3rd National Conference on Enhancement in Biomedical Engineering and Healthcare
Organised by Department of Biomedical Engineering,
Adhiyamaan College of Engineering, Hosur, Tamil Nadu, India

A Study in Sleep Disorders Classification and Comprehensive Analysis

Dr. Anitha S[1], Hemanth Kumar G[1], Annapurna C M[3], Ananya M Rao[4]

[1]Professor Department of Biomedical Engineering ACSCE Bangalore, Karnataka, India
[2]Assistant Professor Department of Biomedical Engineering ACSCE Bangalore, Karnataka, India
[3,4]Student Department of Biomedical Engineering ACSCE Bangalore, Karnataka, India

ABSTRACT

Sleep is a vital, often neglected, component of every person's overall health and well-being. Sleep is important because it enables the body to repair and be fit and ready for another day. It is reported that in India 30% suffer from occasional insomnia and according to a study conducted by a consumer products giant,nearly 93% of Indians are sleep deprived. Sleep, that familiar yet inexplicable condition of repose in which consciousness is in abeyance, is obviously not abnormal, yet it is most appropriately considered in connection with abnormal phenomena because there are a number of interesting and common irregularities of sleep, some of which approach serious extremes. In this paper we have discussed about the classification of sleep disorders, methods of diagnosis and treatment and discussed the technologies used to the treat sleep disorders and their types. Technologies developed for the treatment of sleep disorders such as Continuous positive airway pressure (CPAP), hypoglossal nerve stimulator, sleep apps, wearable s and fitness trackers and many other as discussed in the paper.

Keywords : Sleep Disorders, Classification, Sleep Detection Methods, CPAP, Polysomnography.

I. INTRODUCTION

Sleep is a naturally recurring state of mind and body, characterized by altered consciousness, relatively inhibited sensory activity, reduced muscle activity and inhibition of nearly all voluntary muscles during rapid eye movement (REM) sleep, and reduced interactions with surroundings. It is distinguished from wakefulness by a decreased ability to react to stimuli, but more reactive than a coma or disorders of consciousness, with sleep displaying very different and active brain patterns. Sleep, as everyone knows, is an elemental phenomenon of life and an indispensable phase of human existence. It represents one of the basic 24-h (circadian) rhythms, traceable through all mammalian, avian, and reptilian species. The neural control of circadian rhythms is thought to reside in the ventral-anterior region of the hypothalamus—more specifically, in the suprachiasmatic nuclei. Lesions in these nuclei result in a disorganization of the sleep-wake cycles as well as of the rest-activity, temperature, and feeding rhythms.

There are several factors considered in analyzing the sleep i.e., external factors such as lighting, sleep environment, jetlag, shift - based work, medication and internal factors such as anxiety, stress, body pains and many other factors in our daily life. There are a number of factors that could be negatively affecting your sleep like caffeine, sleeping pills, marijuana, special diet and other food intakes too.

There are two types of sleep that generally occur in a pattern of three-to-five cycles per night:

- Rapid eye movement (REM) – when most dreaming occurs
- Non-REM – has three phases, including the deepest sleep

The quality of our sleep directly affects our mental and physical health and the quality of our waking life, including our productivity, emotional balance, brain and heart health, immune system, creativity, vitality, and even our weight. No other activity delivers so many benefits with so little effort. There is a big difference between the amount of sleep we can get by on and the amount we need to function optimally. According to the National Institutes of Health, the average adult sleeps less than seven hours per night. In today's fast-paced society, six or seven hours of sleep may sound pretty good. In reality, though, it's a recipe for chronic sleep deprivation.While sleep requirements vary slightly from person to person, most healthy adults need between 7 to 9 hours of sleep per night to function at their best. Children and teens need even more. And despite the notion that our sleep needs decrease with age, most older people still need at least 7 hours of sleep.

II. SLEEP DISORDERS

Sleep disorders include problems mainly with the quality, timing and amount of sleep, which cause problems with functioning and distress during the daytime. Sleep disorders are linked to both physical, mental and emotional problems. Sleep problems can both contribute to or accelerate mental health conditions and can become the reasons for several other persisting health conditions.

