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Continuous glucose monitoring as equinox of nocturnal and daytime hypoglycaemia in type 1 diabetes: insights from the randomized controlled HypoDE trial

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ABSTRACT

Aims: This study re-analysed data from the HypoDE trial to assess the prevalence of nocturnal hypoglycaemia, evaluate the impact of continuous glucose monitoring (CGM) on nocturnal and daytime hypoglycaemia, and explore their influence on severe hypoglycaemia (SH).

Methods: The HypoDE trial was a randomized controlled trial involving 141 adults with type 1 diabetes, impaired hypoglycaemia awareness, or prior SH. Participants were randomized to CGM (Dexcom G5) or self-monitoring of blood glucose (control). Outcomes included the percentage of time spent in hypoglycaemia (<3.9 mmol/L, <3.0 mmol/L), episode duration, and SH incidence.

Results: At baseline, nocturnal hypoglycaemia (<3.0 mmol/L) exposure exceeded daytime by 1.4 percentage points (95 % CI 0.6–2.2; $p < 0.002$), with episodes lasting 30.7 min longer (CI 21.5–39.9). Using CGM, these differences disappeared (<3.0 mmol/L: 0.3 percentage points, CI 0.7–1.3), while they persisted in the control group. Daytime hypoglycaemia significantly increased SH risk (IRR 1.10 per percentage point, CI 1.01–1.21; IRR 1.04 per minute, CI 1.01–1.07).

Conclusions: CGM effectively reduced nocturnal and daytime hypoglycaemia. Without CGM, nocturnal hypoglycaemia contributes to daytime risks, while daytime hypoglycaemia elevates SH risk. Expanding CGM access and addressing nocturnal hypoglycaemia in resource-limited settings are critical.

Trial registrationClinicaltrials.gov: NCT02671968.

1. Introduction

Nocturnal hypoglycaemia has long been recognized as a critical factor in diabetes management, with early studies showing that low

nighttime glucose levels can blunt the body's defences against subsequent hypoglycemia [1,2]. This phenomenon was difficult to quantify before continuous glucose monitoring (CGM) became widely available because traditional methods required frequent, impractical nighttime

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blood sampling. CGM now enables accurate measurement of low glucose exposure throughout the day and night, helping to quantify hypoglycaemia in terms of the percentage of time spent below target, duration of hypoglycaemic events, and frequency of episodes.

Randomized, controlled studies have shown that the use of CGM with multiple daily injections (MDI) or insulin pump therapy reduces the time spent below 70 mg/dL by 4–6 percentage points, effectively reducing the likelihood of severe hypoglycaemia [3–5]. Automated insulin delivery (AID) systems further enhance this effect in adults, adolescents, and children with diabetes, particularly at night, with meta-analyses showing a reduction of up to 1.28 percentage points in nocturnal hypoglycaemia [6,7]. Despite these advances, the higher cost of AID systems, primarily for insulin pump devices and consumables, remains a barrier, particularly in healthcare systems with limited reimbursement options. This disparity limits access to advanced technologies, particularly in low- and middle-income countries, where CGM combined with MDI often remains the primary treatment option.

To deepen our understanding of the dynamics of nocturnal and daytime hypoglycaemia, we conducted a re-analysis of the HypoDE study, a randomized controlled trial of CGM use in MDI-treated individuals with type 1 diabetes and frequent hypoglycaemia. This re-analysis aimed to answer the following questions:

- 1) What is the prevalence and duration of nocturnal and daytime hypoglycaemia in people with type 1 diabetes on MDI therapy, and how does the use of CGM affect these outcomes?
- 2) Can complex network analysis reveal key relationships between variables that drive nocturnal and daytime hypoglycaemia in people with type 1 diabetes, potentially aiding in hypoglycaemia prevention?
- 3) How are daytime and nocturnal hypoglycaemia associated with clinical outcomes such as clinical hypoglycaemia or severe hypoglycaemia?

These findings may help guide the development of targeted strategies to minimize hypoglycaemia, improve glycaemic control, and ultimately improve the quality of life for people with diabetes [8,9].

2. Methods

2.1. Study design

For this study, we re-analysed the data from the HypoDE study, which was a six-month multicentre, open-label, parallel, randomized controlled trial to evaluate the efficacy of CGM use in people with type 1 diabetes and hypoglycaemia problems treated with MDI therapy. The study design was described in a previous publication [4]. In brief, following enrolment, participants had to complete a four-week baseline phase with a masked CGM device (Dexcom G4 with software 505; Dexcom, San Diego, CA, USA) before they were eligible for randomization. Participants were randomized either to the control group (see [Supplementary Box 1](#)), in which they continued with self-measurement of blood glucose (SMBG) for the 26-week follow-up period, or to the intervention group, in which participants used an unmasked CGM system for the next 26 weeks (Dexcom G5 Mobile system). The allocation ratio to the control or intervention group was 1:1. Participants were recruited from 12 specialized diabetes practices in Germany. Outcome measurement was performed in the last four weeks (week 22 to week 26) of the follow-up period, in which the control group was again equipped with masked CGM devices, and the intervention group continued using unmasked CGM devices.

