



EVALUATION OF NON-INVASIVE SMARTPHONE BASED DIGITAL BIOMARKER TOOL LYFAS® IN DETECTING SLEEP DEFICIENCY AND ITS EFFECTS: A RETROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT **Aim:** present study was planned to evaluate Lyfas capability to detect sleep deficiency and psychological and physiological effects of sleep deficiency. **Materials and methods:** A retrospective observational study was conducted in patients who have undergone smart phone based screening tool which is a Non-invasive digital biomarker ie Lyfas. This study included 68 patients aged 18 years or older from both genders who had taken Lyfas tests in 2 months study period (Nov 2020 to Dec 2020) and Lyfas detected sleep deficiency in the test and further in the online consultation patient confirmed whether they are having sleep deficiency or not. Also physiological and psychological effects of sleep deficiency on human body were also evaluated. **Results:** Of the 68 patients, 50 were male and 18 were female. Out of 68 patients in which Lyfas had detected sleep deficiency, majority of the patients (n=52, 76 %) had confirmed sleep deficiency during subsequent online consultation. **Conclusion:** Results of our study shows that Lyfas can be used to detect sleep deficiency and its ill effects in general population.

KEYWORDS : Lyfas, Sleep Deficiency, Smartphone Based Digital Biomarker Tool

INTRODUCTION:

Sleep is an altered state of consciousness in which brain gives up its some functioning for some time and the individual went into a state where sensitivity to environment decreases¹. Mostly people spend one – third of their life in sleep. Sleep is vital to human physiological, cognitive, and behavioural functions as well as long term health^{2,3,4,5,6}. It is a recurrent state of bodily rest and reduced consciousness that serves multiple functions, which is associated to the circadian system⁷. Lack of sleep is a major issue in society today, causing many people to suffer from health problems related to sleep deficiency⁸. Also, many people are concerned about changes in their outward appearance due to lack of sleep¹⁰.

Distressed sleep comprises helplessness in went to sleep, the incapability to go back to sleep, and recurrent awakening while sleeping, people experiencing sleep disturbances has many observable symptoms like, difficulty initiating sleep at bed time, frequent awakening throughout night, daytime distress, involuntary day time sleep, decline in motor dexterity, inappropriate behaviour, memory deficits, head bobbing, jaw dropping, snoring, disturbance in breathing, heart failure, renal failure, difficulty waking in the morning, feeling panic, crying, fear, anxiety, negative emotions, jumping, flying out of bed, creeping, crawling, itching, and toxin exposure.¹¹

Risk factors for sleep disruption are vast. Lifestyle factors include consuming excessive amounts of caffeine¹² and drinking alcohol.¹³ Performing shift work¹⁴ is also a risk factor for sleep disruption. Exposure to excessive night-time light pollution and underexposure to daytime sunlight can lead to disruption of circadian rhythms.¹⁵ Stressful life circumstances, such as being the parent of a young infant¹⁶ or serving as a caregiver for a family member with a chronic, life-threatening, or terminal illness,¹⁷ are also contributors to sleep problems.

Psychological well-being is a condition of mental health in which individual comprises a number of capabilities like self-knowing, self-sufficiency, ecological expertise, relationships with others, meaning in life. Sleep disturbance lead toward physical and psychological distress. Research suggests that the relationship between sleep and mental health is complex. sleep problems can lead to changes in mental health, but mental health conditions can also worsen problems with sleep¹⁸. Sleep problems can also be a symptom of depression, but more recently, research has implicated lack of sleep in actually causing depression. One analysis of 21 different studies found that people who experience sleep problems have a two-fold risk of developing depression over those who do not have problems sleeping.¹⁹ Healthy people can experience negative mental health effects of poor sleep. Acute sleep deprivation can lead to an increase in anxiety and distress levels in healthy adults.²⁰ Study suggested that changes in the normal sleep/wake cycle preceded the onset of a manic episode in 25% to 65% of participants.²¹

