Editorial

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Long term sleep quality assessment: a new hope

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Abbrevations: NREM, non-rapid eye movement; REM, rapid eye movement; PSG, polysomnography; EEG, electroencephalogram; EOG, electro-oculogram; EMG, electro-myogram; ESS, epworth sleepiness scale; Act, actigraphy; ANS, autonomic nervous system

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Editorial

Physiologically sleep is defined as a state during which an individual's brain wave activity changes and her/his nervous system is less reactive to external stimuli (i.e., temporarily unconscious). But, this temporal unconsciousness or sleeping is not constant throughout the night or bed time (the time an individual spent in bed). Actually, it cycles through five distinct stages: non-rapid eye movement stage 1 (NREM1) to NREM3, REM, and wakefulness (WAKE) according to the guidelines of American Academy of Sleep Medicine.[1] It is important to note that NREM1 is the lightest sleep stage with decreased consciousness, but the brain still process some external information around the individual (e.g., during listening to a bore lecture with decreased consciousness, when listening his name or some other stimulus jolts him awake). NREM2 is the intermediate light sleep stage during which it is harder to awake an individual, and NREM3 is the deepest, the most restful and most restorative sleep stage. The next and final stage of sleep is REM (Rapid Eye Movement) sleep during which people dream; People spend more time in this stage in the late night.

Sleep is considerably recognized as an important lifestyle contributor to health, and nowadays an increasing number of populations are curtailing sleep in the name of social, leisure, or work-related activities.[2] Sleep is especially considered to be important to body restitution, like thermoregulation, energy conservation, and tissue recovery,[3] moreover, sleep is essential for cognitive performance, especially memory consolidation.[3,4] A number of studies[5–7] reported that individuals with sleep disorder (a condition that frequently effects an individual's ability to have sufficient amount of sleep) e.g., insomnia, sleep apnea, etc are at significantly higher risks for cardiovascular diseases, cerebrovascular diseases (coronary heart disease, heart failure, stroke,…) metabolic disorder (e.g., type II diabetes mellitus, hypertension, …). In addition, a poor quality of sleep or sleepiness has been identified as one of the main reasons of car accidents.[8,9] However, detection of sleep disorder or assessing poor sleep quality and subsequent treatment[10,11] can significantly improve the quality of life and hence reduce mortality. Besides sleeping pills (sedative drugs), physicians can advise physical exercise, relaxation techniques and leading more disciplinary life styles[12,13] for sleep disordered patients.

The precondition of providing any treatment is diagnosis and identifying if an individual is suffering from sleep disordered problem. The quality of sleep is assessed professionally in an especial sleep laboratory using whole night polysomnography (PSG), which requires signals from multiple sensors like electroencephalogram (EEG), electro-oculogram (EOG), and electro-myogram (EMG). Unfortunately, this objective (the standard) measure suffers from some unavoidable serious limitations such as the need of a sleep expert (or Neurologist), expensive equipments, an especial sleep laboratory, which make PSG unsuitable for monitoring large populations. Besides these, the normal behaviour of sleep of a person can even be affected by the new environment and wearing surface electrodes to monitor her/his brain wave. In addition, the investigations to diagnose circadian rhythm sleep disorder or to ascertain an individual's sleep habit which requires long term (over the weeks or months long) monitoring of sleep vs wake pattern is not possible with PSG. There are both subjective e.g., Epworth Sleepiness Scale (ESS)[14] and objective e.g., Actigraphy (Act)[15] methods other than PSG. Although, subjective measurement methods are easy to administer, and they are less accurate than objective methods[16] and there is also a chance of misperceptions of sleep state. Many earlier studies[17–19] have reported sleep vs wake classification from heart rate variability i.e., the variability in the time interval between successive heart beats of an electrocardiogram signal which has the advantages of low cost and non-invasive. However, sleep staging from only HRV is still far from widespread practical implementation due to its lower accuracy.[17–19]

The state of autonomic nervous system (ANS) function is thought to be different between NREM and REM/WAKE stages,[17,20] while it is similar between REM sleep and WAKE. Whereas, the body movement magnitudes differ between REM sleep and WAKE due to its suppressed magnitude during REM sleep. Thus, a multistage (WAKE, NREM and REM) of sleep with better accuracy is possible from the combination of HRV and ACT data. A plenty of works[15,18,21,22] are available that proposed sleep staging either from HRV or wrist ACT, but to the best of my knowledge, none of them considered the combination of both data. The advantages of ACT are that they are low cost, comfortable to use, small size… etc. Mobile-health applications represent the new paradigm of tele-home care monitoring that combines the standard telemedicine approach with the latest Internet of Things concept.[23] In this context, the development of a new generation of sensors led to aggregate different types of sensing units in a single device. Typical examples are wearable T-shirts with ACT and ECG sensors or smart watch with skin conductance and ACT. Inspired from the state-of-art of sleep quality assessment applications and from the recent trend of new sensors, recently, we first interested[24] in sleep wake classification from the combination of HRV and chest ACT instead of wrist ACT, so that if the combination of these signals give acceptable accuracy, all sensors can be integrated on a single belt or T-shirt, which might facilitate the wearing and use of the systems by inexperienced users as well as providing long-term sleep monitoring.

The classification (binary classification) model proposed in the previous study[24] was performed on a very small (only 18 subjects) data set which could have a higher risk of over fitting to the data, as a result it could result a lower performance when applied to a new unknown data from other subjects. The combination of Chest ACT with HRV performed similarly to that of Wrist ACT with HRV which at least opens the possibility of integrating all types of sensors in a single wearable device. However, instead of using the combined information of both HRV and ACT for a binary classification (Sleep vs Wake), the robust HRV features reflecting the autonomic function state can be used for separating NREM sleep from WAKE and REM sleep in the first stage, and in the second hierarchical stage, WAKE can be distinguished from the REM sleep using actigraphy features. Thus, the binary classification problem will be transformed to a ternary (NREM, REM and WAKE) classification problem with the possibility of increasing classification performance. Of course, its performance will depend on the appropriate features extraction and classifiers used in both stages. Hence, more extensive research on a large database including subjects of all categories with respect to age, sex, pathology and healthy conditions are needed to generalize the effectiveness, efficiency and appropriateness of the usage of combined information from chest actigraphy and heart rate variability. If the concept is proved effectively on a large dataset, it will allow long term sleep monitoring of an individual in home environment without the assistance of a sleep expert. Then people will not be needed to wait for an appointment with the Neurologist and will save a lot of money and time used for traditional expensive polysomnography based sleep monitoring.

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Conflict of interest

The author declares no conflict of interest.

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