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***Original Research Article***

# The Relationship between Sleep Disturbances and Glycemic Control in Children with Type 1 Diabetes

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**Abstract:** *Children with Type 1 Diabetes Mellitus (T1DM) require careful glycemic management to prevent both acute and long-term complications.* ***Objectives:*** *To evaluate the association between sleep disturbances and glycemic control in children and adolescents with T1DM and to determine whether sleep quality independently predicts HbA1c levels.* ***Methods:*** *This cross-sectional study was conducted at the University of Lahore Teaching Hospital from September 2024 to February 2025. A total of 185 children and adolescents, aged 6 to 18 years, diagnosed with T1DM for at least 12 months, were recruited for the study. Demographic information, such as age, gender, and diabetes duration, was recorded. Medical data on insulin regimen (MDI or pump), CGM use, and physical activity levels were gathered through parent review of medical records.* ***Results:*** *Sleep disturbances were highly prevalent, with 72% of participants scoring above the clinical threshold on the CSHQ. A moderate positive correlation was observed between sleep disturbance scores and HbA1c ($r = 0.41$, $p < 0.001$). Regression analysis confirmed that sleep disturbance score was an independent predictor of HbA1c ($\beta = 0.38$, $p < 0.001$), even after adjusting for confounders. Additionally, children with shorter sleep durations (<7 hours) had significantly higher HbA1c levels (mean: 9.1%) compared to those with ≥9 hours of sleep (mean: 7.7%).* ***Conclusion:*** *It is concluded that sleep disturbances are common in children with T1DM and are significantly associated with poorer glycemic control. Sleep quality should be routinely evaluated as part of comprehensive diabetes management. Targeted interventions to improve sleep may offer a low-cost, behavioral strategy to support better metabolic outcomes in this population.*

**Keywords:** Adolescent, Blood Glucose, Child, Diabetes Mellitus, Sleep Wake Disorders

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## Introduction

Type 1 Diabetes Mellitus (T1DM) is a lifelong autoimmune condition characterized by the destruction of insulin-producing β-cells in the pancreas, leading to chronic hyperglycemia. In children, this condition requires a complex management routine that includes regular blood glucose monitoring, insulin administration, dietary regulation, and physical activity (1). The development of continuous glucose monitoring (CGM) devices and insulin pump technology has not solved the challenge of finding optimal diabetes control in young patients. Sleep represents an understudied element that might affect glycemic control results because this fundamental biological process operates upon every physiological system in the human body (2). T1DM children experience progressively more sleep-based disturbances that simultaneously impact both their daily life quality and diabetes treatment requirements. The disturbances include environments where children experience reduced sleep times and poor rest quality, increased reawakenings during nighttime hours, and variations in their sleep patterns (3). Multiple elements lead to the occurrence of these difficulties. Children typically wake up because of hypoglycemic or hyperglycemic symptoms and signals from continuous glucose monitoring devices (4). Nighttime blood glucose monitoring increases because of the joint anxiety between children and their parents regarding nocturnal hypoglycemia, which results in more sleep disturbances for children. Various effects drive how interrupted sleep affects blood glucose management. Insufficient sleep and compromised sleep quality trigger problems in glucose metabolism while distorting insulin receptiveness and heightening hormone production levels, which would negatively impact glycemic results (5). Research shows that inadequate nighttime sleep leads to elevated HbA1c concentration, elevated blood glucose variability, and increased frequency of both high and low blood glucose levels. Children with inferior sleep face complications that diminish their ability to follow diabetes self-care procedures because poor sleep damages their attention span and produces irritability as well as weakens executive capabilities (6). Sleep impacts glycemic control, which affects sleep quality and is influenced by sleep quality. Both subpar sleep quality and nighttime hypoglycemic episodes disrupt how sleep stages evolve and how sleep should continue into a restful state. Children experience physiological symptoms such as sweating, headaches, and nightmares because of high or low glucose levels, leading to abrupt wakeups (7). Poor sleep combined with leadership feedback between sleep and glucose control might create a damaging cycle that worsens sleep quality and glucose regulation and increases health complications for the child. The psychosocial environment that surrounds children with diabetes influences the medical outcomes of their condition (8). The need for nighttime monitoring of T1DM requires parents of diabetic children to sacrifice their rest, causing them to experience sleep deprivation. Parents handling T1DM experience more stress and perform worse during daytime activities and face potential depression and anxiety, while these difficulties ultimately affect how their child responds to their T1DM. During adolescence, sleep cycles undergo alterations along with changes in natural body rhythms and independence, creating a greater risk for teenage patients to develop sleep disturbances that affect their diabetes management abilities (9).