2.2. Participants

The study participants were people with type 1 diabetes aged 18 years or older with a HbA1c < 9.0 % and hypoglycaemia problems. These problems were defined as having had at least one event of severe hypoglycaemia (SH), requiring third-party assistance for recovery in the previous year or having impaired hypoglycaemia awareness as defined by a total score of four or more in the hypoglycaemia unawareness questionnaire developed by Clarke and colleagues [10].

2.3. Outcomes measures

For the present analyses, the study outcomes measures were the associations between nocturnal and daytime hypoglycaemia during baseline and follow-up assessments of CGM metrics. We used the following CGM outcomes: Percentages of glucose values <3.9 mmol/L and 3.0 mmol/L, mean duration of periods of glucose values <3.9 mmol/L and 3.0 mmol/L per person and per corresponding event, and mean number of hypoglycaemic events <3.9 mmol/L and 3.0 mmol/L per person and per 28 study days. The nocturnal period was defined as 00.00 a.m. to 5:59 a.m. and the daytime period as 06:00 a.m. to 11:59p.m.

Furthermore, we evaluated the impact of nocturnal and daytime hypoglycaemia outcomes on severe hypoglycaemia by measuring the number of severe hypoglycaemic episodes over the 26-week follow-up period. SH was defined as episodes requiring third-party assistance.

2.4. Statistical analysis

The first analysis focused on the percentage of nocturnal and daytime glucose levels (<3.0 and <3.9 mmol/L), mean duration of hypoglycaemic episodes, and number of episodes per person over 28 days, adjusting for the different durations of nocturnal and daytime periods. A repeated measures ANOVA was performed with nocturnal versus daytime hypoglycaemia as the within-subject factor and CGM use (CGM vs. non-CGM) the between-group factor during both the baseline (masked CGM in both groups) and outcome (unmasked CGM vs. SMBG) phases. We first assessed within-subject differences between nocturnal and daytime hypoglycaemia and then examined the interaction between CGM use and time of day regarding the hypoglycaemia outcomes.

Dynamic structural equation modelling was used to analyse whether nocturnal exposure to hypoglycaemic values is a stronger predictor of daytime exposure to hypoglycaemic values or vice versa. This allowed the simultaneous modelling of both directions (nocturnal on daytime vs. daytime on nocturnal). For this, nocturnal hypoglycaemia predicting daytime hypoglycaemia on the same day was compared with daytime hypoglycaemia predicting hypoglycaemia the next night. Data were nested on the participant level, and random intercepts as well as random slopes were calculated. Thus, the model allowed for each individual to vary in their association between dependent and independent variables. Consequently, an individual association per participant was modelled, which was then aggregated to achieve an overall estimate. Only the follow-up period was used for this analysis and group allocation was entered. Separate analyses for percentages of <3.9 mmol/L and <3.0 mmol/L were conducted. Furthermore, following a significant effect of group allocation on the associations, separate analyses were conducted on the CGM and control groups. Bayes estimation was used and standardized coefficients were reported.

Furthermore, we applied a zero-inflated negative binomial regression to assess the association between nocturnal and daytime hypoglycaemic outcomes (independent variables) and the frequency of

severe hypoglycaemic events during the outcome phase (dependent variable). IRRs were calculated for the independent variables while adjusting the model for group assignment (CGM vs. control), total duration of the outcome phase, and number of severe hypoglycaemic events at baseline.

Repeated measures ANOVA were performed with SPSS 29 (IBM, Armonk, New York), dynamic structural equation modelling with Mplus version 8.6, and negative binomial regression analyses with R statistics (glmmTMB-package).

3. Results

The full analysis dataset consisted of data from 141 participants (control group, $n = 66$; CGM group, $n = 75$) who completed the baseline and follow-up phases (see [Supplementary Fig. 1](#)). The mean baseline HbA1c was 58.5 mmol/mol (7.5 %) for both groups, which is considered satisfactory according to German treatment guidelines for individuals with type 1 diabetes. Approximately 90 % or more of participants used insulin analogs for coverage of basal and prandial insulin requirements. Among CGM participants, the average percentage of glucose sensor wear time was 90.7 % of the study days (first four weeks after randomization and 30 days before the 26-week visit). Approximately two-thirds of participants reported at least one severe hypoglycaemia episode in the preceding year and more than 90 % had impaired hypoglycaemia awareness. Other baseline demographic and medical characteristics are presented in [Table 1](#). We observed no major differences in demographic characteristics between participants in the control and CGM groups.

3.1. Nocturnal and daytime hypoglycaemia at baseline with masked CGM for both groups

At baseline, participants in both study groups used SMBG to adjust insulin and detect low glucose levels. All participants wore a masked CGM for four weeks.