Sleep disorders are classified into eight major categories :

1. Insomnias
2. Sleep-related breathing disorders
3. Hypersomnias of central origin
4. Circardian rhythm sleep disorders
5. Parasomnias
6. Sleep-related movement disorders
7. Isolated symptoms, apparently normal variants and unresolved issues
8. Other sleep disorders

1. INSOMNIAS

The term insomnia signifies a chronic inability to sleep despite adequate opportunity to do so; it is used popularly to indicate any impairment in the duration, depth, or restorative properties of sleep.

Two general classes of insomnia can be recognized
- Primary: one in which there appears to be a primary abnormality of the normal sleep mechanism and Secondary: in which the sleep disturbance is secondary to a medical or psychologic disorder.

Diagnosis : Depending on the situation of the patient, the diagnosis of insomnia and the search for its cause includes :

→ Physical exam - If the cause of insomnia is unknown, a physical test is done to look for science and symptoms indicating insomnia.

→ Sleep Habits review - The doctors ask sleep related questions and the patient maybe asked to fill a questionnaire to determine the sleep-wake pattern.

→ Sleep Study - Tests are done to monitor and record a variety of body activities when the patient is asleep including brain waves, breathing, heartbeat, eye movements and body movements.

Treatment : Changing sleep habits and addressing issues such as stress, medical conditions etc., which maybe associated with insomnia, normal sleep can be restored in many people.

→ Stimulus Control Therapy
→ Relaxation Techniques
→ Sleep Restriction
→ Remaining Passively Awake
→ Light Therapy

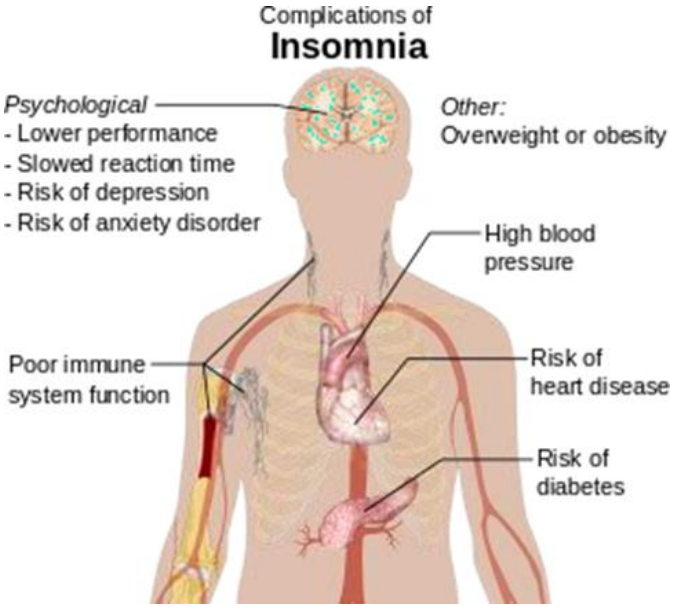

Fig 1 : Complications of insomnia

2. SLEEP-RELATED BREATHING DISORDERS

They are characterized by abnormal respiration during sleep. They are grouped into primary central apnoea, central Apnoea due to Cheyne Stokes Breathing, Central Apnoea due to High Altitude Periodic Breathing, Central Apnoea due to Medical Condition not Cheyne Stokes, Central Apnoea due to Drug or Substance, Obstructive Sleep Apnoea Sleep Related Hypo ventilation/Hypoxemic Syndromes, Sleep Related Hypo ventilation/Hypoxemia due to Medical Condition, Due to pulmonary parenchymal or vascular pathology, Due to lower airways obstruction, Due to neuromuscular & chest wall disorders, Other Sleep Related Breathing Disorders, Sleep apnoea/Sleep related breathing disorder, unspecified.In-laboratory attended diagnostic polysomnography or portable home sleep testing can be used to diagnose sleep apnoea. Continuous positive airway pressure (CPAP) therapy is the first-line treatment for OSA in adults.