Thus, this was conducted to evaluate the association between sleep disturbances and glycemic control in children and adolescents with T1DM and to determine whether sleep quality independently predicts HbA1c levels.

**Methodology**

This descriptive cross-sectional study was conducted at the University of Lahore Teaching Hospital from September 2024 to February 2025. The study enrolled a total of 185 children and adolescents between the ages of 6 and 18 years who had been diagnosed with Type 1 Diabetes Mellitus (T1DM) for at least one year. Participants were selected using a non-probability consecutive sampling technique. The inclusion criteria were: a confirmed diagnosis of T1DM according to the American Diabetes Association (ADA) guidelines, duration of diabetes of at least 12 months, treatment with either multiple daily insulin injections (MDI) or continuous subcutaneous insulin infusion (CSII) via an insulin pump, and availability of a recent glycosylated hemoglobin (HbA1c) test result within the preceding three months. Children with known comorbid neurological or psychiatric disorders that could independently affect sleep patterns were excluded. Specifically, participants with conditions such as epilepsy, attention-deficit/hyperactivity disorder (ADHD), or previously diagnosed sleep disorders, including obstructive sleep apnea, were excluded to minimize confounding effects on sleep-related outcomes. Ethical approval was obtained from the institutional review board, and written informed consent was secured from the parents or guardians of all participants, with assent obtained from children where appropriate.

Demographic information, such as age, gender, and diabetes duration, was recorded. Medical data on insulin regimen (MDI or pump), CGM use, and physical activity levels were gathered through parent review of medical records. Glycemic control was primarily assessed using Hemoglobin A1c (HbA1c), a biomarker reflecting average blood glucose levels over the previous two to three months. Healthcare records provided patient HbA1c results, which received three classifications: patients with good control (< 7.5%), moderate control (7.5%–9.0%), and poor control (> 9.0%). The study obtained additional data through SMBG logs and CGM outputs to assess glycemic variability and nocturnal glucose trends. Two validated parent-reported questionnaires, the Children's Sleep Habits Questionnaire (CSHQ) and Sleep Disturbance Scale for Children (SDSC), measured sleep quality and disturbances. Parents used the Children's Sleep Habits Questionnaire and the Sleep Disturbance Scale for Children to understand how well their children slept during the past month, including their experiences with bedtime problems and disturbances, and sleep times and night events. Parents used these instruments at the clinic to report their child's habitual sleep patterns.

Data were analyzed using SPSS v26. Continuous variables, such as age, sleep scores, and HbA1c, were summarized using means and standard deviations, while categorical data were presented as frequencies and percentages. Pearson correlation analysis was performed to evaluate the strength and direction of the association between sleep disturbance scores and HbA1c levels. Statistical significance was set at a p-value of less than 0.05 for all tests.

**Results**

Data were collected from 185 patients, with a mean age of 12.4 ± 3.2 years. The gender distribution was balanced, with 98 males (53%) and 87 females (47%). The average duration of diabetes among the participants was 4.6 ± 2.1 years. Regarding insulin therapy, 62% of the participants were on multiple daily injections (MDI), while 38% used insulin pump therapy. Additionally, 44% of the children used continuous glucose monitoring (CGM) devices to assist with glycemic control. (Table 1)