results in hair loss.²² One study demonstrated the relationship between stress levels and hair growth. The release of neurohormones, neurotransmitters, and cytokines related to excess stress level affects the hair growth cycle²³. Previous reports suggest that poor sleep could affect the skin condition. People generally come up with some noticeable skin attributes as symptoms of sleep deficiency including rough, dull, and dry skin as well as droopy eyelids and dark eye circles.²⁴ Study suggested that a lack of sleep is linked to more painful headaches.^{25,26} A study found that people with insomnia and other sleeping issues appear to be more sensitive to pain than those who don't experience these issues.²⁷ Heartburn and gastroesophageal reflux disease, or GERD, are frequent causes of sleeplessness. In a study, patients with worse GERD symptoms report poorer subject sleep quality.²⁸ Sleep deficiency impairs attention, working memory, long term memory and decision making.²⁹

Lyfas is a non-invasive, smart phone based, digital biomarker tool which is developed for capturing psychological, cardiovascular, cardiometabolic, cerebrovascular, neuroendocrine, neuro immunological functional biomarkers. These functional biomarkers are indicative of physiological, pathological and psychological state of an individual useful in predicting and monitoring health and disease status.

Lyfas tool is based on the principles of photo-plethysmography (PPG) and photochromatography (PCG). PPG measure blood volume changes in the microvasculature and PCG measures the reflected light of various blood components. This is carried out from an optical sensor (camera and the flashlight of a smartphone) acting as an input layer. A signal processing layer, our proprietary mathematical modelling and an algorithm, converts the input signal into actionable metrics which constitute the functional biomarker parameters. These parameters were then validated in clinical settings to reflect psychological, cardiovascular mechanics, hemodynamics, hemorheology, heart rate variability^{30,31,32}, indicative hematology and biochemistry in an individual.

Sleep is one of the 101 digital biomarkers in Lyfas and When this marker appears in the report of the patient it suggests that the individual is having sleep deficiency. During subsequent online clinical consultation, clinician in the history taking evaluates for sleep deficiency and its ill effects and confirms it. In view of this this present study was planned to evaluate Lyfas capability to detect sleep deficiency and psychological and physiological effects of sleep deficiency.

Materials and Methods:

Primary objective:

- Lyfas can detect sleep deficiency accurately (by comparing clinicians' observation with that of Lyfas)

Secondary objectives:

- Lyfas is capable of detecting physiological effect of sleep

Poor sleep and improper circadian cycle raise the cortisol level that

deficiency

- Lyfas is capable of detecting psychological effect of sleep deficiency

Study Participants

A retrospective observational study was conducted in patients who have undergone smart phone-based screening tool which is a Non-invasive digital biomarker ie Lyfas. This study included 68 patients aged 18 years or older from both genders who had taken Lyfas tests in 2 months study period (Nov 2020 to Dec 2020) and Lyfas detected sleep deficiency in the test and further in the online consultation patient confirmed whether they are having sleep deficiency or not. Also, physiological and psychological effects of sleep deficiency on human body were also evaluated.

RESULTS

Of the 68 patients, 50 were male (74%) and 18 were female (26%). The mean age of the male patients was 46.12 ± 12.9 years & mean weight was 68.30 ± 9.8 kgs. The mean age of the female patients was 42.12 ± 11.4 years & mean weight was 70.48 ± 11.4 kgs.

Out of 68 patients in which Lyfas had detected sleep deficiency, majority of the patients (n=52, 76 %) had confirmed sleep deficiency during subsequent online consultation. Out of 50 males, 42 (80%) confirmed sleep deficiency in online consultation. Among females n=18, 13 (72 %) patients confirmed the same in subsequent online consultation.

Table 1 and 2 shows the sleep deficiency associated with psychological and physiological issues respectively.

