Student's Journal of Health Research Africa
Vol. 4 No. 6 (2023): June 2023 Issue
https://doi.org/10.51168/sjhrafrica.v4i6.499
Original article

A REVIEW OF DIABETES RISK AND SLEEP DURATION: TRENDS IN THE POPULATION AND POTENTIAL MECHANISMS.

Anand Shankar*

Shankar Diabetes Care Centre, Patna, Bihar, India.

Abstract

Sleep plays a critical role in controlling a variety of metabolic-related physiological processes. As a result, there is strong evidence to support the link between sleep patterns and the risk of diabetes. The risk of diabetes has specifically been linked to inadequate sleep duration and/or sleep restriction in the lab, poor sleep quality, and sleep disorders such as insomnia and sleep apnea. Epidemiological and laboratory studies are included in this study. Diabetes and obesity are both predisposed to behavioral risk factors like increased food intake, impaired judgment, and a higher likelihood of other behavioral risk factors like smoking, sedentary behavior, and alcohol use as well as physiological risk factors like insulin resistance, decreased leptin, increased ghrelin, and inflammation. Obesity is also a significant diabetes risk factor. The evidence relating sleep to diabetes risk is discussed in this review at both the population and laboratory levels.

Keywords: Sleep, Circadian rhythm, Diabetes, Insomnia, and Obesity, Submitted: 2023-06-22
Accepted: 2023-06-29

1. Introduction:

A major unmet public health need, insufficient sleep duration has been listed as a national health priority in Healthy People 2020 [Figure 1; 1]. Numerous earlier research has linked a regular lack of sleep to serious negative cardiometabolic effects, such as weight growth, obesity, diabetes, cardiovascular disease, and stress. It has been hypothesized that these interactions are caused by inadequate sleep duration, which results in immune response and metabolism dysregulation [2,3], which in turn causes hunger dysregulation and cardiometabolic illness.

Uncertain routes may link insufficient sleep to diabetes. Partial sleep deprivation protocols have been employed in a number of research to induce sleep loss and investigate the metabolic effects. These studies often enlist young, healthy volunteers who typically get 8 to 9 hours of sleep each night to participate in an acute sleep restriction of 4-6 hours spread out over a few days to a few weeks. Lack of sleep is frequently found to be linked to insulin resistance and glucose intolerance [4,5]. This conclusion has been drawn from research that used both challenge paradigms, such as glucose tolerance testing, and continuous glucose monitoring [6, 7]. As a result, numerous research have been conducted with the goal of deciphering potential molecular pathways and further exploring this link [8–10]. Numerous epidemiologic studies have explored self-reported short sleepers in relation to obesity and diabetes risk, paralleling these laboratory findings, and frequently found overlapping patterns.

*Corresponding author.
Email address: shankardiab@gmail.com (Anand Shankar)

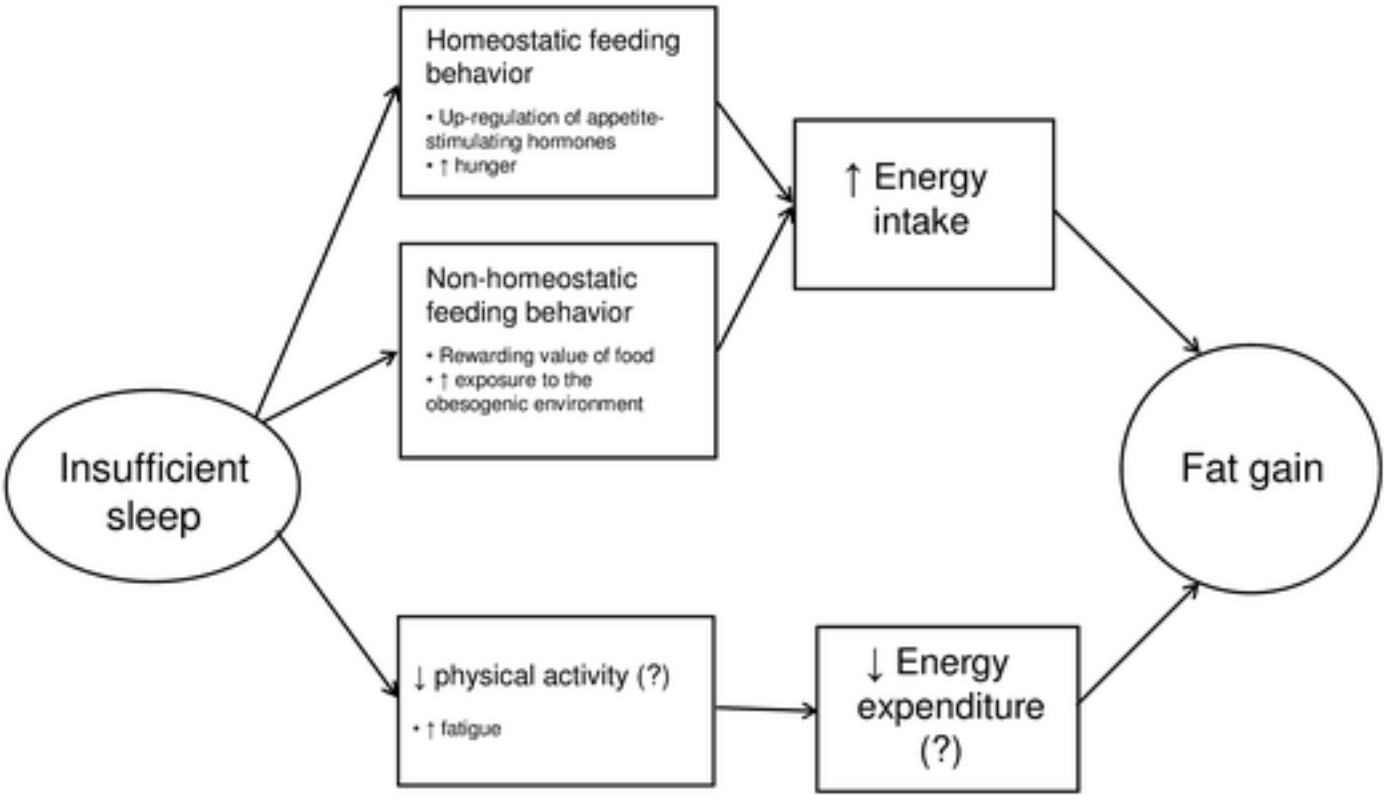

Figure 1: **Insufficient sleep linked with Obesity**

The current review discusses the following topics: (1) population trends linking chronic sleep deprivation to diabetes risk; (2) potential physiological mechanisms; (3) potential behavioural mechanisms; (4) increased prevalence of diabetes in individuals with obstructive sleep apnea and treatment implications; and (5) significance of circadian control of metabolism in the relationship between sleep and diabetes. We conclude with conclusions and suggestions for additional research