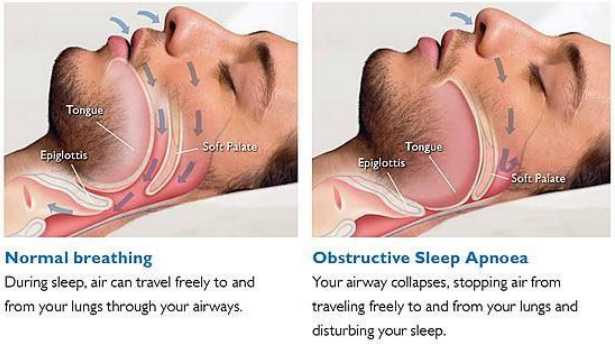

Fig 2 : Comparison of airways in normal breathing and sleep apnoea

3. HYPERSOMNIAS OF CENTRAL ORIGIN

Hypersomnia is a frequently encountered symptom in clinical practice. The cardinal manifestation is inappropriate daytime sleepiness, common to all types of hypersomnias. Hypersomnias of central origin are a rare cause of excessive daytime sleepiness, much rarer than the Hypersomnia related to other pathologies, such as sleep-disordered breathing.

4. CIRCARDIAN RHYTHM SLEEP DISORDERS

CRSDs are caused by alterations of the central circadian time-keeping system, or a misalignment of the endogenous circadian rhythm and the external environment.Either disruption of the endogenous circadian control mechanism or misalignment between internal circadian rhythms with the 24-hour outside environment would result in circadian rhythm disorders with adverse consequences in sleep and many other aspects of human health, including metabolism dysfunction, cognitive impairment, cardiovascular abnormalities, gastrointestinal and genitourinary dysfunctions.

The diagnosis of CRSD is based on a detailed history of the patient's sleep and wake pattern, and diagnostic tools, such as a sleep diary and actigraphy. In addition, assessment of the timing of physiological circadian rhythm markers, such as core temperature and melatonin are useful diagnostic tools that can be used to confirm the diagnosis.

5. HYPERSOMNIAS OF CENTRAL ORIGIN

Hypersomnia is a frequently encountered symptom in clinical practice. The cardinal manifestation is inappropriate daytime sleepiness, common to all types of hypersomnias. Hypersomnias of central origin are a rare cause of excessive daytime sleepiness, much rarer than the Hypersomnia related to other pathologies, such as sleep-disordered breathing.

6. CIRCARDIAN RHYTHM SLEEP DISORDERS

CRSDs are caused by alterations of the central circadian time-keeping system, or a misalignment of the endogenous circadian rhythm and the external environment.Either disruption of the endogenous circadian control mechanism or misalignment between internal circadian rhythms with the 24-hour outside environment would result in circadian rhythm disorders with adverse consequences in sleep and many other aspects of human health, including metabolism dysfunction, cognitive impairment, cardiovascular abnormalities, gastrointestinal and genitourinary dysfunctions.

The diagnosis of CRSD is based on a detailed history of the patient's sleep and wake pattern, and diagnostic tools, such as a sleep diary and actigraphy. In addition, assessment of the timing of physiological circadian rhythm markers, such as core temperature and melatonin are useful diagnostic tools that can be used to confirm the diagnosis.

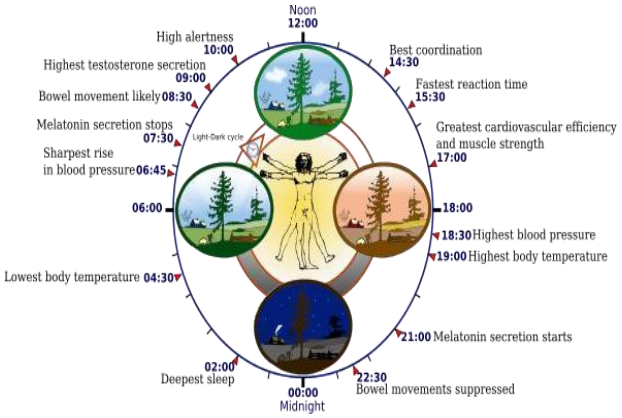

Fig 3 : Circardian rhythm cycle

PARASOMNIAS

Sleepwalking, sleep terrors, sleep talking and sleep paralysis are some of the behavioral manifestations from sleep known as Parasomnias — a group of sleep disorders defined as undesirable physical events or experiences that occur during the initiation of sleep, during sleep or during arousal from sleep. Although more common in children, parasomnias can occur at any age. All parasomnias occur from sleep, and NREM parasomnias usually occur among individuals aged 5–25 years with a family history of similar parasomnias and involve physical and verbal activity of varying complexity.

SLEEP - RELATED MOVEMENT DISORDERS

Several movement disorders may occur during nocturnal rest disrupting sleep. A part of these complaints is characterized by relatively simple, non-purposeful and usually stereotyped movements. Patients reporting poor sleep due to these abnormal movements should undergo non-pharmacological or pharmacological treatments.

