

Chapter 160

Sleep Deprivation — A Modern Epidemic

S RAMNATHAN IYER, REVATI R IYER

INTRODUCTION

Sleep has important homeostatic functions. The maintenance of 'sleep-wake' cycle has an important bearing on the health of the individual. Before the advent of electricity human beings like animals resigned themselves to sleep since their vision was limited by darkness. Scientific progress has eliminated darkness with sports and games being played till late night under flood lights. The 24 x 7 lifestyle has relegated sleep to a secondary level of importance since humans have made a conscious decision to sacrifice sleep for completion of their tasks. Insufficient sleep syndrome, an extrinsic sleep disorder is commonly observed. Sleep deprivation (SD) refers to loss of sleep and this has been used as a major tool in understanding the function of sleep. Sleep deprivation is more than scientific tool since chronic partial sleep deprivation is the most common unrecognized public health problem. SD has wide ranging ill effects on various system of the body resulting considerable morbidity and mortality.

TOTAL SLEEP DEPRIVATION

Over 1,000 studies on sleep deprivation have been published during the past 100 years. Several studies relating to sleep deprivation have been done in animals, but the results are not comparable with humans.

The first published study on total sleep loss demonstrated that prolonged sleep loss in animals can be fatal. In humans the behavioral effects of sleep loss is sleepiness. This can be observed clinically and also demonstrated in the sleep laboratory. The impact of sleep loss is determined by sleep circadian influences, arousal system influences, subject characteristics and test characteristics.

SLEEP CIRCADIAN INFLUENCES

Subjective Characteristics Include

Age, personality, Psychopathology.

Arousal Influences Include

Activity, Bright Light, Noise, Temperature, Posture, Interest, Motivation, Drugs, Repeated Periods of Sleep Loss.

Test Characteristics and Types Include

Length of Test, Knowledge of Results, Test Pacing, Proficiency Level, Difficulty or Complexity of Test, Short Term memory requirement, Subjective vs. Objective Measures, EEG Measures (MSLT).

The impact of sleep loss is reflected easily on tasks which are long, monotonous without feedback, externally paced, newly learned and have a memory component. Driving a vehicle is the commonly cited example. Marcus, et al¹ demonstrated that 49% of medical residents who worked on call and averaged 2.7 hours of sleep reported falling asleep at the wheel. 90% episodes were post call. The residents also had 67% more citations for moving violations and 82% more car accidents than control group. Cassel, et al² reported that patients with sleepiness secondary to sleep apnea had more accidents both on the road and in simulators and their driving performance improved after continuous positive airway pressure treatment.

PHYSIOLOGICAL EFFECTS OF SLEEP DEPRIVATION

1. **Neurological:** Mild nystagmus intermittent slurring of speech, hand tremor, ptosis has been noted in subjects with extended sleep loss (> 205 hours)³

Sluggish corneal reflexes, hyperactive gag reflex, hyperactive tendon reflexes and increased sensitivity to pain has also been reported⁴. All these changes were reversed after recovery of sleep. It is interesting to note that sleep loss has repeatedly shown to be highly activating stress in individuals suffering from seizure disorders. Sleep deprivation increases cortical excitability in epilepsy⁵.

2. **Autonomic changes:** They are usually minor even during prolonged periods of sleep loss. Changes have been reported in blood pressure, heart rate, respiration rate and finger pulse volume⁶. SD has been associated with small decreases in forced expiratory volume in 1 second (FEV₁) and forced vital capacity in patients with pulmonary disease⁷. Sleep loss results in more apneic events and longer apneic events⁸.
3. **Biochemical changes:** There are no major changes. Hormones such as noradrenaline, prolactin and growth hormone which are dependent on sleep for their circadian rhythmicity or appearance lose their periodic pattern of excretion during sleep loss^{9,10}. Studies have reported rebounds in growth hormone during recovery sleep following sleep loss or Slow Wave Sleep (SWS) deprivation¹¹.
4. **Immune functions:** Studies indicate that sleep deprivation has adverse effect on the immune function. Irwin, et al¹² observed that partial or short term total sleep deprivation resulted in decreases in natural killer cell activity (upto 50%) or numbers.