1.1. Diabetes Risk and Lack of Sleep: **Population Trends.**

1.2. Conflicting Definitions and Operationalizations of Insufficient Sleep—

Numerous research have looked at habitual sleep length as an independent variable in connection to outcomes like morbidity and mortality from cardiometabolic disease. Sleep duration has been operationalized in a variety of ways in population-level studies, despite the fact that there is a growing consensus on how it should be characterised. First of all, other studies have used prospective self-report, single-timepoint objective measures, such as polysomnography, and prospective objective measures, such as actigraphy, despite the most common method being the use of retrospective self-report survey items because these are the most practical for population-level research. All of these estimates evaluate various components of sleep because there is no direct way to measure it in people, and there is currently no accepted gold standard for determining the average duration of sleep. As a result, different study approaches must be taken into account during evaluation.

Methods may differ even within measurement methodologies (such as survey questions, sleep diaries, or actigraphy). For instance, some survey questions ask for "typical" or "weekday" (i.e., modal) sleep duration, while others ask for "average" (i.e., mean or median) sleep duration. Additionally, some questions only concern nighttime sleep, while others evaluate 24-hour sleep. On how to operationalize sleep duration as a vari-

able, there is disagreement. Some studies assess it as a continuous variable under the presumption that effects are linear and continuous. To account for nonlinear and probable threshold effects, other research looked at sleep duration as a three-level variable (short, normal, and long). To further clarify nonlinear effects, some researchers have employed a four-factor method (very short, short, normal, and long), while others have used more categories with a reference in the middle of the distribution. Comparisons between researches are challenging due to these disparate methodologies. With these caveats in mind, there are a number of significant inferences that can be made from the present research on sleep and the risk of developing diabetes.

1.3. Agreed Recommendations:

Adult sleep duration recommendations were recently made by a group that the American Academy of Sleep Medicine and Sleep Research Society jointly assembled. According to this guideline, 7 or more hours of sleep were probably required to sustain good health and functioning. [8,9] In a companion document, it was found that there was disagreement over the appropriateness of sleep longer than 9 hours, but that less than 7 h was generally considered improper for the domain of metabolic health. While this group did reach agreement that more than 9 hours of sleep was not necessary, it did advocate at least 7 hours of sleep as part of a concurrent National Sleep Foundation initiative [10,11]. In line with these suggestions, the American Thoracic Society has issued a statement in which its consensus panel cautions that inadequate sleep length (defined by them as 6 hours or less) is probably related to ill health, including diabetes [12].

1.4. Population Prevalence Estimates for the Prevalence of Insufficient Sleep:

The Centres for Disease Control and Prevention used the 2014 Behavioural Risk Factor Surveillance System to release prevalence data for insufficient sleep based on the consensus statement issued by the American Academy of Sleep Medicine and Sleep Research Society. A third of US adults, according to this survey, may not get the appropriate amount of sleep [12]. The distribution of sleep length of the population was determined using the question, "On average, how many hours of sleep do you get in a 24-hour period?," and these estimates are consistent with those from other studies. As an illustration, the prevalence of 7 h is estimated to be 28.3% [13], or 6 h since hours were only measured in whole numbers. This value was greater in the 2007–2008 wave, at 39.92% [13].

Despite assertions to the contrary, data suggest that sleep duration has not dropped significantly in recent years, despite claims to the contrary. For instance, a study [14] looked at 15 different countries' patterns in worldwide sleep duration from the 1960s. In general, they discovered scant to no evidence that sleep duration is decreasing globally, and particularly in the USA. Two US-based studies that used a comparable technique both indicated an increase in the proportion of those sleeping 6 hours or less while one found a minor decrease in the amount of sleep time [15,16]. The extremely high frequency of short sleep duration is therefore supported by the data, even though a claim of an increased prevalence of short sleep is not well supported by the current data.

1.5. Sleep duration: Social and demographic influences:

It should be mentioned that the population's distribution of sleep length varies. For instance, women are more prone than men to have short sleep durations [17]. Minority groups are also more prone to have short sleep duration [18]. Although poverty is a risk factor for poor sleep, these effects are not dependent on socioeconomic status [19]. Given the gender, racial/ethnic, and socioeconomic disparities in diabetes prevalence rates, as well as the possibility that sleep is contributing, these trends are particularly important. Particularly, sleep duration might contribute to racial/ethnic differences in diabetes and obesity [20]. The socialecological model of sleep and health makes an effort to integrate these elements into a single, cohesive theory that explains how sleep interacts with upstream social-

environmental causes and downstream health effects.

1.6. Short Sleep Duration and Diabetes in Epidemiologic Studies of Sleep and Diabetes Risk:

The Centres for Disease Control and Prevention used the 2014 Behavioural Risk Factor Surveillance System to release prevalence data for insufficient sleep based on the consensus statement issued by the American Academy of Sleep Medicine and Sleep Research Society. A third of US adults, according to this survey, may not get the appropriate amount of sleep [12]. The distribution of sleep length of the population was determined using the question, "On average, how many hours of sleep do you get in a 24-hour period?," and these estimates are consistent with those from other studies. As an illustration, the prevalence of 7 h is estimated to be 28.3% [13], or 6 h since hours were only measured in whole numbers. This value was greater in the 2007–2008 wave, at 39.92% [13].