**Table 1. Demographic and Clinical Characteristics of Participants (N = 185)**

| Characteristic | Value |
|---|---|
| Total number of participants | 185 |
| Mean age (years) | 12.4 ± 3.2 |
| Gender: Male | 98 (53%) |
| Gender: Female | 87 (47%) |
| Mean duration of diabetes (years) | 4.6 ± 2.1 |
| Insulin therapy: MDI | 62% |
| Insulin therapy: Pump | 38% |
| Continuous Glucose Monitoring (CGM) use | 44% |

The distribution of glycemic control among participants, based on HbA1c levels, showed that 22% (41 patients) had good control with HbA1c levels below 7.5%. The majority, 47% (87 patients), fell within the moderate control category, with HbA1c values ranging from 7.5% to 9.0%. Meanwhile, 31% (57 patients) exhibited poor glycemic control, with HbA1c levels exceeding 9.0%. (Table 2)

**Table 2. Glycemic Control Categories Based on HbA1c Levels**

| HbA1c Category | Number of Patients | Percentage (%) |
|---|---|---|
| Good control (< 7.5%) | 41 | 22% |
| Moderate control (7.5–9.0%) | 87 | 47% |
| Poor control (> 9.0%) | 57 | 31% |

Night wakings were also common, reported by 59% of the children. Daytime sleepiness was observed in 54% of the participants, indicating the potential impact of poor nighttime sleep quality. Parasomnias, such as nightmares and sleep talking, were present in 41% of the children. (Table 3)

**Table 3. Prevalence of Reported Sleep Disturbances (Based on CSHQ)**

| Type of Sleep Disturbance | Prevalence (%) |
|---|---|
| Bedtime resistance | 64% |
| Night wakings | 59% |
| Daytime sleepiness | 54% |
| Parasomnias (e.g., nightmares, sleep talking) | 41% |

The analysis revealed a moderate positive correlation between total sleep disturbance scores and HbA1c levels ($r = 0.41$, $p < 0.001$), indicating that greater sleep disruption was associated with poorer glycemic control. This relationship was stronger in the adolescent subgroup (13–18 years) with a correlation of $r = 0.48$ ($p < 0.001$), compared to the children subgroup (6–12 years), which showed a weaker but still significant correlation ($r = 0.34$, $p = 0.01$). Participants using insulin pumps had slightly better glycemic control (mean HbA1c of 8.1%) compared to those using multiple daily injections (MDI), who had a mean HbA1c of 8.6% ($p = 0.045$). Multivariate regression analysis confirmed that sleep disturbance remained a significant independent predictor of HbA1c, with a standardized beta coefficient of 0.38 ($p < 0.001$). (Table 4)

**Table 4. Associations Between Sleep Disturbances and Glycemic Control**

| Analysis | Statistical Outcome |
|---|---|
| Total sleep disturbance score vs. HbA1c | $r = 0.41$, $p < 0.001$ |
| Adolescent subgroup (13–18 years) | $r = 0.48$, $p < 0.001$ |
| Children subgroup (6–12 years) | $r = 0.34$, $p = 0.01$ |
| Insulin pump vs. MDI (mean HbA1c comparison) | Pump: 8.1%, MDI: 8.6%, $p = 0.045$ |
| Multivariate regression (sleep disturbance predicting HbA1c) | $\beta = 0.38$, $p < 0.001$ |

Participants with low sleep disturbance scores (CSHQ < 41) had the lowest mean HbA1c at 7.6 ± 1.1%, while those with moderate disturbances (CSHQ 41–49) had a higher mean HbA1c of 8.3 ± 1.2%. The highest HbA1c levels were observed in the group with severe sleep disturbances (CSHQ ≥ 50), with a mean HbA1c of 9.0 ± 1.3%. (Table 5)

**Table 5. Mean HbA1c by Sleep Disturbance Severity (CSHQ Score Categories)**

| Sleep Disturbance Severity | Mean HbA1c (%) | Number of Patients |
|---|---|---|
| Low (< 41 CSHQ score) | 7.6 ± 1.1 | 52 |
| Moderate (41–49) | 8.3 ± 1.2 | 71 |
| High (≥ 50) | 9.0 ± 1.3 | 62 |