As expected, group allocation had no differential effect on nighttime or daytime exposure to hypoglycaemia, as shown by the non-significant interaction effect between group allocation and daytime and nighttime

hypoglycaemia (see [Table 2](#)). However, exposure to low glucose levels was significantly higher during the night. The between-group difference was 1.4 (95 % CI 0.6–2.2; $p < 0.001$) percentage points for glucose below 3.0 mmol/L and 1.8 (95 % CI 0.6–3.1; $p = 0.003$) for glucose below 3.9 mmol/L. The mean duration of glucose events below 3.0 mmol/L was 30.7 min (95 % CI 21.5–39.9 min; $p < 0.001$) longer during the night than during the day, and 48.0 min (95 % CI 38.0–58.5 min; $p < 0.001$) longer for events below 3.9 mmol/L.

The number of low events was not significantly higher at night than during the day, suggesting that the higher hypoglycaemia burden at night was primarily due to a longer duration of nocturnal events rather than a higher frequency of these events (see [Table 2](#)).

3.2. Comparison of nocturnal and daytime hypoglycaemia in CGM users versus the control group

The predominance of nocturnal hypoglycaemia relative to daytime hypoglycaemia shifted during the intervention phase, in which the CGM group had access to open CGM. [Supplementary Table 1](#) and [Fig. 1](#) show that CGM seems to be an equalizer of nocturnal and daytime exposure to hypoglycaemia by demonstrating that group allocation significantly interacted with nocturnal and daytime hypoglycaemia. The nocturnal glucose values lower than 3.0 mmol/L were 2.6 percentage points (95 % CI 1.5–3.6; $p < 0.001$; [Fig. 1A](#)) higher than during daytime in the control group. In the CGM group the respective difference was only 0.3 percentage points; 95 % CI 0.7–1.3 percentage points; $p = 0.523$. For the percentage lower than 3.9 mmol/L, the results were 3.0 percentage points (95 % CI 1.4–4.6; $p = 0.008$) higher for nocturnal events than day events in the control group, whereas in the CGM group, the percentage was only 0.5 points (95 % CI 0.9–2.0; $p = 0.427$) higher. In the control group, the duration of a < 3.0 mmol/L event lasted 45.1 min (95 % CI 34.0 to 83.3; $p < 0.001$; [Fig. 1B](#)) longer during the night than the day, whereas the respective duration was only three minutes (95 % CI 7.3–13.4 min; $p = 0.562$) longer during the night in the CGM group. For < 3.9 mmol/L events, there was a significantly longer duration of nocturnal events in both groups, but with a rather large difference between CGM and control group, at 69.3 min (95 % CI 55.4–56.2 min; $p <$

Table 1
Sample characteristics.

	Control group ($n = 66$)	CGM group ($n = 75$)
Demographic and medical characteristics		
Age in years (SD)	47.3 (11.7)	45.8 (12.0)
Gender—female, n (%)	25 (33.8)	35 (46.7)
Body mass index in kg/m^2 (SD)	26.0 (4.6)	26.1 (6.7)
Diabetes duration in years (SD)	21.6 (13.9)	20.9 (14.0)
A1c (central laboratory), % (SD)	7.3 (1.0)	7.6 (1.0)
mmol/mol (SD)	56.7 (10.6)	59.3 (10.9)
Treatment characteristics		
# with basal analog insulin, n (%)	73 (98.6)	71 (94.7)
# > 1 basal insulin injection per day, n (%)	47 (64.4)	39 (52.0)
Dose of basal insulin, IU (SD)	20.1 (10.8)	23.9 (16.2)
# with bolus analog insulin, n (%)	66 (89.2)	67 (90.5)
Dose of bolus insulin, IU (SD; based on $n = 127^1$)	24.3 (12.2)	26.8 (29.5)
Hypoglycemia problems		
# with severe hypoglycemia (third-party assistance) during the past year, n (%)	45 (60.8)	47 (62.7)
Hypoglycemia unawareness, (hypoglycemia unawareness score ≥ 4), n (%)	68 (91.9)	71 (94.7)
Hypoglycemia unawareness score, mean score (SD)	4.7 (1.3)	5.0 (1.1)
Numbers are means and standard deviations (SD) or numbers (%).		

Table 2

Prevalence, duration, mean hypoglycemic glucose level, and number of events during nocturnal and daytime hypoglycemia at baseline (masked CGM for all participants).

Hypoglycemia parameter	Control group N = 66		CGM group N = 75		Within differences between nocturnal minus daytime hypo glycemia (95 % CI group)	p within effect: day vs. night	p interaction: CGM vs. no CGM x day vs. night
	Night	Day	Night	Day			
% <54 mg/dl/<3.0 mmol/L	4.2 ± 5.9	2.8 ± 2.7	3.6 ± 5.4	2.2 ± 3.0	1.4 (0.6–2.2)***	<0.001	0.990
% <70 mg/dl/<3.9 mmol/L	8.9 ± 9.1	7.4 ± 5.5	8.1 ± 9.5	5.9 ± 5.7	1.8 (0.6–3.1)**	0.003	0.560
Mean duration of glucose < 54 mg/dl/3.0 mmol/L in min	65.2 ± 51.4	34.1 ± 19.0	62.1 ± 61.1	31.8 ± 19.0	30.7 (21.5–39.9)***	<0.001	0.931
Mean duration of glucose < 70 mg/dl/3.9 mmol/L in min.	103.9 ± 66.5	47.4 ± 19.9	89.0 ± 62.8	49.0 ± 23.3	48.0 (38.0–58.5)***	<0.001	0.114
Number of episodes per hour < 70 mg/dl ^{a,b}	16.0 ± 15.5 ^c	17.9 ± 14.9	13.3 ± 14.9 ^c	14.6 ± 12.3	1.6 (3.8–0.6)	0.142	0.790
Number of episodes per hour < 54 mg/dl ^{a,b}	25.1 ± 20.7 ^{b,c}	36.3 ± 21.4	22.0 ± 19.0 ^c	29.2 ± 18.3	9.3 (12.7–5.8)	<0.001	0.259

