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Original Research Article

A cross-sectional study to evaluate the effect of subjective sleep quality on autonomic functions in different age groups of adults

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ABSTRACT

Background: Poor sleep quality adversely affects the person's homeostasis via combination of impairments to multiple physiological-mechanisms. Autonomic functions are important for different aspects of health and disease. Objective of study was to analyze the impact of subjective sleep quality on autonomic functions in different age groups of adults.

Methods: A total of 375 apparently healthy adults from community were randomly selected for this cross-sectional observational study. They were divided into three groups based on the age distributions: Group 1: 18-30 years (n = 146); Group 2: 31-45 years (n = 112); and Group 3: 46-60 years (n = 117). Following assessments were done in all the participants in three groups: Anthropometric measurements, Pittsburgh Sleep-quality Index (PSQI), Electrocardiography (ECG), Autonomic functions based on frequency domain heart rate variability (HRV). Two-way analysis of variance followed by post hoc analysis was done for intergroup comparisons of all assessment characteristics. Spearman's correlation was done to find the correlation coefficients between PSQI scoring and all other parameters mentioned above.

Results: BMI, GPSQIS, SSQS, SDS and SMS were observed more in group2 and 3 as compared to group1, whereas SD and SE were more in group1 as compared to group 2 and 3. HF, Total Power and RR were more in group 1 as compared to group 3, whereas VLF and HR were less in group 1 as compared to group 3. LF/HF ratio and HR were more in group 3 as compared to group 2, whereas HF was more in group 2 as compared to group 3. There was statistically significant negative correlation between GPSQI and Total power, SMS and HF, SIT and HF, SD and LF/HF ratio, whereas statistically significant positive correlation between SMS and LF, SMS and LF/HF ratio, SIT and LF, SIT and LF/HF ratio, SD and total power as well as SE and total power.

Conclusions: Ageing in adults affects the sleep-quality, reduces the sleep duration and decreases the sleep efficiency; these contribute to autonomic dysfunction as increased sympathetic activity and decreased parasympathetic activity in older adults as compared to younger adults.

Keywords: Autonomic, Ageing, Sleep-quality, Heart rate variability

INTRODUCTION

Adequate sleep is needed for all human being. It helps to maintain the homeostasis and thus overall health. Poor sleep quality is also being considered as the main causative factor for large number of serious health disorders.[1,2] The persons who get regular good quality of sleep are reported to be remaining physically active, mentally sound and can perform daily activities more efficiently. However, nowadays inadequate sleep is very common in all age group of human. Its prevalence has been increasing in almost every part of world. Proposed reasons for poor sleep qualities are bad lifestyle, stress related factors, smoking habits, late night awakeners, taking beverages at odd time, and other habits.

Sleep loss in itself is a kind of stress in humans. Acute sleep deprivation affects the attention and reduces the ability to respond on sensory stimuli.[3] Lack of proper sleep caused many tragic incidents in past and this trend is increasing.[4] Chronic sleep deprivation has been associated with an increased incidence of adverse cardiovascular and metabolic disorders.[5] Many sleep related disorders are also implicated as the important causative factor for many cardiovascular conditions like hypertension, ischemic heart disease and sudden cardiac death. The physiological mechanism for this relationship links autonomic nervous system (ANS) and sleep. ANS also plays a major role in regulation of sleep architecture. Both wings of ANS, parasympathetic as well sympathetic play their significant role in the maintenance of sleep.[6,7] Proper sleep in itself appears to have calming or relaxing effect on mind and body of person; it reduces the activity of sympatho-adrenal system and increase the activity of vagal parasympathetic system. Therefore, sleep deprivation might be associated with dominance of sympathetic system over parasympathetic system.

Few earlier studies shown acute sleep deprivation leads to abnormality of cardiac autonomic activities.[8,9] Previous studies also suggest that sleep disturbances leads to increased risk of cardiovascular diseases.[10] However, the research related to the impact of sleep quality on autonomic functions in different age groups of adults is lacking. The aim of this study was to evaluate the effect of subjective sleep quality on autonomic functions in different age groups of adults.

METHODS

This observational, cross-sectional study was conducted in the Autonomic Function Laboratory of the Department of Physiology, Dr Ram Manohar Lohia Institute of Medical Sciences, Lucknow, Uttar Pradesh, India.

The study was approved by the institutional ethical committee. All the participants had given their informed written consent.

Inclusion criteria

Apparently healthy adults in the age group of 20-65 years.

Exclusion criteria

Participants were screened with the help of questionnaire for any history of drugs/alcohol intake, any family history of coronary heart disease, diabetes mellitus, hypertensive conditions, any metabolic disorders and any other known cardiac diseases, or presence of any other medical illness likely to affect the HRV parameters. No study participants reported any symptoms suggestive of peripheral or autonomic neuropathy. The symptoms particularly enquired about were giddiness on changing posture from supine to standing, symptoms related to gastrointestinal system like gastric hurrying, diarrhoea, and constipation, frequency or urgency for micturition, pins or needles or any burning or tingling sensations in extremities etc.