7. ISOLATED SYMPTOMS, APPARENTLY ALL VARIANTS AND UNRESOLVED ISSUES

Long sleeper is a person who sleeps more in the 24-h day than the typical person. Sleep is normal in

architecture and quality. Usually, sleep lengths of 10 h or greater qualify for this diagnosis. Symptoms of excessive sleepiness occur if the person does not get that amount of sleep. A short sleeper is a person with a routine pattern of obtaining 5 h or less of sleep in a 24-h day. Sleep talking can be either idiopathic or associated with other disorders, such as REM sleep behavior disorder or sleep-related eating disorder.

8. OTHER SLEEP DISORDERS

Other organic disorders are frequently encountered in the differential diagnosis of sleep disorders, psychiatric/behavioral disorders frequently encountered in the differential diagnosis of sleep disorders.

III. METHODS OF ASSESSMENT OF SLEEP

Current sleep assessment methods have been classified according to different criteria:

i) Medical Assistance:polysomnography, actigraphy etc
ii) Self-Assessment:sleep questionnaires, diaries etc

Medical Assistance

1. Polysomnograghy:

Polysomnography, also called a sleep study, is a test used to diagnose sleep disorders. Polysomnography monitors your sleep stages and cycles to identify if or when your sleep patterns are disrupted and why. The doctor recommends polysomnography if he suspects the patient has :

→ Sleep apnoea or another sleep-related breathing disorders
→ Periodic limb movement disorder
→ Narcolepsy
→ REM Sleep behavior disorder
→ Unusual behavior during sleep
→ Unexplained Chronic Insomnia

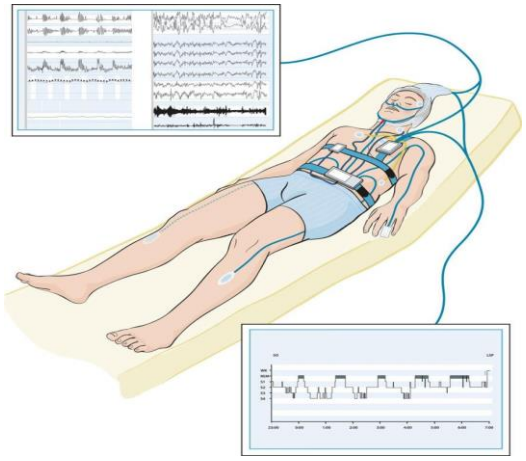

Fig 4 : Polysomnography

2. Multiple Sleep Latency Test:

The multiple sleep latency test (MSLT) tests for excessive daytime sleepiness by measuring how quickly you fall asleep in a quiet environment during the day. Also known as a daytime nap study, the MSLT is the standard tool used to diagnose narcolepsy and idiopathic Hypersomnia.The MSLT is a full-day test that consists of five scheduled naps separated by two-hour breaks. During each nap trial, patient will lie quietly in bed and try to go to sleep. Once the lights go off, the test will measure how long it takes for the patient to fall asleep. Patient will be awakened after sleeping 15 minutes. If the patient do not fall asleep within 20 minutes, the nap trial will end. Each nap will be taken in a dark and quiet sleep environment that is intended for patient's comfort and to isolate any external factors that may affect patient ability to fall asleep. A series of sensors will measure whether the patient is asleep. The sensors also determine patient sleep stage.

3. Maintenance of Wake fullness test:

The Maintenance of Wakefulness Test (MWT) is used to measure how alert you are during the day. It shows whether or not the patient is able to stay awake for a defined period of time. This is an indicator of how well the patient able to function and remain alert in quiet times of inactivity. The test is based on the idea that the patient ability to stay awake may be more important to know in some cases than how fast the patient fall asleep. This is the case when the MWT is used to see how well a sleep disorders patient is able to stay awake after. The MWT is used to see if someone with a sleep disorder is responding well to treatment. Results of multiple tests may be compared over a period of time. This can show if treatment is helping a patient overcome sleepiness. The MWT may be used to evaluate how well a person with a sleep disorder is able to stay awake. This is critical when the person's job involves public transportation or safety. The results of the test will be only one factor used to assess the potential risk of a work-related accident.

