observed in the levels of reported physical activity by the FoH status. FoH has, previously, been identified as a major barrier to regular physical activity in type 1 diabetes [10]. One explanation to the observed difference could be the method used to assess physical activity. While in our study, participants were instructed to report the actual physical activity during the record-keeping days, Brazeau et al, in their study, queried how likely it would be that FoH would keep the respondents from engaging in physical activity over a particular period of time [10]. Given the frequency of iatrogenic hypoglycaemias, in this patient population, it is likely that most individuals would agree restraining from physical activity when facing a risk of low blood glucose level. This does not mean, however, that the actual amount of physical activity would automatically be lower. It should also be noted that the frequencies of reported hypoglycaemias during the record-keeping days, in the current study, were low and did not differ by the FoH status. This could further explain why the levels of physical activity were not different between the groups. On the other hand, should FoH unconditionally reduce the level of overall physical activity, the reason it was not observed in the current study could be due to the limitations related to the questionnaire used. Given the high percentage of FoH observed, it is possible that also individuals with minor concerns related to hypoglycaemias, and not only those with actual "fear", were also included in the population with "FoH". Should this have taken place, it would most likely have diluted, not only the results related to physical activity, but also to other self-management practices.

Of the dietary variables, higher carbohydrate intake and lower scores in the "high fat" factor were, in men, associated with FoH, while women with FoH reported somewhat higher energy intakes. In the bivariate analyses, also women with FoH tended to show higher carbohydrate intakes. Comparing our results with previous research is difficult, as the association between FoH and dietary

Table 4
Dietary factor scores in the groups divided by gender and fear of hypoglycaemia

	Men			Women		
	FoH, yes n = 154 (43.9%)	FoH, no n = 197 (56.1%)	p	FoH, yes n = 283 (63.3%)	FoH, no n = 164 (36.7%)	p
Vegetable	−0.30 (−0.69–0.25)	−0.26 (−0.71–0.39)	0.736	−0.15 (−0.65–0.68)	−0.07 (−0.54–0.68)	0.374
Sweet	−0.21 (−0.54–0.31)	−0.26 (−0.60–0.27)	0.220	−0.06 (−0.51–0.50)	−0.26 (−0.58–0.32)	0.034
Snack	−0.19 (−0.69–0.25)	−0.38 (−0.78–0.09)	0.064	0.09 (−0.37–0.68)	0.10 (−0.35–0.79)	0.365
Modern	−0.11 (−0.58–0.42)	−0.18 (−0.65–0.19)	0.278	−1.00 (−0.51–0.32)	−0.14 (−0.60–0.24)	0.405
Traditional	−0.10 (−0.40–0.36)	0.02 (−0.36–0.59)	0.152	−0.22 (−0.67–0.38)	−0.24 (−0.62–0.23)	0.809
Fish	−0.27 (−0.54–0.68)	−0.26 (−0.58–0.68)	0.723	−0.28 (−0.56–0.61)	−0.23 (−0.54–0.71)	0.128
High-fat	−0.10 (−0.36–0.19)	−0.02 (−0.32–0.53)	0.045	−0.28 (−0.52–0.14)	−0.22 (−0.49–0.36)	0.257

Data are presented as median (interquartile range). FoH, fear of hypoglycaemia.

Table 5
The association between fear of hypoglycaemia and diabetes self-management

	Men	Women
Mean of the serial HbA1c measurements	1.534 (1.094–2.151)	-
Reported SMBG/day, n	1.215 (1.003–1.473)	1.153 (1.001–1.328)
Energy intake	-	1.001 (1.001–1.001)
Carbohydrate, g/day	1.008 (1.003–1.013)	-
High-fat (factor)	0.416 (0.219–0.791)	-

Forward stepwise logistic regression. Data are presented as odds ratio (95% confidence interval). SMBG, self-monitoring of blood glucose.

intake has not been extensively studied. What has been previously observed is that FoH and non-compliance with dietary advices are unrelated [21], that FoH is not associated with any particular eating style [22] and the more the individuals were anxious about hypoglycaemia, the more frequently they ate snacks [11]. Based on the surprisingly small number of studies conducted in this field, it can be concluded that there is a clear need to more closely study the association between FoH and dietary intake. Our results regarding higher carbohydrate consumption in FoH does, however, intuitively make sense as higher carbohydrate intake may be used to keep the blood glucose concentrations elevated. Moreover, the fact that high fat intake reduces the absorption of carbohydrates, could explain why FoH was associated with low scores in "high-fat" factor in men.