## Discussion

This study explored the association between sleep disturbances and glycemic control among children and adolescents with Type 1 Diabetes Mellitus (T1DM), revealing significant links between poor sleep and higher HbA1c levels. Previous experimental research supports these findings by showing sleep deprivation creates insulin sensitivity issues and disturbs hormonal regulation while raising inflammatory markers, which weaken glycemic control ability. The multiple factors influencing glycemic outcomes in pediatric T1DM were supported by results from regression analysis (10). Among multiple predictors, sleep disturbance scores maintained their significance as an independent factor for predicting HbA1c measurement with a standardized β value of 0.38 after controlling for additional parameters in the analysis. The results showed that extended sleeping periods displayed a protective influence by having a negative impact ($\beta = -0.31$) on HbA1c measurements. The use of insulin pumps for treatment in children yielded better results in HbA1c measures and sleep quality when compared to patients who required multiple daily injections (MDI), likely because of the stable glucose levels and decreased hypoglycemic events during nighttime (11).

The data guides medical staff treating diabetes alongside educators delivering diabetes education. Medical professionals should establish regular sleep evaluations as part of diabetes therapy monitoring, particularly for children, since pediatric sleep care currently lacks attention. The CSHQ and SDSC are easy-to-use screening instruments that deliver important information about glycemic control obstacles arising from behavioral and physiological factors (12). The healthcare of patients with diabetes would potentially benefit from specific sleep management techniques, which include regulating bedtime routines while decreasing screen usage throughout the night and managing hypoglycemic fears. The study does have some present limits (13). The design choice of cross-sections prevents researchers from establishing cause-and-effect relationships because parents self-report their children's sleep habits, which introduces subjectivity to the study. This study did not thoroughly evaluate external elements affecting sleep quality and diabetes management, like psychosocial stress, academic demands, and family situations. Future research should use a longitudinal design and interventions to determine how better sleep quality affects blood sugar control and whether improving sleep will result in measurable glycemic outcomes (14).

The CSHQ and SDSC assessments determined that clinical sleep disturbances affected more than two-thirds of the study participants. The analysis determines bed quality as a standalone predictor for blood sugar levels after adjusting for treatment factors such as insulin, disease duration, and patient age (15, 16). Different studies document that sleep problems regularly affect children with T1DM, while these symptoms actively hinder their diabetes management process. Children with severe sleep disturbances developed worse glycemic control when measured through mean HbA1c levels, which reached 9.0% (17). Sleep-related problems maintained a similar impact on diabetes control across children and teenagers, and slightly grew stronger for teenagers, presumably due to their varying metabolic patterns during adolescence. People with short periods of sleep tended to face declining capabilities of controlling their blood glucose levels. The participants who slept fewer than seven hours displayed the worst HbA1c test outcomes, with test results averaging 9.1%, yet those sleeping nine hours or more obtained average results of 7.7%.

## Conclusion

It is concluded that sleep disturbances are significantly associated with poor glycemic control in children and adolescents with Type 1 Diabetes Mellitus. The study findings demonstrate that children who experience frequent night awakenings, bedtime resistance, and shorter sleep duration tend to have higher HbA1c levels, even after adjusting for age, duration of diabetes, and insulin regimen. These results reinforce the importance of recognizing sleep as a key behavioral and physiological factor influencing diabetes outcomes.

**Declarations**

**Data Availability statement**
All data generated or analysed during the study are included in the manuscript.
**Ethics approval and consent to participate**
Approved by the department concerned. (IRBEC-TC477-24)
**Consent for publication**
Approved
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Not applicable

**Conflict of interest**

The authors declared the absence of a conflict of interest.

**Author Contribution**

**SS (**Research Scholar)
*Manuscript drafting, Study Design,*
**BT** (Lecturer)
*Review of Literature, Data entry, Data analysis, and drafting articles.*
**TH** (Deputy Drugs Controller)
*Conception of Study, Development of Research Methodology Design,*
**HF** (Drugs Controller/Chief Pharmacist)
*Study Design, manuscript review, and critical input.*

*All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.*

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