4. CPAP Titration Test:

A CPAP titration study is a type of in-lab sleep study used to calibrate continuous positive airway pressure (CPAP) therapy. CPAP is a common treatment used to manage sleep-related breathing disorders including obstructive sleep apnea, central sleep apnoea and hypo ventilation and hypoxaemia. Once the patient is diagnosed with one of these disorders, patient may need a CPAP study before beginning of treatment.In some cases, members of the sleep team may perform a CPAP titration study on the same night as an in-lab sleep study. This is known as a split-night sleep study. The CPAP titration occurs in the second half of the night. This is usually only offered if the sleep apnoea is severe and the diagnosis is clear.

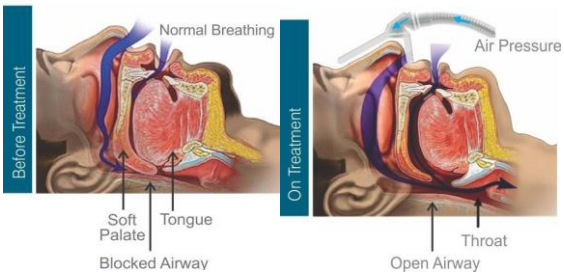

Fig 5 : CPAP Titration before and during treatment

Self - Assessment

1. Questionnaires

The questionnaire is a screening tool for physicians to assist their clinical evaluation of insomnias. It can be used to screen for a sleep disorder.

2. Sleep Diaries

A sleep diary is a record of a patient's sleep patterns and habits that can be extremely useful in helping doctors make a diagnosis of a sleep disorder and better determine if a sleep study should be prescribed. A sleep diary can serve the purpose of giving the patient a better of their sleep patterns and habits and can help maintain good sleep hygiene. This method also helps the patient monitor the effectiveness of his treatment.

3. Hardware Devices

i) Contact Devices: The sleep detection method which involves using wearables like wrist watches, head bands, ankle band and chest band.

Examples are: Fitbit ionic, Viatom O2, Misfit shine and many other.

Fig 6 : Viatom O2

ii) Non-Contact Devices: The sleep detection method which involves using devices like microphone, video

camera, echo based devices etc. Examples: SleepScoreMax, Sensors under the mattresses, beddit and many other.

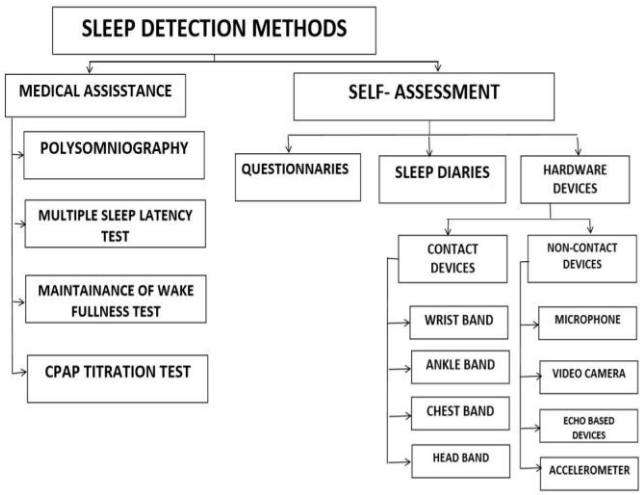

Fig 7 : Flowchart representation of sleep detection methods

IV. CONCLUSION

Various sleep disorders are prevalent in our society due to a wide range of life style practices, genetic conditions or trauma. These conditions may be a primary or a secondary factor in accelerating or persisting the presence of other diseases. Several studies have been conducted and many new methods like polysomnography are being used to diagnose, treat sleep disorders. Many contact and non-contact devices have been developed to monitor and assess sleep patterns by the patient himself with the help of this.

V. REFERENCES

[1]. "Adams and Victor's Principles of Neurology" , Allan . H . Ropper and Robert H . Brown, 8th edition, McGraw-Hill, 2005.

[2]. ASA (2017) American Sleep Association (ASA) Sleep devices. 2017. https://www.sleepassociation.org/sleep-products/sleep-devices/ https://www.sleepassociation.org/ sleep-products/sleep-devices/

[3]. AASM. The International Classification of Sleep Disorders: Diagnostic and Coding Manual. second edn. AASM; 2005.

[4]. Abeyratne U, Patabandi C, Puvanendran K. Pitch-jitter analysis of snoring sounds for the diagnosis of sleep apnea. Engineering in Medicine and Biology Society, 2001; Proceedings of the 23rd Annual International Conference of the IEEE; IEEE; 2001. pp. 2072–2075.