Consistent with previous studies, we observed a higher frequency of FoH among women than men [14,23]. This observation is also in concordance with what is known about sex difference in anxiety disorders in the general population [24]. Despite the observed sex difference in the prevalence of FoH, both men and women with FoH reported higher SMBG frequency. While SMBG is an important tool to manage one's blood glucose, more frequent monitoring in FoH could indicate the concern related to too low glucose concentrations. However, unlike among men, no difference was observed in the mean of serial HbA_{1c} measurements in women. Instead women, regardless of their FoH status, had identical mean serial HbA_{1c} levels with men with FoH.

Given the high prevalence of FoH and the significance of the self-management practices for the long term complications of diabetes, the current subject is of major importance. A large number of well characterised participants provides sufficient power to study the described associations. There are, however, a number of important weaknesses that need to be discussed. One major shortcoming is the use of a non-validated questionnaire to assess FoH. The questionnaire used was not originally intended for measuring FoH, but rather for exploring the patients' subjective perceptions of their disease. From this questionnaire, we identified two questions; one that measures worry ("Are you afraid of hypoglycaemia"), and one that measures the behavioural aspect of the fear ("Has fear of hypoglycaemia led you to eat just in case"), as these two sections are found in a widely used questionnaire [25]. While the validity of our questionnaire remains unknown, we believe it gives a sufficient approximation of the participants' subjective perceptions of their FoH in the real life situation. Importantly, the aim of the current study was not to assess the frequency of FoH, *per se*, but rather to assess how these subjective perceptions are related to various diabetes self-management practices and glycaemic control. Another weakness is the cross-sectional nature of the study that will not permit causal interpretations of the results. This limitation should not be of major importance, however, as we did not study the long term consequences of fear, but rather the current self-management practices. Whether the cross-sectional nature of the study has consequences for interpreting the HbA_{1c} results, that reflect the glycaemic status over a three-month period, is not known. Third, the use of a journal to collect data has various limitations. The very act of reporting self-management practices may lead individuals to change their habits to reflect what is generally thought as advisable. Also, underreporting the unhealthy, and over-reporting the recommended practices may take place. Furthermore, as the journal was also used to collect data on the SMBG frequency, we cannot be sure if every measurements conducted were actually reported. It is likely, however, that the above-mentioned limitations, in the use of journals, are found in those with and without FoH, alike.

In conclusion FoH, in the current study, was independently associated with higher frequency of blood glucose monitoring in both men and women. Moreover, in women, FoH was also associated with higher energy intake, and in men higher mean of the serial HbA_{1c} measurements, higher carbohydrate intake, and lower scores in "high-fat" factor. We observed no association in the level of physical activity and insulin administration by FoH status. More studies should be conducted to assess the association between FoH and self-management practices, and FoH and its long term consequences, such as the emergence of diabetic complications and mortality.

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Conflict of interest

PHG has received research grants from Eli Lilly and Roche, is an advisory board member for AbbVie, Boehringer-Ingelheim, Eli Lilly, Janssen, Medscape, and Novartis. He has received lecture fees from Astra Zeneca, Boehringer-Ingelheim, Eli Lilly, Genzyme, Novartis, Novo Nordisk, Sanofi and MSD. SM is an employee of Novo Nordisk A/S. All other authors declare that there is no conflict of interest.

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Appendix. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jcte.2016.02.002.

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