Despite assertions to the contrary, data suggest that sleep duration has not dropped significantly in recent years, despite claims to the contrary. For instance, a study [14] looked at 15 different countries' patterns in worldwide sleep duration from the 1960s. In general, they discovered scant to no evidence that sleep duration is decreasing globally, and particularly in the USA. Two US-based studies that used a comparable technique both indicated an increase in the proportion of those sleeping 6 hours or less while one found a minor decrease in the amount of sleep time [15,16]. The extremely high frequency of short sleep duration is therefore supported by the data, even though a claim of an increased prevalence of short sleep is not well supported by the current data.

Short Sleep Duration and Diabetes in Epidemiologic Studies of Sleep and Diabetes Risk

Overwhelming evidence from meta-analyses shows that reduced sleep duration, such as 5 h per day (very short sleep) and 6 h per day (short sleep), is equally predictive of diabetes, with relative risks of 1.48 (95% CI 1.25, 1.76) and 1.18 (95% CI 1.10, 1.26), respectively [21]. This is in contrast to other traditional diabetes risk factors, such as being overweight, having a family history of diabetes, and being physically inactive. In prediabetes, a condition that precedes diabetes and is characterised by decreased fasting glucose and glucose tolerance and blood sugar levels between 5.6 and 6.9 mmol/L, the cardiometabolic effects of short sleep duration may be more pronounced. In one study, researchers discovered that people with short sleep duration (5 h) had a 2.06 greater risks of prediabetes (95% CI 1.00-4.22) than people with long sleep duration (>7 h) [22].

Short sleep duration has a strong correlation with diabetes and its effects in a variety of settings and across various populations. Men are more severely impacted by the harmful effects of short sleep duration on diabetes than women are [23]. The detrimental effects of short sleep duration on diabetes are consistently seen by racial/ethnic minorities in the USA [24]. A study discovered that black and white short sleepers (5 h) were 91% more likely to report a diabetes diagnosis than those who slept on average 6–8 h per day [25] in a nationally representative sample.

Compared to blacks, whites had a greater correlation between short sleep duration and diabetes [26]. These two sets of studies show that inadequate sleep and its link to diabetes affect people of all socioeconomic backgrounds, and that it is a widespread problem that needs immediate attention. Although there is strong evidence for the potential link between insufficient sleep and diabetes, the underlying causative pathways are not well understood. Haemoglobin A1c (HbA1c), a measure of glucose metabolism, and sleep duration, particularly short sleep duration, are linked, according to meta-analytical data [27]. The aforementioned data suggest that unhealthy glucose levels and insulin resistance may act as a mediator in the association between insufficient sleep duration and diabetes and its effects.

Obesity in the present and in the future is linked to short sleep duration. Previous research suggests that a number of processes, including increased appetite/dietary intake, physical activity, and/or thermoregulation, influence the link between inadequate sleep and obesity [28]. Ac-

cording to a meta-analysis of 16 cross-sectional research, short sleepers are more likely to have unconventional eating patterns that stray from the recommended three meals per day, which typically lead to eating very high-calorie items only occasionally during the day. Chronic health issues like obesity, cardiovascular disease, and cardiometabolic disorders can develop over time as a result of these bad eating and sleeping habits. Understanding the causal chain that connects short sleepers to harmful dietary consumption behaviors is crucial for addressing this tendency. Leptin and ghrelin, the hormones responsible for the physiological impulses of satiation and increased appetite, respectively, have a mediating function that may provide one explanation. Short sleepers typically had lower levels of leptin, higher levels of ghrelin, and higher body mass indices than ordinary sleepers [29]. Increased opportunities for eating, increased weariness, and decreased thermoregulation are additional potential mechanisms.

1.7. Sleep loss and diabetes risk: **Potential Physiologic**

1.8. Mechanisms Insulin Resistance

In a groundbreaking investigation, 11 healthy men were evaluated in the lab after 12 or 4 hours in bed. An intravenous glucose tolerance test was used to measure insulin and glucose levels at 5 and 10 hours after meals. The findings demonstrated very clearly that the sleep deprivation condition was linked to greater baseline levels of insulin and glucose, which in turn led to higher homeostatic model assessment (HOMA) values, a sign of insulin resistance [14]. Numerous studies that were conducted after this one revealed similar results: lack of sleep was linked to higher insulin sensitivity and may eventually result in insulin resistance [30]. These studies are often regarded as providing the most compelling physiological evidence connecting sleep loss to the elevated prevalence of diabetes documented in epidemiologic studies. To better understand the mechanisms through which lack of sleep may cause insulin resistance, follow-up research are looking at the function of processes prior to insulin signalling. Sleep deprivation may change adipocyte insulin signalling, which may be the cause of insulin resistance [31].

1.9. Leptin and Ghrelin

The metabolic hormones leptin and ghrelin may play a role in the relationship between sleep and the risk of developing diabetes, according to a number of studies. Adipose tissue produces the hormone leptin, which is involved in signaling feelings of fullness. Acute sleep loss has been found in sleep laboratory experiments to lower leptin [13, 17], which would presumably lead to decreased satiety. In contrast, the hormone ghrelin, which increases appetite, is produced by the stomach in a pulsatile way before meals. Acute sleep deprivation has been shown to raise ghrelin in laboratory investigations, which may indicate increased physiologic appetite [12, 13, 17]. This interplay of heightened appetite and diminished satiety may lead to excessive eating, which could put people at risk for obesity and diabetes. This interplay of heightened appetite and diminished satiety may lead to excessive eating, which could put people at risk for obesity and diabetes. Convergent alterations to energy balance and subjective feelings of hunger have been seen in studies, which support this idea [13]. Additionally, disturbances in leptin and ghrelin may potentially lead to insulin and glucose dysregulation, which has been investigated in a number of different studies in relation to sleep deprivation [17].

