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Letter to the Editor

LETTER TO THE EDITOR

Type 1 diabetes as a prototypical condition challenging what we know about sleep

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Dear Editor,

Type 1 diabetes (T1D) is a form of organ failure impacting pancreatic insulin production. Without insulin, blood glucose levels become perilously high and can damage multiple organs. Exogenous insulin is lifesaving, but levels need to be constantly tweaked, and misjudgment can cause hypoglycemia, which can constitute a medical emergency. There is both circadian and sleep regulation of glucose metabolism, and acute complications from T1D are perhaps greatest whilst asleep. In this letter, we argue that T1D can be considered a prototypical condition that threatens some of what we know about sleep; and acts as a reminder to take care when conceptualizing sleep and offering advice on this topic to those with conditions and comorbidities necessitating a degree of nighttime management. We also outline a research agenda.

Sleep and T1D are jarring bedpartners [1]. This difficult relationship can appear even prediagnosis, with nocturnal enuresis constituting a presenting symptom of T1D. Unfortunately, T1D is a 24-h condition meaning that the urgency with which hypoglycemia and hyperglycemia must be treated does not diminish at night when vigilance decreases and sleep arrives. Furthermore, when critical treatment decisions are made at night, they may be suboptimal due to circadian factors, sleep inertia (a groggy state following waking) or sleep deprivation. The future of T1D management currently appears to be technological advances, exemplified by incredible developments in closed-loop systems. Such technologies impressively improve blood glucose levels, but also necessitate 24/7 access to electronic insulin pumps, continuous glucose monitors, and mobile phones [2]. Ironically, standard sleep hygiene advice involves removing technology from the bedroom.

Optimal sleep occurs when we feel safe; and restful, consolidated sleep occurring at an appropriate circadian phase promotes health [3]. Sleep and circadian rhythms are linked to cardiovascular health [4], immune functioning, and, importantly within this context, insulin resistance, and glucose control [5]. Good sleep and circadian function are also associated with mental health, emotional regulation, learning, and memory.

T1D challenges the entire framework of sleep and circadian health. For example, sleep must occur despite risks associated with losing vigilance. Instead of the recommendation of restful, consolidated sleep, some people with T1D are advised to monitor their blood glucose at night. The sweet spot between sleeping well for health and waking to manage diabetes is unclear and will vary between individuals depending on factors such as risk and awareness of hypoglycemia, diabetes management skills,

family priorities, technological support, and advice from diabetes teams. When it comes to some of the functions of sleep, T1D (by definition) destroys the physiological nighttime glucose regulation that normally interweaves with sleep and circadian rhythms.

What is more, some of the assumptions underlying models of sleep pathology may not apply to those with T1D. For example, leading models of insomnia highlight concerns about not being able to sleep, not getting enough sleep, and the daytime consequences that may result. In contrast, the sleep worries of individuals with T1D and insomnia may focus on the potentially serious consequences of not waking up (e.g. missed alarms).

Moreover, the usual techniques that we employ to improve sleep may in themselves pose certain risks to individuals with T1D. For instance, pediatric sleep practice advises parents to let babies "self soothe" so that they can fall back to sleep without caregiver intervention when they wake at night [6]. Such advice may prove problematic for caregivers who need to provide T1D support to infants during the night, which often results in disturbing their sleep [7, 8]. Furthermore, the first-line treatment for chronic insomnia in adults is cognitive behavioral therapy (CBT-I) [9], a key component of which is sleep restriction designed to produce more consolidated sleep. Such sleep typically involves more N3 (deep sleep) from which it is more difficult to awaken, hence increasing the likelihood of sleeping through warning alarms. CBT-I can also involve recommendations to establish regular waking and sleeping times, and to avoid eating late at night. But regular sleep times are challenging when blood glucose is out of range and needs attention, and "hypotreats" before bed or during the night can be a necessary component of glucose management. Regular exercise at a consistent time is also recommended in conjunction with CBT-I to improve sleep, help set the circadian rhythm, and support glucose management. But once again, regular physical activity can prove challenging in some people with T1D who may need to delay or alter exercise plans based on blood glucose levels.

The juxtaposition between the needs of sleep health and T1D management requires further consideration in both research and clinical settings. Toward the aim of improving understanding and clinical advice we recommend studies incorporating:

1) *Novel qualitative research*: Studies should aim to understand more about the causes and consequences of sleep disturbances in T1D as well as attitudes and sleep priorities of those with the condition (and their families). For example, it is critical to understand patient preferences and strategies for balancing the conflicting needs of sleep and glucose monitoring.
2) *Mixed methods to assess sleep*: Understanding more about the subjective experience of sleep and rhythmicity is important as is increasing understanding of how sleep architecture is altered in those with T1D and their family members. For example, studies examining the impact of closed-loop systems on sleep, should consider both subjective sleep quality as well as sleep architecture. If feelings of safety are increased by closed-loop systems, reduced light sleep, increased deep sleep, and even hemispheric effects may result [10].
3) *Longitudinal epidemiological designs*: Both short- and long-term associations between sleep and T1D are necessary to learn more about the direction of effects between variables (e.g. sleep quality, glucose, and HbA1c). Such studies would also ensure that sleep is not only assessed during periods of instability, such as during alterations in diabetes management, which could result in short-term sleep disruptions.
4) *The family/systems context*: Research must consider the family context when it comes to sleep, rhythms, and T1D. The way one family member sleeps can impact others; and those with T1D may be supported by family members whose own sleep may be impacted. In general, misalignment in partners sleep timing can contribute to poorer sleep quality; however, for families of those with T1D such misalignment or "taking turns" may benefit both sleep quality and diabetes management.
5) *Industry collaboration to optimize technology for both blood glucose and sleep*: The challenge for T1D technology is to optimize glucose control while minimizing waking (caused by mobile phones in the bedroom, glucose alarms set overly cautiously and technology malfunctions such as "compression lows"). Furthermore, considering how to minimize unnecessary waking in family members (e.g. using vibration watch alarms) may prove valuable.
6) *Intervention studies*: More data are required to understand the impact of changes in T1D management on sleep characteristics and vice versa. These data will help guide clinicians on the use of appropriate clinical interventions.

While sleep can be elusive in those with T1D, it remains vitally important—and perhaps especially so as it can additionally support diabetes-related health variables (e.g. HbA1c) as well as provide an important respite from the challenges of this condition. Here, we argue that T1D provides a prototypical condition reminding us of the need to question and challenge what we know about sleep in the context of disease and comorbidity. It is our hope that such research can be applied beyond T1D and to other conditions involving 24-h monitoring or intervention (such as asthma, epilepsy, and cystic fibrosis) with the ultimate aim of helping those most in need of a good night's sleep.

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