ns = non-significant; ***p < 0.001; **p < 0.01; *p < 0.05. Between-group differences were calculated by subtracting daytime from nocturnal hypoglycemic parameters.

^a Number of episodes per participant per 28 days.

^b A hypoglycemic episode is considered any hypoglycemic episode regardless of its duration.

^c Number of nocturnal events was adjusted to the length of nocturnal period vs. daytime period by multiplying the number of nocturnal events by three.

0.001) longer during the night in the control group and only 16.1 min (95 % CI 3.3–29.1 min; p = 0.016) longer in the CGM group. The number of nocturnal and daytime events lower than 3.0 mmol/L between the groups was not significantly different (p = 0.610 in the control group; p = 0.674 in the CGM). Events lower than 3.9 mmol/L again showed a significantly higher frequency during the day in the control group (6.0 events; 95 % CI 10.2–1.9; p = 0.005); in the CGM group, the difference was not significant (3.0; 95 % CI 6.9–0.8 events; p = 0.124; Fig. 1C).

Supplementary Fig. 2 shows the between-group difference of CGM and the control group regarding the percentage of hypoglycaemic values in two-hour intervals during the night and day. CGM was most effective in reducing hypoglycaemia compared to SMBG during the night between 4:00 and 6:00 am.

3.3. Comparison of nocturnal hypoglycaemia predicting daytime hypoglycaemia and vice versa

Across all participants, nocturnal hypoglycaemia was a stronger predictor for daytime hypoglycaemia compared to daytime hypoglycaemia predicting hypoglycaemia the following night (Fig. 2A). However, group allocation (CGM vs. SMBG) had a significant effect on the prediction of daytime hypoglycaemia by nocturnal hypoglycaemia (% <3.9 mmol/L: $\beta = 0.28$, p < 0.001; % <3.0 mmol/L: $\beta = 0.30$, p < 0.001). Fig. 2B and 2C show that nocturnal hypoglycaemia was a stronger predictor of daytime hypoglycaemia on the same day in the control group (% <3.9 mmol/L: $\beta = 0.24$, p < 0.001; % <3.0 mmol/L: $\beta = 0.27$, p < 0.001) compared to the CGM group (% <3.9 mmol/L: $\beta = 0.10$, p < 0.01; % <3.0 mmol/L: $\beta = 0.06$, p > 0.05). In the CGM group, the difference in prediction (daytime on nocturnal vs. nocturnal on daytime) nearly vanished (Fig. 2B).

Association between nocturnal and daytime and the occurrence of severe hypoglycaemic episodes.

During the six-month intervention phase, there were 63 SH events. Of these, 39 occurred in the control group and 24 in the CGM group, resulting in a significantly lower IRR of 0.36 (p = 0.03) in the CGM group.

To analyse the impact of nocturnal and daytime hypoglycaemia on SH events, we used a negative binomial regression model, adding the

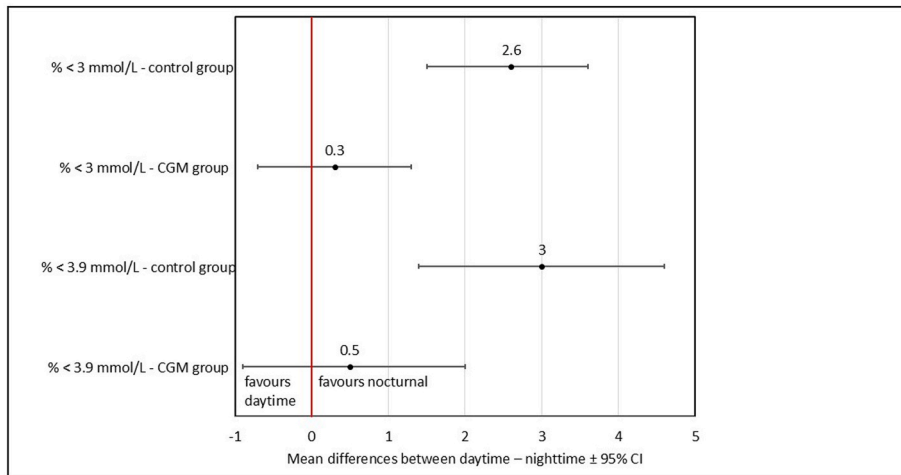
percentage of nocturnal and daytime hypoglycaemia to group allocation. The effect of the intervention group was no longer significant when hypoglycaemia percentage, duration, and number of events were included, which indicates that the intervention group effect was partially mediated by the reduction of hypoglycaemia exposition. A 1 % increase in glucose values <3.9 mmol/L during the day raised the IRR for SH events by 10 % (Fig. 3A), while each additional minute of daytime hypoglycaemia increased the IRR by 4 % (Fig. 3B). Each daytime event of glucose levels <3.9 mmol/L or 3.0 mmol/L increased the IRR by 2 % and 3 %, respectively (Fig. 3C). Nocturnal hypoglycaemia was not significantly associated with SH (Fig. 3A–C).