Leptin has been investigated as a marker for adiposity because it is a hormone that is largely released by white adipose tissue [31]. However, it appears that its main roles involve alerting the hypothalamus to the level of available energy reserves in order to modify food intake and energy expenditure [32]. When energy reserves are low, hypoleptinemia prompts the arcuate nucleus to upregulate agouti-related protein and neuropeptide Y, and the lateral hypothalamus to upregulate orexin and melanin-concentrating hormone. By downregulating pro-opiomelanocortin, cocaine, and amphetamine-regulated transcripts in the arcuate nucleus and brain-derived neurotrophic factor in the ventro-medial hypotha-

lamus, hypoleptinemia signals also increase appetite [33]. Additionally, leptin regulates reward perceptions and food motivation in the ventrotegmental region and operates in the brainstem to increase satiety [34].

In comparison to a nonobese control group (mean BMI = 23), a human investigation found that sleep and leptin levels were higher before and after drastic weight loss (mean BMI = 41 to 27). The obese group slept less than the nonobese group, averaging 360 minutes of sleep per night, which improved to 385 minutes after weight loss. Compared to the nonobese group (12 g/L), the obesity group had increased mean leptin secretion (35 g/L) during the 24-hour period [35]. Leptin levels considerably dropped after weight loss, falling to 17 g/L, where they no longer statistically differed from the nonobese group. Accordingly, it appears that the decrease in fat mass caused decreases in leptin production, and that this effect overwhelmed any effects due to changes in sleep duration [35].

Sleep deprivation for 4 hours causes alterations in leptin secretion. They discovered that lack of sleep decreased leptin levels by 20% in rhythm amplitude, 26% in peak levels, and 19% in mean levels [36]. Similar to the last study, another one was conducted by the same team over the course of two days [13]. They discovered an 18% drop in leptin levels. Following a single night of sleep deprivation, leptin levels increased. Leptin amplitude decreases after sleep limitation [13]. However, research found that one night of insufficient sleep did not affect leptin levels. However, among teenagers, shorter-sleeping guys were the only ones with decreased leptin levels. There were no further connections discovered. A study discovered that a 3-week sleep intervention in a group of kids aged 8 to 11 decreased energy intake and weight but showed lower leptin levels. [36].

Leptin levels drop and ghrelin levels rise when healthy sleepers are deprived of sleep, according to laboratory research [37]. This finding has been confirmed by epidemiologic research, which show relationships between habitually short sleep duration and both decreased leptin and higher ghrelin [37]. Ghrelin controls hunger and is produced in the stomach and pancreas. It is an endogenous ligand for the growth hormone secretagogue receptor 1-a (GHSR), a 28-amino acid peptide that has only recently been identified and given its name [37]. Most pertinent to this discussion are its activities in the hypothalamus, which are largely released by the stomach [37]. Ghrelin has distinct orexigenic and adipogenic actions at the level of the hypothalamus via the GHSR pathway.

With increasing release during the day, especially before meals, and considerable decrease at night, ghrelin has a well-established circadian rhythm. According to animal research, this suppression can be lessened with restricted feeding [15]. Ghrelin increases slow wave sleep in humans, according to numerous research [18].

Ghrelin may rise if you don't get enough sleep. Animal models have demonstrated this [68, 109]. In a now-classic study, 12 healthy, young males were subjected to two nights of sleeping for only four hours. In comparison to a rested condition, total ghrelin levels were 28% higher following two nights of 4 hours of sleep [13]. The numerous studies on ghrelin's role in sleep limitation have been sparked by this one finding, which is commonly mentioned. Morning ghrelin concentrations were shown to be considerably higher after an acute sleep loss regimen [17]. Although ghrelin has not changed in other research, one of them discovered that it reduced during a 5-day sleep restriction period [22,23]. Men, but not women, who experienced sleep deprivation had higher ghrelin levels [37,28]. Few studies have used total sleep deprivation in contrast to those that used partial sleep deprivation, but one study discovered higher ghrelin levels [37-39].

Age may also be important. A 1.5-hour sleep time reduction in a study of 8 to 11-year-olds did not result in a change in ghrelin levels [39]. Greater ghrelin levels were linked to shorter sleep duration [35], particularly in the nonobese subsample. greater sleep durations were positively correlated with greater ghrelin levels [40]. Sleep and ghrelin levels were found to be related [41]. Actigraphically assessed sleep in adults in the general population was not linked to ghrelin or a sam-

ple of postmenopausal, sedentary, or overweight women [32]. Shorter habitual sleep duration was linked to higher ghrelin in the Wisconsin Sleep Cohort Study's data, which was a prospective cohort study that included middle-aged adults [35].

1.10. Inflammatory Cytokines:

A cytokine produced by active macrophages is TNF-α. It performs a variety of proinflammatory functions, including activating the acute phase response. Additionally, it contributes to chronic inflammation. TNF-α was given its name when it was found to cause tumour cells to undergo apoptosis [42]. Several relevant immune cell functions are encouraged by TNF-α [42]. The nuclear factor kappa (NFk) B and mitogen-activated protein (MAP) kinase pathways are two of TNF-α's main targets. MAP kinase is involved in many physiological activities, including reaction to stressors and gene expression. NFkB is a protein complex that regulates DNA transcription and is implicated in cellular responses to stressors. These functions support immune response and cell control when combined.

Although TNF-α and sleep have been the subject of numerous studies, some of the findings are conflicting. For instance, one study discovered that males, but not women, had higher 24-hour TNF-levels when their sleep was limited to 6 hours over the course of 12 nights. Increases in TNF-α messenger RNA expression were discovered in another investigation of one night of sleep restriction [43,44]. Not all studies produced encouraging results. TNF-α levels did not rise in a research when sleep was limited to two 2-hour naps [45]. The TNF-p55 receptor, a crucial part of many of TNF-α's functions, was not altered by sleep restriction for 10 days, according to another study [44]. However, it is possible to demonstrate increases in TNF-α without corresponding increases in receptor levels, as was the case in one investigation with complete sleep deprivation [22].