PARTIAL SLEEP DEPRIVATION

Partial sleep deprivation refers to nonsleep stage specific reduction in total sleep. This is the most common form of sleep deprivation seen in modern world. Partial sleep deprivation can be acute or chronic.

The acute partial sleep deprivation studies suggest that all stages of sleep except slow wave sleep are reduced during sleep restriction¹³. When the sleep restrictions continue beyond a single night, which is a common in today's modern life style, cumulative effects may be seen depending upon the sleep quota each night. Such sleep restrictions is reflected by shifting of SWS to beginning of sleep period, the REM being reduced by 25% and the REM latencies being reduced by 10–30 minutes. Carskadon and Dement¹⁴ restricted sleep to 5 hours per night for 7 consecutive nights and observed that MSLT scores were significantly reduced after second restriction night and continued a declining trend from baseline values of 17 minutes (after sleep satiation) to about 7 minutes after the last night of sleep reduction.

CLINICAL IMPLICATIONS

Subjects deprived of sleep for several days or more become irritable, fatigued, unable to concentrate and usually disoriented. Partial sleep loss affects functional impairment and this will appear rapidly when the nocturnal sleep periods is 5 hours or less. For most people accumulating huge sleep debt appears to have happened so gradually that they blame their physical tiredness to stress, growing older, depression and changing metabolism.

It should be noted that insomniacs do not generally suffer from chronic partial sleep deprivation. The usual causes of sleep deprivation are:

1. Not allowing enough time for sleep.
2. Sleep disorders.
3. Excessive worry, depression.
4. Repeated awakenings from noise. e.g. door bell ringing often in early hours by morning newspaper vendor, milkman etc.
5. Working at night.
6. Travel across time zones.
7. Disorders like, backaches, cardiac failure, asthma causing sleep disturbances.

Sleep deprived subjects have tendency to overeat. Daytime sleepiness may be prevented by drinking water/tea/coffee/juices, eating food, chewing tobacco, smoking cigarettes and sometimes by self-pinching particularly during important meetings. Chronic sleep restriction coupled with eating contributes separately to the development of obesity. Chronic partial sleep deprivation is seen in many important groups including doctors, soldiers, shift workers, mothers particularly nursing mothers, cross country truck drivers and taxi drivers. It is important to appreciate that individual differ in their biological sleep need. When subjects fail to fulfill their biological sleep needs¹⁵ increasing consequences vis a vis their wake time activities are likely to become apparent. Limited duration in sleep is reflected in higher risk for cumulative waking neuro behavioral deficits. However, the factors that determine the timing of development of symptoms of excessive daytime sleepiness among populations affected with chronic insufficient sleep is not well understood. The negative effects of acute and/or chronic sleep deprivation are likely to become more apparent during long boring tasks, e.g. driving and operating machinery. Sleep related vehicle accidents are common in today's society. These accidents can be fatal or cause serious injuries. In fact there is evidence suggesting that over 30% of fatal to the driver of commercial truck crashes and highway accidents may be attributed to driver

falling asleep at the wheel. The peak incidence of vehicular accidents is early to mid afternoon and very early morning. A sleepy driver with minimum alcohol levels is more dangerous than a alert driver with high blood alcohol levels. The best advice to drivers would be to stop driving and give the steering to somebody else. A nap may be taken to ensure freshness. Alternatives would be of use if caffeine and tea and talk to fellow boy in driver cabin.

The prevalence of chronic sleep deprivation has increased. 30% of adults reported less sleeping than 7 hours per night in 2002¹⁶. Chronically reduced sleep times are associated with obesity¹⁷. Sleep deprivation induces or aggravates snoring by increasing muscular hypotonia and delaying contractions of the dilator muscles of the pharynx¹⁸. Snoring and excessive daytime sleepiness are prominent symptoms of obstructive sleep apnea (OSA). Sleep apnea and obesity are closely associated¹⁹. Recently, Vgontzas in a theoretical review has suggested that sleep apnea is a manifestation of metabolic syndrome²⁰. Subjects residing far from place of work are often forced to cut down sleeping times to complete long hours of travel. This chronic sleep restriction can ultimately result in the development of metabolic syndrome.