4. Conclusion

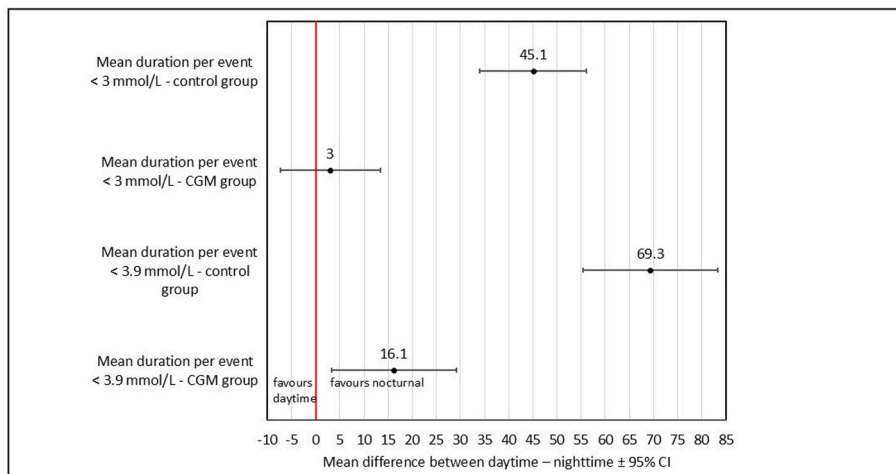
This study highlights the distinct but interrelated roles of nocturnal and daytime hypoglycaemia in people with type 1 diabetes, particularly those prone to hypoglycaemia. Our findings confirmed that without CGM, nocturnal hypoglycaemia often goes undetected, resulting in proportionally higher percentage of low glucose values as well as prolonged low glucose levels, particularly below 3.0 and 3.9 mmol/L. The frequency of nocturnal and daytime hypoglycaemia was similar. However, nocturnal episodes lasted significantly longer, resulting in challenges for diabetes management. In addition nocturnal episodes disrupt sleep, cause fatigue, and reduce function the following day, adding to the overall burden of type 1 diabetes [11–15]. Our results furthermore show that, without CGM, nocturnal hypoglycaemia is a stronger predictor for daytime hypoglycaemia than vice versa.

The use of CGM systems significantly reduced both nocturnal and daytime hypoglycaemia, particularly in the duration and percentage of time spent in the low glucose range at night. CGM users also showed a smaller difference between nocturnal and daytime hypoglycaemia, demonstrating its ability to balance the effects of hypoglycaemic glucose exposure. This compensatory effect may reflect the impact of the real-time glucose feedback and alarms provided by CGM systems, which help users to identify and treat nocturnal hypoglycaemia earlier and prevent subsequent reactive insulin mismanagement that can trigger daytime hypoglycaemia. In other words, CGM can break the vicious cycle of unrecognised nocturnal hypoglycaemia leading to over-correction or increased daytime glucose variability. It is also possible

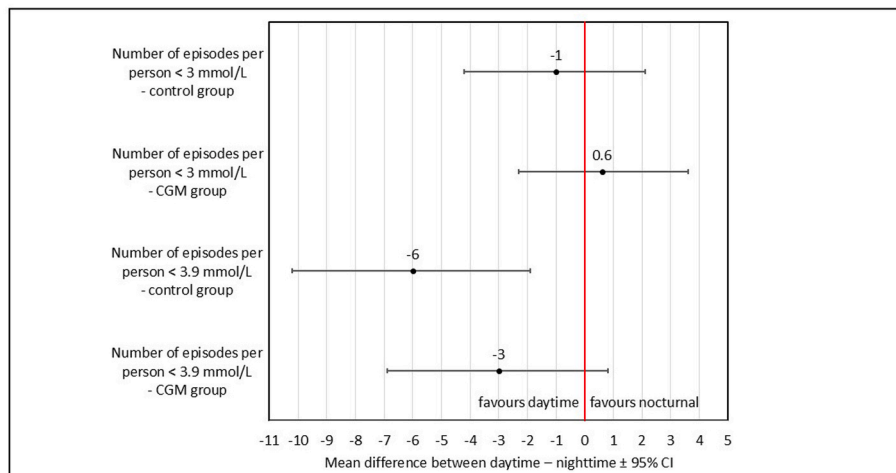
A) Percentage below range per person



B) Mean duration per event per 28 days



C) Number of hypoglycemic episodes per person per 28 days



*The number of nocturnal hypoglycemia events was adjusted for different for the different duration of daytime period by multiplying nocturnal events by 3.