The contradictory results could be partially explained by individual variability in susceptibility to sleep loss and the many receptor types investigated [9]. TNF-α has only been examined once in a population-based environment. Shorter polysomnographic sleep, which might not be connected to habitual sleep, was linked to higher TNF-α in the Cleveland Family Study, where each hour of sleep was linked to an 8% increase in TNF-α [20]. When considered collectively, these results imply that sleep may regulate TNF-α function.

IL-6 is a pro-inflammatory molecule, similar to TNF-α. Similar to TNF-α, it is released by macrophages and T-cells and is crucial for both the acute phase response and chronic inflammation. It also affects how the body regulates its temperature and encourages the use of energy in adipose tissue, where 15–30% of IL-6 is expressed. Interestingly, visceral adipose tissue releases IL-6 2-3 times more than subcutaneous adipose tissue [45]. This could be a factor in the association between IL-6 levels and obesity. It should be emphasised that IL-6 can have anti-inflammatory effects as a result of its ability to suppress TNF-α and IL-1 while promoting the anti-inflammatory IL-10 [45].

There is a diurnal rhythm to IL-6. It is strongest at night, and an increase is seen right before falling asleep [23]. Slow wave sleep, which makes up a large portion of the early stages of sleep, then suppresses IL-6 [23]. Lack of sleep causes the nighttime peak of IL-6 to be delayed (pushed back), which may explain why there is oversecretion during the day and undersecretion at night has been seen [23]. When IL-6 is given exogenously, slow wave and REM sleep are inhibited in the early hours of the night, with a rebound in the late hours [23]. Interestingly, a study of night shift work found greater secretion at night [24], despite the fact that sleep deprivation in the lab may result in nocturnal undersecretion.

Numerous lab tests have looked at how experimental sleep deprivation affects IL-6. When sleep was limited to 4 hours per night (as opposed to 8 hours), Haack and colleagues discovered that after 12 days in the lab, IL-6 levels had increased by 62% [46]. Similarly, IL-6 secretion was increased in a subsequent 12-day laboratory experiment (this time with a 6-hour sleep restriction) [15]. Since 24-hour sampling was possible, it was demonstrated that variations were discovered between 18:00 and 24:00 and 3:30 and 6:00. An rise

in IL-6 was seen in 13 healthy young men following five nights of sleep deprivation to 4 h, and this increase persisted even after a brief window of recovery [25].

Numerous studies have also looked on routinely sleeping. Elevated IL-6 (7% rise per hour) was linked to self-reported lengthy sleep duration in the Cleveland Family Study [20]. Long periods of sleep were linked to increased IL-6. The actigraphic sleep duration was found to be negatively correlated with IL-6 in a study of Alzheimer's carers and controls [27], and a study of mothers found that self-reported short sleep of 5 h was associated with elevated IL-6 at 3 years postpartum. However, these studies did not find associations with short sleep [47].

The risk of cardiovascular disease has been linked to habitually short sleep duration [4, 7], while the underlying causes are unclear. Increased neurobehavioral stress response, increased oxidative stress, and increased inflammation are some of the proposed mechanisms. The discovery of elevated inflammatory biomarkers associated with brief sleep duration lends evidence to some of these suggested processes. This finding has been examined in the context of population-based investigations of habitually short sleepers as well as laboratory studies of sleep deprivation of normal sleepers [4]. In particular, increases in IL-6 and TNF-α have been linked to short sleep in population [20, 28] and laboratory [15-18] research, but they have not been tested in confirmed short sleepers.

1.11. Possible Behavioural Mechanisms Correlating Sleep Deprivation with Diabetes Risk:

There are several potential indirect channels by which behavioural mechanisms may be involved, in addition to physiologic pathways linking sleep loss and diabetes risk. Lack of sleep may increase calorie intake over the course of a day, impair decision-making, which may cause a person to choose more unhealthy foods, and increase the possibility of other harmful behaviours that raise the risk of diabetes.

1.11.1. More calories consumed:

Studies have indicated that losing sleep might lead to an increase in calorie consumption over the course of a 24-hour period. When given only 5 hours of sleep, wealthy people consumed roughly 500 more calories per day than those who were well-rested, and this increase in caloric intake was linked to a rise in energy expenditure at night, when people are typically asleep[48]. Additionally, this study demonstrated that the increased calorie intake only happened at night, but the caloric intake in the morning was somewhat decreased. This conclusion was confirmed in a group with a wider range of backgrounds in a sizable investigation by Spaeth and colleagues[29,30].

Over the course of five days, this higher energy consumption was linked to a weight gain of roughly 1 kg, but Black and African-American males were more likely to gain weight than non-Hispanic White men or Black or African-American women. White women who are non-Hispanic showed the least weight gain. In a different laboratory experiment, increased food consumption after sleep deprivation was limited to high-calorie snacks [49]. In order to avoid gaining weight and increasing the risk of developing diabetes, sleep loss may increase energy intake at night, especially from sources that are high in energy [49].

1.11.2. Decision-Making Issues:

Unhealthy food selections might also result in unhealthy eating. Making appropriate dietary choices can be challenging, and this difficulty may increase if you are experiencing sleep loss. Executive function is hampered by lack of sleep [32–36]. A person's capacity to appropriately balance the risks and advantages of a course of action may be restricted by sleep loss, which also encourages hedonic decision-making [37, 38]. These can result in bad eating habits, which could raise the chance of developing diabetes.

1.12. Possibility of Other Unhealthy Behaviours Being More Likely:

Regularly short sleep duration is linked to other bad behaviors that may raise the risk of diabetes.

A more sedentary lifestyle is linked to general sleep disruptions [42], perceived insufficient sleep [41], and habitually short sleep duration [39, 40]. Additionally, smoking has been linked to both short sleep duration and poor sleep quality [43, 40]. Alcohol abuse is also more common in people who have trouble sleeping [44, 45]. When combined, sleep issues like insufficient sleep time and poor sleep quality can result in unhealthy behaviors that are risk factors for diabetes.