SELECTIVE SLEEP DEPRIVATION

Selective REM sleep deprivation is known to affect memory consolidation adversely. REM sleep deprivation may cause anxiety, over eating and hypersexuality²¹. Antidepressant medications except trimipramine are known to cause REM sleep suppression. REM sleep deprivation is helpful in patients suffering from depression.

To answer the question whether selective sleep stage deprivation is reflected in daytime performance, several studies were conducted. Based on these studies *Johnson et al*²² concluded that specific stage amounts were not related to daytime waking behavior in normal young adults. Many behavioral and electrophysiological studies in animals and humans have suggested that sleep and circadian rhythms influence memory consolidation²³.

SLEEP FRAGMENTATION

It refers to interruption of the normal continuity of sleep. There is experimental evidence to show that actual arousal from sleep is the critical factor producing daytime consequences. Evidence of sleep fragmentation can be appreciated in the increased number of shifts from other sleep stages to stage I NREM and increased percentage of stage I sleep.

Sleep fragmentation is a feature of sleep disordered breathing (SDB). Patients with SDB experience excessive

daytime sleepiness as result of several arousals in sleep. Cyclical hypoxemia in sleep in patients of OSA has several systemic effects so much so that OSA is now labelled as a systemic disease. Sleep deprivation due to life style changes and sleep fragmentation due to OSA may be combined in the same patient. Such patients when travel across time zones can experience sleep problems out of proportion of jet lag symptoms. Cardiovascular patients are at particular risk in these situations.

SLEEP DEPRIVATION AND CARDIOVASCULAR EVENTS

Chronic sleep deprivation is associated with cardiovascular events by more than one mechanism. Irwin et al²⁴ has recently concluded that sleep loss induces a functional alteration of the monocyte pro-inflammatory cytokine response. A modest amount of sleep loss also alters molecular processes that drive cellular immune activation and induce inflammatory cytokines; mapping the dynamics of sleep loss on molecular signaling pathways has implications for understanding the role of sleep in altering immune cell physiologic characteristics. Intervention that target sleep might constitute new strategies to constrain inflammation with effects on inflammatory disease risk.

Chronic sleep deprivation causes an autonomic imbalance and decreases intracellular magnesium which could be associated with chronic sleep deprivation induced cardiovascular events²⁵.

Chronic sleep deprivation in young healthy volunteers has been reported to increase levels of proinflammatory cytokines decrease parasympathetic and increase sympathetic tone, increase blood pressure, increases cortisol levels as well as elevate insulin and blood glucose levels²⁶.

SLEEP DEPRIVATION AND AGEING

Sleep deprivation has multiple effects on endocrine and metabolic functions²⁷. In particular, sleep restriction is accompanied by increased cortisol levels in the afternoon and early evening and a shorter of quiescent period compared with extended sleep periods. These alteration could facilitate central and peripheral disturbances that are aggravated with glucocorticoid excess such as memory deficits and are similar to those observed in ageing. This chronic sleep loss could contribute to aging process. Chronic sleep deprivation may increase the risk of diabetes.

SLEEP DISORDERED BREATHING AND PREGNANCY

Increased waist hip ratio is a symptom of chronic hypothalamic arousal. Hypothalamopituitary Axis may

be aroused even in utero. It is interesting to note the sleep disordered breathing in pregnant women may have adverse effects on both mother and foetus (pregnancy induced hypertension and small gestational age birth)²⁸.

RECOVERY SLEEP

Only sleep can reverse the effects of sleep deprivation but an equal amount of sleep is not required to recover from the lost sleep. This is because that core sleep (part of normal night of sleep) is essential and that the remaining sleep exists as a buffer²⁹. Core sleep refers to slow wave sleep with REM or a sleep not fragmented by arousals or awakenings.

MANAGEMENT

Sleep deprivation is to be treated by practising sleep hygiene. Patients who do not respond to these need to be evaluated for their sleep both clinically and in the sleep laboratory. OSA can be precipitated by chronic sleep deprivation and therefore it must be screened in all chronically deprived subjects. Also such subjects must be screened for cardiovascular disorders, viz. hypertension, ischemic heart disease and diabetes mellitus. There is complex interplay of sleep disorders with psychiatric disorders and therefore sleep complaints need to be dissected and treated for rewarding results.

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