Fig. 1. Difference between nocturnal and daytime hypoglycaemia regarding percentage (A), duration per episode and person (B), and number of events per person and per 28 days of glucose values lower than 3.0 mmol/L and 3.9 mmol/L (C).

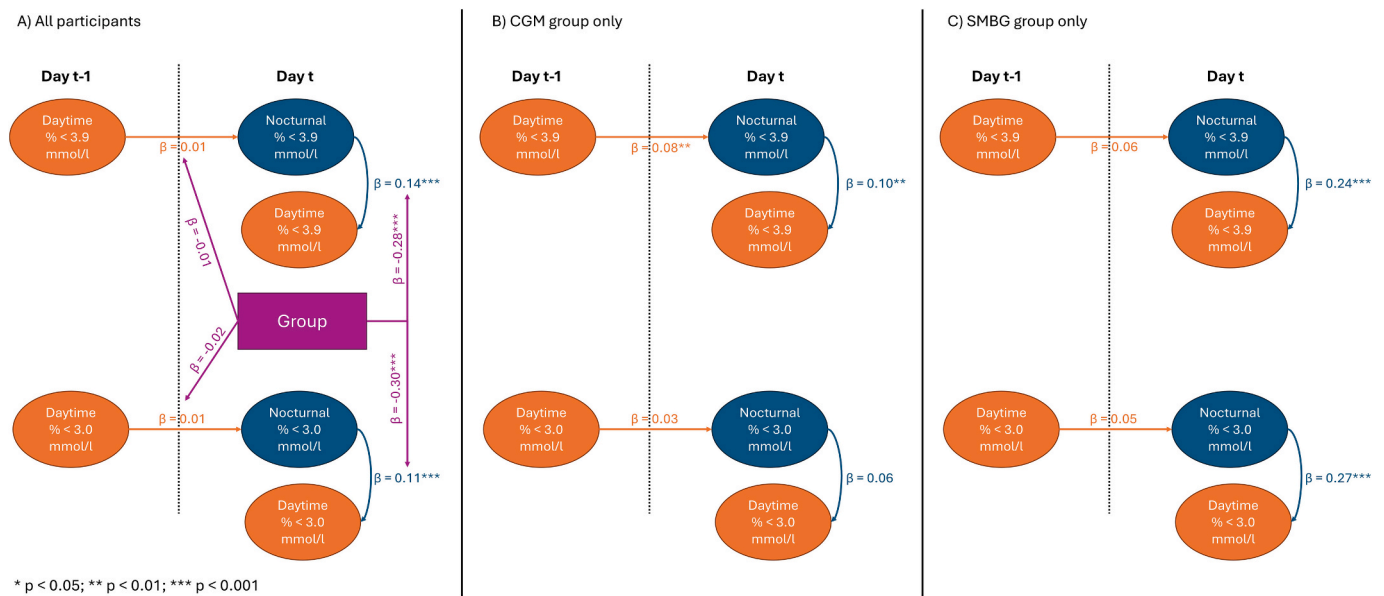


Fig. 2. Dynamic structural equation modeling for nocturnal predicting daytime hypoglycaemia and vice versa for A) all participants, B) CGM group only, and C) control group only.

that behavioural adaptations, e.g. pre-bed snacks, and/or improved insulin dosing strategies due to CGM may contribute to stabilising glucose profiles over the 24-hour period. Further physiological studies may help to disentangle the relative roles of behavioural and physiological mechanisms in this balancing effect. The reduction achieved through CGM is critical, as nocturnal hypoglycaemia was shown to often exacerbate the risk of daytime episodes, which reinforces earlier research on hypoglycaemia’s etiology [1,2,16–18].

More importantly, our analysis showed that daytime hypoglycaemia was more strongly associated with SH events requiring third-party assistance for recovery than nocturnal hypoglycaemia. Each percentage point increase in time spent with glucose levels below 3.9 mmol/L significantly increased the IRR for SH events. This highlights the importance of not only preventing nocturnal hypoglycaemia but actively managing daytime low glucose exposure to reduce the overall burden of severe hypoglycemia [8,19]. The stronger association between daytime hypoglycemia and SH events may partly be explained by higher levels of physical and cognitive activity during the day, increasing both the risk and the danger of unrecognized hypoglycemia. Daytime episodes may also be more likely to occur during meals, work, or exercise — contexts in which attention to symptoms is variable and self-treatment may be delayed, thereby increasing the severity. In contrast, nocturnal hypoglycemia, while often longer in duration, may remain asymptomatic and less likely to result in immediate help-seeking or third-party intervention, especially when undetected. This pattern emphasizes the importance of targeted daytime hypoglycemia prevention strategies even in individuals using CGM.