Obese people frequently have type 2 diabetes mellitus (T2DM) and obstructive sleep apnea (OSA). When the information from the five NHANES investigations was combined, it became clear that among the three factors of age, race, and body mass index (BMI), BMI was the one that most significantly influenced the prevalence of diabetes [46]. Insulin resistance and decreased insulin secretion are two features of T2DM in obese people. It has been demonstrated that OSA causes insulin resistance even in the absence of fat, albeit the precise mechanism is unknown [47].

The frequency of OSA among T2DM patients varies greatly. This disparity results from the different study populations and respiratory disturbance index (RDI) definitions used to quantify sleep-breathing issues [48]. In his obese, diabetic population, OSA was present 86% of the time. Similarly, their T2DM patients had an OSA prevalence of 77%. They also observed worsening glycemic control as OSA severity increased. Although this study was constrained by its size and the use of a screening questionnaire for excessive tiredness and snoring prior to recruitment [49], the prevalence of OSA in his diabetic sample was estimated to be 70%. 36%, which is a slightly lower prevalence. The anticipated prevalence in the aforementioned research was substantially higher than the actual prevalence, which was only about 18% of the population. The bidirectional association between these chronic medical problems has also been confirmed by a higher prevalence of T2DM in OSA patients [50].

1.12.1. ***Obesity and obstructive sleep apnea:***

With a proportionally rising prevalence of OSA with increasing BMI, obesity is one of the biggest risk factors for its onset [51]. While the prevalence of OSA is thought to be between 0.15 and 0.3% in the general population, it is thought to be between 19 and 31% in the obese population. The upper airway obstruction is caused by changes in upper airway mechanics brought on by an increase in BMI. The development and progression of OSA have been linked to a number of causes, including increased pharyngeal fat deposition, airway edema, changes in leptin signaling pathways, as well as a decrease in functional residual capacity.

1.12.2. Diabetes Type 2 and Sleep Apnea:

Reduced peripheral insulin responsiveness, which leads to decreased glucose absorption and glucose intolerance, is a hallmark of insulin resistance. It has been demonstrated that sleep apnea is independently linked to increased insulin resistance, regardless of weight, age, or body fat distribution. This association's pathophysiology is thought to be caused by sleep apnea's effects on sleep, specifically intermittent hypoxia (IH) and sleep fragmentation, which cause sympathetic nervous system activation, oxidative stress, systemic inflammation, dysregulation of the hormones that control appetite, and activation of the hypothalamic-pituitary-adrenal axis. These processes play a role in the development of insulin resistance [52].

Insulin resistance is assumed to be mostly influenced by the activation of the sympathetic nervous system by IH brought on by sleep apnea, which decreases insulin sensitivity, insulin-mediated glucose absorption, and insulin production. By stimulating the hypothalamic-pituitary-adrenal axis, sympathetic nervous system activity may enhance cortisol production. Cortisol boosts glucose synthesis, lowers peripheral glucose absorption, and prevents pancreatic beta cells from secreting insulin. Reactive oxygen species (ROS), which are produced as a result of oxidative stress related to IH, may exacerbate insulin resistance by preventing muscle and adipose tissue from absorbing insulin-induced energy substrates. Low levels of hormones that control hunger, such as leptin and adiponectin, have been linked to increased insulin resistance. Reduced glucose toler-

ance may also be a result of sleep apnea, which causes sleep fragmentation, sleep deprivation, and REM sleep loss [53].

1.12.3. Oxidative stress, inflammation, and sleep apnea:

Sleep apnea-related H may cause oxidative damage and the generation of ROS, which supports an inflammatory state [54]. The release of insulin may be suppressed and the uptake of glucose may be inhibited in peripheral tissues. Both cell proliferation and cell death in pancreatic beta cells have been linked to oxidative stress [54]. Continuous positive airway pressure (CPAP) therapy has been demonstrated to lessen oxidative stress. Endothelial dysfunction, increased arterial stiffness, and raised serum inflammatory markers are all linked to moderate to severe OSA [54]. With higher levels of circulating inflammatory cytokines including interleukin-6 and tumour necrosis factor alpha, which have been demonstrated to play a role in the aetiology of insulin resistance and T2DM, diabetic individuals also exhibit a baseline proinflammatory state [54]. It is unknown how precisely chronic inflammation contributes to the development of insulin resistance in patients with sleep apnea.

1.13. Therapy for Sleep Apnea:

Uncertainty surrounds the potential method by which CPAP therapy may affect glycemic control. Improved glycemic control may arise from the elimination of occasional hypoxia and sleep fragmentation with CPAP therapy [55]. CPAP therapy's favourable impact on individuals with OSA and T2DM's insulin resistance [55].Due to short-term follow-up and small sample numbers, the few randomised control trials (RCT) that have been conducted to assess the impact of CPAP therapy on glucose control in diabetes patients have shown mixed results.

Over the course of 24 weeks, CPAP therapy had a positive impact on insulin resistance and glycemic management in OSA patients with poorly managed diabetes mellitus. Patients with severe OSA did not just benefit from these advantages. This improvement was believed to be attributable to the proinflammatory condition associated with CPAP therapy being reversed [56]. It is unclear how long CPAP therapy should last. According to research, rather than non-rapid eye movement (NREM) sleep, apneas and hypopneas connected to REM sleep are associated with glycemic control in T2DM [51]. When compared to individuals who only used CPAP for 4 hours, patients who continued using it for up to 7 hours experienced higher reductions in HbA1c levels [51].

In conclusion, CPAP use is linked to better glycemic control and insulin sensitivity. The longer duration of CPAP usage and higher compliance with CPAP therapy in patients with inadequate diabetes management may be connected to these positive outcomes.

2. Conclusion:

Numerous physiological functions, many of which are involved in the control of metabolism, depend on sleep. It's possible that this is why inadequate sleep and sleep disturbances have been recognised as novel and significant risk factors for the onset of diabetes. This is especially concerning given that a third of Americans report getting little sleep, and that three quarters or more of diabetics also suffer from sleep apnea, a sleep disease that is quite common in middle-aged and older adults.

3. Limitations:

The study limitations include that we may not have identified some studies that were unpublished or published in other languages. Second, all the studies relied on self-reported sleep duration, whereas actigraphy and polysomnography (the gold standard) may provide more objective measures.