May 2018 to April 2019 was the study period.

Study population

Apparently healthy adult individuals (age ranged 20-65 years) were invited to participate from the community. Participants were also recruited from the medical students, paramedical staffs, and security-guards of the hospital as well as the healthy attendants of the hospitalized patients.

All participants were divided into three groups based on the age distributions: Group 1: 18-30 years (n = 146); Group 2: 31-45 years (n = 112); and Group 3: 46-60 years (n = 117).

Methodology followed

The anthropometric measurements were done for all the participants. The BMI (kg/m2) was calculated as weight (in kilograms) divided by square of the height (in meters). Subjective sleep quality of all participants was assessed with the help of Pittsburg Sleep quality index (PSQI) Questionnaire. The PSQI contains 19 self-rated questions and 5 questions rated by bed partner or room-mate (if one is available). Only self-rated questions are included in the scoring. The 19 self-rated items are combined to form seven “components’’ scores each of which has a range of 0 - 3 points. The seven components included: Subjective sleep quality score, Sleep latency score, Sleep duration score, Habitual sleep efficiency score, Sleep disturbance score, Sleep medication score, Day time dysfunction score. In all cases a score of “0” indicates no difficulty while score of “3” indicates severe difficulty. The seven components scores are then added to yield one “global score” with the range of 0 - 21 points, “0” indicating no difficulty and “21” indicating severe difficulties in all areas. Sleep induction time (min), Sleep duration (hr) and Sleep efficiency (%) were also calculated.

Resting Heart rate (HR) ,RR, QT, QTc intervals were measured respectively using standard Electrocardiograph (ECG) and sphygmomanometer based on oscillatory principles.

Heart Rate Variability (4-channel polygraph, AD instruments) measured continuous recording of Resting

Frequency domain HRV. Very low frequency (VLF), low frequency (LF), high frequency (HF), LF/HF ratio, and total power were noted after calculation of power spectral analysis of 300 continuous RR intervals.

Statistical analysis

Two-way Analysis of variance (ANOVA) followed by post-hoc test were applied to find out the significant difference among the groups. Spearman's correlations coefficients (r) were used to analyze the strength of association. frequency domain parameters of HRV (VLF, LF, HF, LF/HF, Total power) and ECG parameters (mean HR, mean RR, mean QT and mean QTc interval).

RESULTS

Table 1 shows significant differences in age, weight and BMI in all three groups. Group 3 participants had BMI as compared to both other groups.

Table 1: Anthropometric measurements of all three group of adults.

	Group 1 (N=146)	Group 2 (N=112)	Group 3 (N=117)	ANOVA (p value)	POST-HOC (p<0.05)
Age (Years)	21.76±3.65	36.11±5.23	51.45±6.40	0.000	1 and 2, 2 and 3,3 and 1
Height(Ht)	164.94±12.01	161.82±8.39	163.89±7.55	0.544	NS
Weight(Wt)	58.79±8.05	61.24±7.09	74.97±15.42	0.000	1 and 2, 2 and 3,3 and 1
Body mass Index (BMI)	21.98±2.02	23.34±1.53	28.66±3.62	0.000	1 and 2, 2 and 3,3 and 1

Table 2: Subjective sleep quality (PSQI) of all three group of adults.

	Group 1 (N=146)	Group 2 (N=112)	Group 3 (N=117)	ANOVA (p value)	POST-HOC (p<0.05)
Global PSQI score (GPSQI)	4.89±2.07	7.89±3.63	8.29±3.17	0.036	1 and 2, 2 and 3,3 and 1
Subjective sleep quality score (SSQS)	0.84±0.50	1.17±0.52	1.10±0.45	0.108	1 and 2, 3 and 1
Sleep latency score (SLS)	1.63±0.76	1.52±1.01	1.31±0.74	0.503	NS
Sleep duration score (SDS)	1.31±0.88	1.82±0.72	1.89±0.87	0.040	1 and 2, 3 and 1
Habitual sleep efficiency score (HSES)	0.52±0.84	0.76±0.83	0.94±1.35	0.466	NS
Sleep disturbance score (SDisS)	1.42±0.50	1.41±0.50	1.31±0.47	0.774	NS
Sleep medication score (SMS)	0.05±0.22	0.17±0.72	0.15±0.68	0.008	1 and 2, 3 and 1
Day time dysfunction score (DTDS)	1.10±0.80	1.41±0.71	1.15±1.01	0.531	NS
Sleep induction time (SIT) (min)	26.31±24.65	32.64±33.91	37.89±15.75	0.058	NS
Sleep duration (SD) (hr)	6.10±1.14	5.67±0.88	5.44±1.02	0.017	1 and 2, 2 and 3,3 and 1
Sleep efficiency (SE) (%)	87.20±11.64	82.05±10.65	81.83±17.38	0.003	1 and 2, 3 and 1

Table 3: Heart rate variability and electrocardiography of all three group of adults.