These results have clear clinical implications. In healthcare settings where CGM is not widely available, nocturnal hypoglycaemia remains a significant risk factor, not only for its immediate effects but its impact on daytime glucose regulation. The evidence suggests that managing nocturnal hypoglycaemia could play a key role in reducing daytime risks, thereby improving overall glycaemic control and reducing the likelihood of serious events [18]. However, once CGM is introduced, the dynamic between nocturnal and daytime hypoglycaemia changes dramatically, leading to more balanced glucose control throughout the day and night. Thus, CGM is an equalizer of nocturnal and daytime hypoglycaemia.

While CGM has proven to be an effective tool for reducing hypoglycaemia in high-income settings, its limited accessibility in low- and

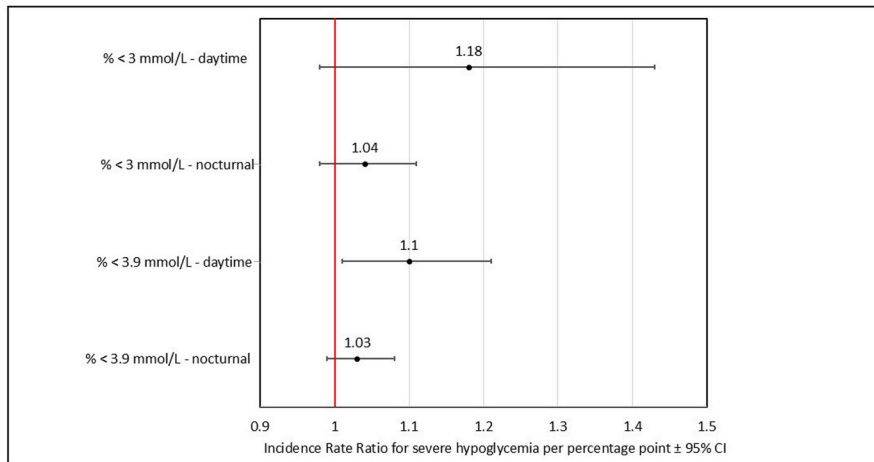
middle-income countries poses a challenge to equitable diabetes care. In these populations, the management of nocturnal hypoglycaemia remains a critical goal, as unrecognized nocturnal episodes can undermine the success of daytime glycaemic control and increase the risk of severe hypoglycaemia. The significantly higher cost of CGM and advanced systems such as AID means that many people still rely on traditional methods such as MDI and SMBG. However, over the past decade, the cost of CGM has declined to a level comparable to that of multiple daily blood glucose tests. Additionally, economic analyses indicate that the decreasing cost of CGM is offset by significant cost savings from reduced emergency room visits, hospitalizations, and productivity losses associated with hypoglycemia [20,21]. Given CGM, when combined with less advanced insulin therapy such as MDI [4], is highly effective in preventing hypoglycaemia, it may become a more affordable option for middle- and low-income countries or individuals with limited insurance coverage. In contrast, AID systems tend to have higher associated costs due to the use of insulin pump technology and consumables such as catheters and insulin reservoirs [22,23]. Future research should focus on understanding how best to mitigate hypoglycaemia in resource-limited settings where advanced diabetes technologies are lacking. In addition, exploring strategies to reduce the cost of CGM and AID systems may help bridge the gap and ensure that more people with diabetes can benefit from the protective effects of real-time glucose monitoring.

Some limitations of this study must be acknowledged. The sample consisted of individuals with type 1 diabetes and frequent or severe hypoglycaemia, a group that particularly benefits from CGM. Therefore, the generalizability of these findings to individuals with less pronounced hypoglycaemia remains uncertain. Future research should investigate whether CGM offers similar protective effects in broader populations, including those with moderate or infrequent hypoglycemic episodes.

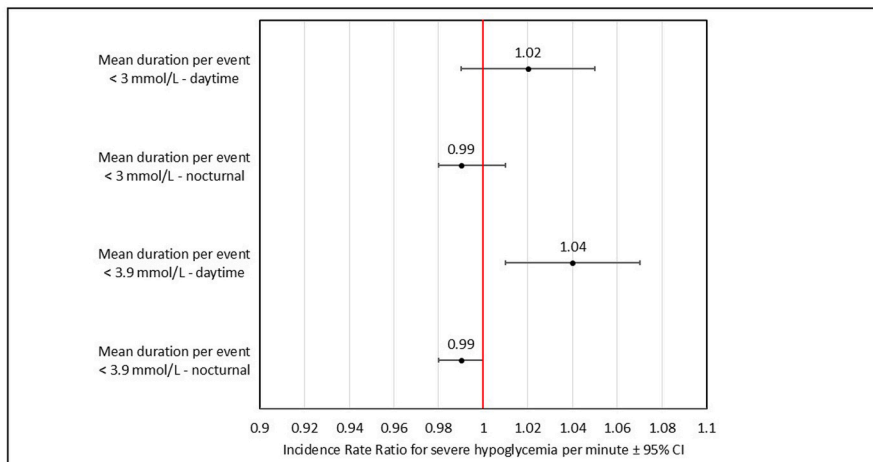
In addition, the HypoDE study was not specifically powered to analyse the impact of CGM on nocturnal and daytime hypoglycaemia.