4. Recommendations:

It is necessary to raise awareness of the value of sleep in understanding and controlling diabetes. Current research points to behavioural and physiological pathways that connect sleep to the risk of

diabetes and obesity. Future studies are required to determine the molecular relationships between sleep and metabolic dysfunction as well as the epidemiologic associations between diabetes and particular sleep phenotypes.

5. Acknowledgement:

None

6. List of abbreviations:

HOMA- Homeostatic model assessment
GHSR- Growth hormone secretagogue receptor
TNF- Tumor necrosis factor
NFk- Nuclear factor kappa

7. Source of funding:

Nil

8. Conflict of Interest:

None declared

9. Publisher details:

Publisher: Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256775434261
Location: Wisdom Centre, P.O.BOX. 148, Uganda, East Africa.

10. References:

1. Office of Disease Prevention and Health Promotion. Healthy People 2020 objective topic areas. US Department of Health and Human Services; Washington: 2011.
2. Beccuti G, Pannain S. Sleep and obesity. Curr Opin Clin Nutr Metab Care. 2011; 14(4):402–12.
3. Grandner MA, Patel NP, Gehrman PR, Perlis ML, Pack AI. Problems associated with short sleep: bridging the gap between laboratory and epidemiological studies. Sleep Med Rev. 2010; 14:239–47.
4. Zizi F, Jean-Louis G, Brown CD, Ogedegbe G, Boutin-Foster C, McFarlane SI. Sleep duration and the risk of diabetes mellitus: epidemiologic evidence and pathophysiologic insights. Curr Diab Rep. 2010; 10(1):43–7.
5. Sharma S, Kavuru M. Sleep and metabolism: an overview. Int J Endocrinol. 2010:2010.
6. Knutson KL. Sleep duration and cardiometabolic risk: a review of the epidemiologic evidence. Best Pract Res Clin Endocrinol Metab. 2010; 24(5):731–43.
7. Faraut B, Boudjeltia KZ, Vanhamme L, Kerkhofs M. Immune, inflammatory and cardiovascular consequences of sleep restriction and recovery. Sleep Med Rev. 2012; 16(2):137–49.
8. Mullington JM, Haack M, Toth M, Serrador JM, Meier-Ewert HK. Cardiovascular, inflammatory, and metabolic consequences of sleep deprivation. Prog Cardiovasc Dis. 2009; 51(4):294–302.
9. Reutrakul S, Zaidi N, Wroblewski K, Kay HH, Ismail M, Ehrmann DA, et al. Sleep disturbances and their relationship to glucose tolerance in pregnancy. Diabetes Care. 2011; 34(11):2454–7.
10. Van Cauter E. Sleep disturbances and insulin resistance. Diabet Med. 2011; 28(12):1455–62.
11. Van Cauter E, Spiegel K, Tasali E, Leproult R. Metabolic consequences of sleep and sleep loss. Sleep Med. 2008; 9(Suppl 1):S23–8.

12. Spiegel K, Tasali E, Penev P, Van Cauter E. Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. Ann Intern Med. 2004; 141(11):846–50.
13. Spiegel K, Leproult R, Van Cauter E. Impact of sleep debt on metabolic and endocrine function. Lancet. 1999; 354(9188):1435–9.
14. Spiegel K, Tasali E, Leproult R, Scherberg N, Van Cauter E. Twenty-four-hour profiles of acylated and total ghrelin: relationship with glucose levels and impact of time of day and sleep. J Clin Endocrinol Metab. 2011; 96(2):486–93.
15. Balbo M, Leproult R, Van Cauter E. Impact of sleep and its disturbances on hypothalamo-pituitaryadrenal axis activity. Int J Endocrinol. 2010; 2010:759234.
16. Knutson KL, Van Cauter E. Associations between sleep loss and increased risk of obesity and diabetes. Ann N Y Acad Sci. 2008; 1129:287–304.
17. Altman NG, Izci-Balserak B, Schopfer E, Jackson N, Rattanaumpawan P, Gehrman PR, et al. Sleep duration versus sleep insufficiency as predictors of cardiometabolic health outcomes. Sleep Med. 2012; 13(10):1261–70.
18. Buxton OM, Marcelli E. Short and long sleep are positively associated with obesity, diabetes, hypertension, and cardiovascular disease among adults in the United States. Soc Sci Med. 2010; 71(5):1027–36.
19. Gangwisch JE, Malaspina D, Babiss LA, Opler MG, Posner K, Shen S, et al. Short sleep duration as a risk factor for hypercholesterolemia: analyses of the National Longitudinal Study of Adolescent Health. Sleep. 2010; 33(7):956–61.
20. Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, et al. Sleep duration as a risk factor for diabetes incidence in a large U.S. sample. Sleep. 2008; 30(12):1667– 73.
21. Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, et al. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. Hypertension. 2006; 47(5):833–9.
22. Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, Buysse D, et al. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. J Clin Sleep Med. 2015; 11(6):591–2.
23. Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, Buysse D, et al. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. Sleep. 2015; 38(6):843–4.
24. Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, Buysse D, et al. Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: methodology and discussion. J Clin Sleep Med. 2015; 11(8):931–52.
25. Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, Buysse D, et al. Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: methodology and discussion. Sleep. 2015; 38(8):1161–83.
26. Hirshkowitz M, Whiton K, Alpert SM, Alessi C, Bruni O, DonCarlos L, et al. National Sleep Foundation's updated sleep duration recommendations: final report. Sleep Health. 2015; 1:233–43.
27. Hirshkowitz M, Whiton K, Alpert SM, Alessi C, Bruni O, DonCarlos L, et al. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. Sleep Health. 2015; 1:40–3.
28. Mukherjee S, Patel SR, Kales SN, Ayas NT, Strohl KP, Gozal D, et al. An official American Thoracic Society statement: the importance of healthy sleep. Recommendations and future priorities. Am J Respir Crit Care Med. 2015; 191(12):1450–8.