[5]. Abeyratne UR, Karunajeewa AS, Hukins C. Mixed-phase modeling in snore sound analysis. Med Biol Eng Comput. 2007;45(8):791–806.

[6]. Abeyratne UR, Wakwella AS, Hukins C. Pitch jump probability measures for the analysis of snoring sounds in apnea. Physiol Meas. 2005;26(5):779–798.

[7]. Ahmadi N, Chung S, Gibbs A, Shapiro C. The berlin questionnaire for sleep apnea in a sleep clinic population: relationship to polysomnographic measurement of respiratory disturbance. Sleep Breath. 2008;12(1):39–45.

[8]. Ahmed B, Redissi A, Tafreshi R. An automatic sleep spindle detector based on wavelets and the teager energy operator. Engineering in Medicine and Biology Society, 2009. EMBC 2009; Annual International Conference of the IEEE; IEEE;

[9]. Aldrich MS. Automobile accidents in patients with sleep disorders. Sleep. 1989;12(6):487–494.

[10]. Allen J. Photoplethysmography and its application in clinical physiological measurement. Physiol Meas. 2007;28(3):R1–R39.

[11]. Ancoli-Israel S, Cole R, Alessi C, Chambers M, Moorcroft W, Pollak CP. The role of actigraphy in the study of sleep and circadian rhythms. Sleep. 2003;26(3):342–392.

[12]. Antic NA, Buchan C, Esterman A, Hensley M, Naughton MT, Rowland S, Williamson B, Windler S, Eckermann S, McEvoy RD. A randomized controlled trial of nurse-led care for symptomatic moderate-severe obstructive sleep apnea. Am J Resp Crit Care. 2009;179(6):501–508.

[13]. Banno K, Kryger M. Use of polysomnography with synchronized digital video recording to diagnose pediatric sleep breathing disorders. Cab Med Assoc J. 2005;173(1):28–30.

[14]. Bixler EO, Kales A, Soldatos C, Kales J, Healey S. Prevalence of sleep disorders in the Los Angeles metropolitan area. Am J Psychiat. 1979;136(10):1257–1262.

[15]. Banks et al. (2004) Banks S, Barnes M, Tarquinio N, Pierce RJ, Lack LC, McEvoy RD. The maintenance of wakefulness test in normal healthy subjects. Sleep. 2004;27(4):799–802.

[16]. Armon et al. (2016) Armon C, Johnson KG, Roy A, Nowack WJ. Polysomnography. 2016. Medscape. https://emedicine.medscape.com/article/1188764-overview .

[17]. Blackwell et al. (2008) Blackwell T, Redline S, Ancoli-Israel S, Schneider JL, Surovec S, Johnson NL, Cauley JA, Stone KL. Comparison of sleep parameters from actigraphy and polysomnography in older women: the SOF study. Sleep. 2008;31(2):283–291. doi: 10.1093/sleep/31.2.283.

[18]. Bobes et al. (1998) Bobes J, González MP, Vallejo J, Sáiz J, Gibert J, Ayuso JL, Rico F. Oviedo sleep questionnaire (OSQ): a new semistructured interview for sleep disorders. European Neuropsychopharmacology. 1998;8(2):S162. doi: 10.1016/S0924-977X(98)80198-3.

[19]. Carney et al. (2012) Carney CE, Buysse DJ, Ancoli-Israel S, Edinger JD, Krystal AD, Lichstein KL, Morin CM. The consensus sleep diary: standardizing prospective sleep self-monitoring. Sleep. 2012;35(2):287–302. doi: 10.5665/sleep.1642.

[20]. Cruz, Littner & Zeidler (2014) Cruz SD, Littner MR, Zeidler MR. Home sleep testing for the diagnosis of obstructive sleep apnea-indications and limitations. Seminars in Respiratory and Critical Care Medicine. 2014;35(5):552–559. doi: 10.1055/s-0034-1390066.

Cite this article as :

Dr. Anitha S, Hemanth Kumar G, Annapurna C M, Ananya M Rao, "A Study in Sleep Disorders Classification and Comprehensive Analysis", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 5 Issue 5, pp. 38-45, March-April 2020.
Journal URL : http://ijsrst.com/EBHAC030