In conclusion, our study reaffirms the important role that nocturnal hypoglycaemia plays in the broader context of hypoglycaemia management. Without CGM, people with type 1 diabetes face prolonged periods of low glucose at night, which may increase the risk of daytime hypoglycaemia. However, management of both nocturnal and daytime hypoglycaemia can be improved with the introduction of CGM, leading to fewer severe hypoglycemic events. These findings highlight the importance of equitable access to CGM and the need for continued

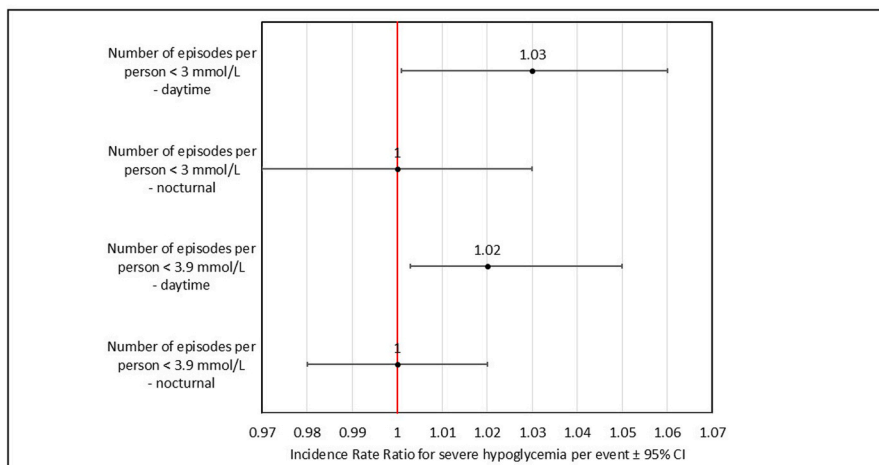
A) Percentage below range per person



B) Mean duration per event per 28 days



C) Number of hypoglycemic episodes per person per 28 days*



The number of nocturnal hypoglycemia events was adjusted for different for the different duration of daytime period by multiplying nocturnal events by 3.

Fig. 3. IRR for the association between the occurrence of the number of severe hypoglycaemia and percentage, duration per episode and person, and number of events per person per 28 days of glucose values lower than 3.0 mmol/L and 3.9 mmol/L (C).

efforts to make these technologies available to all people with type 1 diabetes, regardless of their socioeconomic status.

Author contributions

N.H. and D.E. analyzed the data and wrote the manuscript. L.H., B.K., M.J., and A.S. contributed to the interpretation of the data and revised the manuscript for important intellectual content.

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CRediT authorship contribution statement

Norbert Hermanns: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Lutz Heinemann:** Writing – review & editing, Funding acquisition, Conceptualization. **Bernhard Kulzer:** Writing – review & editing, Writing – original draft, Conceptualization. **Arne Schäfer:** Writing – review & editing. **Malte Jacobsen:** Writing – review & editing. **Dominic Ehrmann:** Writing – review & editing, Writing – original draft, Visualization, Methodology.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: N.H. and D.E. are the guarantors of this work and, as such, have full access to all data and take responsibility for the integrity and accuracy of the data. N.H. reports Advisory Board member fees from Dexcom, Abbott Diabetes Care and Insulet as well as honoraria for lectures from Sanofi Germany, Roche Diabetes Care, and Dexcom Germany. D.E. reports Advisory Board member fees from Dexcom Germany and Roche Diabetes Care as well as honoraria for lectures from Berlin-Chemie AG, Sanofi-Aventis, Dexcom Germany, Roche Diabetes Care, Boehringer Ingelheim, and Eli Lilly. L.H. reports consulting fees from Roche Diabetes Care, Lifecare, Medtronic, Spiden, Embecta, Dexcom, OneTwenty, Perfood, Boydsense, PharmaSens, Unomedical, and Sinocare. A.S. reports no conflict of interest. M.J. reports no conflict of interest. B.K. reports Advisory Board member fees from Abbott Diabetes Care, Embecta, Roche Diabetes Care, Novo Nordisk, Berlin Chemie AG, and Dexcom Germany as well as honoraria for lectures from Sanofi Germany, Novo Nordisk, Abbott Diabetes Care, Roche Diabetes Care, Berlin Chemie AG, Embecta, Dexcom, and Feen. In addition, he reports support for travel and fees for scientific meetings from Sanofi, Roche Diabetes Care, and Berlin Chemie AG.

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Data sharing

Individual participant data underlying the results reported in this article (text, tables, figures, and appendices) may be shared after de-identification. Additionally, the study protocol can be made available. Data sharing can commence immediately following publication and continue until 10 years after publication. The data will be shared with researchers who provide a methodologically sound proposal. The sharing of the data needs to fulfill the purpose of achieving the aims of

the approved proposal. Proposals should be directed to hermanns@fidam.de. To gain access to the data, the requestors will need to sign a data access agreement.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.diabres.2025.112228>.

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