29. Liu Y, Wheaton AG, Chapman DP, Cunningham TJ, Lu H, Croft JB. Prevalence of healthy sleep duration among adults—United States, 2014. MMWR Morb Mortal Wkly Rep. 2016; 65(6):137–
30. Krueger PM, Friedman EM. Sleep duration in the United States: a cross-sectional population-based study. Am J Epidemiol. 2009; 169(9):1052–63.
31. Grandner MA, Chakravorty S, Perlis ML, Oliver L, Gurubhagavatula I. Habitual sleep duration associated with self-reported and objectively determined cardiometabolic risk factors. Sleep Med. 2014; 15(1):42–50.
32. Bin YS, Marshall NS, Glozier N. Secular trends in adult sleep duration: a systematic review. Sleep Med Rev. 2012; 16(3):223–30. [PubMed: 22075214]
33. Whinnery J, Jackson N, Rattanaumpawan P, Grandner MA. Short and long sleep duration associated with race/ethnicity, sociodemographics, and socioeconomic position. Sleep. 2014; 37(3):601–11. [PubMed: 24587584]
34. Grandner MA, Williams NJ, Knutson KL, Roberts D, Jean-Louis G. Sleep disparity, race/ ethnicity, and socioeconomic position. Sleep Med. 2016; 18:7–18
35. Knutson KL. Sociodemographic and cultural determinants of sleep deficiency: implications for cardiometabolic disease risk. Soc Sci Med. 2013; 79:7–15.
36. Anothaisintawee T, Reutrakul S, Van Cauter E, Thakkinstian A. Sleep disturbances compared to traditional risk factors for diabetes development: systematic review and meta-analysis. Sleep Med Rev. 2015; 30:11–24.
37. Engeda J, Mezuk B, Ratliff S, Ning Y. Association between duration and quality of sleep and the risk of pre-diabetes: evidence from NHANES. Diabet Med. 2013; 30(6):676–80.
38. Mallon L, Broman JE, Hetta J. High incidence of diabetes in men with sleep complaints or short sleep duration: a 12-year follow-up study of a middle-aged population. Diabetes Care. 2005; 28(11):2762–7.
39. Beihl DA, Liese AD, Haffner SM. Sleep duration as a risk factor for incident type 2 diabetes in a multiethnic cohort. Ann Epidemiol. 2009; 19(5):351–7.
40. Zizi F, Pandey A, Murrray-Bachmann R, Vincent M, McFarlane S, Ogedegbe G, et al. Race/ ethnicity, sleep duration, and diabetes mellitus: analysis of the National Health Interview Survey. Am J Med. 2012; 125(2):162–7.
41. Jackson CL, Redline S, Kawachi I, Hu FB. Association between sleep duration and diabetes in black and white adults. Diabetes Care. 2013; 36(11):3557–65.
42. Lee SW, Ng KY, Chin WK. The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: a systematic review and meta-analysis. Sleep Med Rev. 2016 doi:10.1016/j.smrv. 2016.02.001.
43. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. Obesity (Silver Spring). 2008; 16(3):643–53. [PubMed: 18239586]
44. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. PLoS Med. 2004; 1(3):e62. [PubMed: 15602591]
45. Dashti HS, Scheer FA, Jacques PF, Lamon-Fava S, Ordovas JM. Short sleep duration and dietary intake: epidemiologic evidence, mechanisms, and health implications. Adv Nutr. 2015; 6(6):648–
46. This review provides information regarding connections between sleep and dietary intake. [PubMed: 26567190] 47. Grandner MA. Addressing sleep disturbances: an opportunity to prevent cardiometabolic disease? Int Rev Psychiatry. 2014; 26(2):155–76.
47. St-Onge MP. The role of sleep duration in the regulation of energy balance: effects on energy intakes and expenditure. J Clin Sleep Med. 2013; 9(1):73–80.
48. Morselli LL, Guyon A, Spiegel K. Sleep and metabolic function. Pflugers Arch. 2012; 463(1):139– 60.
49. Broussard JL, Ehrmann DA, Van Cauter E, Tasali E, Brady MJ. Impaired insulin

signaling in human adipocytes after experimental sleep restriction: a randomized, crossover study. Ann Intern Med. 2012; 157(8):549–57.
50. Spiegel K, Leproult R, L'Hermite-Baleriaux M, Copinschi G, Penev PD, Van Cauter E. Leptin levels are dependent on sleep duration: relationships with sympathovagal balance, carbohydrate regulation, cortisol, and thyrotropin. J Clin Endocrinol Metab. 2004; 89(11):5762–71.
51. Copinschi G. Metabolic and endocrine effects of sleep deprivation. Essent Psychopharmacol. 2005; 6(6):341–7.
52. Markwald RR, Melanson EL, Smith MR, Higgins J, Perreault L, Eckel RH, et al. Impact of insufficient sleep on total daily energy expenditure, food intake, and weight gain. Proc Natl Acad Sci U S A. 2013; 110(14):5695–700.
53. St-Onge MP, Roberts AL, Chen J, Kelleman M, O'Keeffe M, RoyChoudhury A, et al. Short sleep duration increases energy intakes but does not change energy expenditure in normal-weight individuals. Am J Clin Nutr. 2011; 94(2):410–6.
54. Reynolds AC, Dorrian J, Liu PY, Van Dongen HP, Wittert GA, Harmer LJ, et al. Impact of five nights of sleep restriction on glucose metabolism, leptin and testosterone in young adult men. PLoS One. 2012; 7(7):e41218.
55. Darukhanavala A, Booth JN 3rd, Bromley L, Whitmore H, Imperial J, Penev PD. Changes in insulin secretion and action in adults with familial risk for type 2 diabetes who curtail their sleep. Diabetes Care. 2011; 34(10):2259–64.
56. Padilha HG, Crispim CA, Zimberg IZ, De-Souza DA, Waterhouse J, Tufik S, et al. A link between sleep loss, glucose metabolism and adipokines. Braz J Med Biol Res. 2011; 44(10):992–9.

Author biography

Anand Shankar Diabetologist, Shankar Diabetes Care Centre, Patna, Bihar, India.