Table 1 (n=68). Sleep deficiency associated with psychological issues

Parameter	Male (n=50)	Female (n=18)
Anger	n = 37 (75%)	n = 9 (50%)
Aggression	n = 37 (75%)	n = 7 (38 %)
Depression	n = 13 (26%)	n = 4 (22 %)
Anxiety	n = 12 (24%)	n = 3 [16 %]
Negative thoughts	n = 18 (36%)	n = 5 (27 %)
Memory issues	n = 25 (50%)	n = 11 (61 %)

Table 2 (n=68) Sleep deficiency associated with physiological issues

Parameter	Male (n=50)	Female (n=18)
Headache	n=36 (72%)	n=11 (61%)
Body pain	n=32 (64 %)	n=13 (72%)
Hair fall	n=26 (52%)	n=13 (72%)
Dry skin	n=11 (22 %)	n=8 (44 %)
Acidity	n=48 (72%)	n=14 (77%)
Tiredness	n=44 (88%)	n=15 (83%)

DISCUSSION

Sleep problems have become a modern epidemic that is taking a toll on individual bodies and minds. The penalty of sleep deficiency is significant distress or impairment in social, occupational, or other important areas of functioning.

Present study was designed to study the accuracy of Lyfas to detect sleep deficiency and Lyfas can detect psychological and physiological effects of sleep deficiency. Results of this study clearly confirms that Lyfas can detect sleep deficiency and its psychological and physiological effects. Modern lifestyle and the demands that it brings have affected the sleep schedule of many people around the world. Sleep deficiency is the initial stage of many disorders, affecting all people irrespective of age, race, or ethnicity.

Although sleep deprivation is estimated to affect one out of three people, it is not easily diagnosed. Lyfas is a very simple test through which one can determine the sleep deficiency and its ill effects. Most individuals recognize that they sleep far better at home than they might in a sleep centre. As a result, the need of the present day is - using technology, developing a test allows home assessment of sleep deficiency. Lyfas being non-invasive, reliable, less time consuming and cheap can be used to detect the sleep deficiency at home also. This can also enable the physicians to assist and monitor sleep deficiency and its ill effects in a remote care setting using telemedicine platforms.³³ Such an initiative can further add value towards reducing unwanted hospital or clinic visits. Results of our study shows that Lyfas can be used to detect sleep deficiency and its ill effects in general

population.

REFERENCES

1. Gray, P. (2002). Mechanism of motivation, sleep and emotion. Psychology. 4. Worth publishers, New York
2. Knutson, K.L., Spiegel, K., Penev, P. and Van Cauter, E. (2007) The Metabolic Consequences of Sleep Deprivation. *Sleep Medicine Reviews*, 11, 163-178.
3. Pilcher, J.J. and Huffcutt, A.J. (1996) Effects of Sleep Deprivation on Performance: A Meta-Analysis. *Sleep*, 19, 318-326.
4. Drummond, S.P., Brown, G.G., Gillin, J.C., et al . (2000) Altered Brain Response to Verbal Learning Following Sleep Deprivation. *Nature*, 403, 655-657.
5. Ferrara, M. and De Gennaro, L. (2001) How Much Sleep Do We Need? *Sleep Medicine Reviews*, 5, 155-179.
6. Alvarez, G.G. and Ayas, N.T. (2004) The Impact of Daily Sleep Duration on Health: A Review of the Literature. *Progress in Cardiovascular Nursing*, 19, 56-59.
7. Lange, T., Dimitrov, S. and Born, J. (2010) Effects of Sleep and Circadian Rhythm on the Human Immune System. *Annals of the New York Academy of Sciences*, 1193, 48-59.
8. Majde, J.A. and Krueger, J.M. (2005) Links between the Innate Immune System and Sleep. *Journal of Allergy and Clinical Immunology*, 116, 1188-1198.
9. Rajaratnam, S.M. and Arendt, J. (2001) Health in a 24-h Society. *The Lancet*, 358, 999-1005.
10. Sundelin, T., Lekander, M., Kecklund, G., et al. (2013) Cues of Fatigue: Effects of Sleep Deprivation on Facial Appearance. *Sleep*, 36, 1355-1360.
11. American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders*. 5. Washington, DC.
12. Clark I, Landolt HP. Coffee, caffeine, and sleep: a systematic review of epidemiological studies and randomized controlled trials. *Sleep Med Rev* 2017;31:70–78.
13. Thakkar MM, Sharma R, Sahota P. Alcohol disrupts sleep homeostasis. *Alcohol*. 2015;49(4):299–310.
14. Boivin DB, Boudreau P. Impacts of shift work on sleep and circadian rhythms. *Pathol Biol (Paris)*. 2014;62(5):292–301.
15. Smolensky MH, Sackett-Lundeen LL, Portaluppi F. Nocturnal light pollution and underexposure to daytime sunlight: complementary mechanisms of circadian disruption and related diseases. *Chronobiol Int*. 2015;32(8):1029–1048.
16. Malish S, Arastu F, O'Brien LM. A preliminary study of new parents, sleep disruption, and driving: a population at risk? *Matern Child Health J*. 2016;20(2):290–297.
17. Celik G, Annagur BB, Yilmaz M, Demir T, Kara F. Are sleep and life quality of family caregivers affected as much as those of hemodialysis patients? *Gen Hosp Psychiatry*. 2012;34(5):518–524.
18. Scott AJ, Webb TL, Rowse G. Does improving sleep lead to better mental health?. A protocol for a meta-analytic review of randomised controlled trials. *BMJ Open*. 2017;7(9):e016873. doi:10.1136/bmjopen-2017-016873
19. Baglioni C, Battagliese G, Feige B, et al. Insomnia as a predictor of depression: a meta-analytic evaluation of longitudinal epidemiological studies. *J Affect Disord*. 2011;135(1-3):10-9.
20. Babson KA, Trainor CD, Feldner MT, Blumenthal H. A test of the effects of acute sleep deprivation on general and specific self-reported anxiety and depressive symptoms: an experimental extension. *J Behav Ther Exp Psychiatry*. 2010;41(3):297–303
21. Frank E, Swartz HA, Boland E. Interpersonal and social rhythm therapy: an intervention addressing rhythm dysregulation in bipolar disorder. *Dialogues Clin Neurosci*. 2007;9(3):325–332.
22. Hirotsu C., Tufik S., Andersen M.L. Interactions between sleep, stress, and metabolism: From physiological to pathological conditions. *Sleep Sci*. 2015;8:143–152
23. Botchkarev VA. Stress and the hair follicle: exploring the connections. *Am J Pathol*. 2003;162(3):709-712
24. Kim MA, Kim EJ, Kang BY et al. The effects of sleep deprivation on the biophysical properties of facial skin. *Journal of Cosmetics, Dermatological Sciences and Applications*. 2017;07(01):34-47
25. Durham P, Garrett F, Hawkins J. REM sleep deprivation promotes sustained levels of proteins implicated in peripheral and central sensitization of trigeminal nerves: role in pain chronification. *D06 Regulation Of Gene Expressions*. 2011;12(4):31.
26. Fernández-de-Las-Peñas C, Fernández-Muñoz JJ, Palacios-Ceña M, Parás-Bravo P, Cigarán-Méndez M, Navarro-Pardo E. Sleep disturbances in tension-type headache and migraine. *Ther Adv Neurol Disord*. 2017;11:175-62
27. Sivertsen, Borge; Lallukka, Tea; Petrie, Keith J. et al. Sleep and pain sensitivity in adults. 2015;156(8):1433-1439
28. Dickman R; Green C; Fass SS; Quan SF; Dekel R; Risner-Adler S; Fass R. Relationships between sleep quality and ph monitoring findings in persons with gastroesophageal reflux disease. *J Clin Sleep Med* 2007;3(5):505-513.
29. Alhola P, Polo-Kantola P. Sleep deprivation: Impact on cognitive performance. *Neuropsychiatr Dis Treat*. 2007;3(5):553-567.
30. The scientific concept of Lyfas document.
31. Analysis of a Pulse Rate Variability Measurement Using a Smartphone Camera
32. HEART RATE VARIABILITY: CLINICAL APPLICATIONS AND INTERACTION BETWEEN HRV AND HEART RATE
33. Telemedicine Practice Guidelines Enabling Registered Medical Practitioners to Provide Healthcare Using Telemedicine prepared in partnership with NITI Aayog 25 March 2020