	Group 1 (N= 146)	Group 2 (N= 112)	Group 3 (N= 117)	ANOVA (p value)	POST-HOC (p<0.05)
VLF (%)	33.41±17.97	36.22±12.37	46.95±20.13	0.048	1 Vs 3
LF (%)	28.91±14.08	26.08±10.03	29.13±12.68	0.721	NS
HF (%)	36.55±20.81	35.02±14.35	22.95±16.24	0.040	2 Vs 3; 1 Vs 3
LF/HF	1.24±1.24	0.89±0.54	2.05±1.77	0.030	2 Vs 3
Total Power	1772.21±1229.73	1462.88±1278.79	924.39±723.72	0.065	1 Vs 3
HR	70.83±9.48	74.03±8.88	81.16±12.06	0.010	2 Vs 3; 1 Vs 3
RR	0.86±0.11	0.82±0.10	0.75±0.11	0.018	1 Vs 3
QT	0.32±0.02	0.32±0.01	0.32±0.02	0.696	NS
QTc	0.35±0.02	0.36±0.04	0.38±0.02	0.107	NS

Table 2 shows significant differences in Sleep quality indices in three groups. GPSQIS, SSQS, SDS and SMS were observed more in group2 and 3 as compared to group1, whereas SD and SE were more in group1 as compared to group 2 and 3. GPSQI was more in group 3 as compared to group 2, whereas SD was more in group 2 as compared to group 3.

Table 4: Spearman's rank correlation between PSQI components and HRV and ECG of all three group of adults (combined).

	VLF	LF	HF	LF/HF	Total Power	HR	RR	QT	QTc
GPSQI	r_s = -0.345, p= 0.801	r_s = -0.586, p= 0.670	r_s = 0.260, p= 0.845	r_s = -0.269, p= 0.841	r_s = -0.259, p= 0.021	r_s = -0.210, p= 0.876	r_s = 0.283, p= 0.834	r_s = 0.093, p= 0.498	r_s = 0.220, p= 0.884
SSQS	r_s = -0.028, p= 0.834	r_s = -0.601, p= 0.989	r_s = -0.105, p= 0.968	r_s = 0.047, p= 0.729	r_s = -0.233, p= 0.08	r_s = 0.214, p= 0.116	r_s = -0.025, p= 0.851	r_s = -0.045, p= 0.742	r_s = 0.032, p= 0.815
SLS	r_s = -0.128, p= 0.350	r_s = -0.021, p= 0.873	r_s = 0.114, p= 0.406	r_s = -0.105, p= 0.445	r_s = 0.203, p= 0.135	r_s = -0.103, p= 0.451	r_s = -0.069, p= 0.615	r_s = 0.088, p= 0.522	r_s = 0.038, p= 0.778
SDS	r_s = -0.040, p= 0.769	r_s = -0.022, p= 0.872	r_s = -0.032, p= 0.812	r_s = 0.044, p= 0.747	r_s = -0.055, p= 0.686	r_s = 0.163, p= 0.233	r_s = 0.059, p= 0.666	r_s = 0.079, p= 0.562	r_s = 0.116, p= 0.396
HSES	r_s = 0.027, p= 0.841	r_s = -0.047, p= 0.733	r_s = - 0.091, p= 0.506	r_s = 0.086, p= 0.531	r_s = 0.208, p= 0.127	r_s = -0.130, p= 0.343	r_s = 0.089, p= 0.514	r_s = 0.095, p= 0.486	r_s = -0.110, p= 0.420
SDisS	r_s = 0.147, p= 0.283	r_s = -0.086, p= 0.532	r_s = -0.050, p= 0.713	r_s = 0.003, p= 0.979	r_s = -0.041, p= 0.764	r_s = -0.117, p= 0.391	r_s = -0.021, p= 0.875	r_s = 0.146, p= 0.286	r_s = 0.033, p= 0.810
SMS	r_s = -0.238, p= 0.078	r_s = 0.280, p= 0.037	r_s = -0.321, p= 0.016	r_s = 0.321, p= 0.016	r_s = 0.216, p= 0.112	r_s = -0.080, p= 0.557	r_s = 0.079, p= 0.562	r_s = -0.015, p= 0.910	r_s = -0.127, p= 0.354
DTDS	r_s = -0.016, p= 0.904	r_s = -0.001, p= 0.993	r_s = 0.083, p= 0.543	r_s = -0.098, p= 0.474	r_s = 0.131, p= 0.336	r_s = -0.019, p= 0.889	r_s = 0.078, p= 0.567	r_s = -0.111, p= 0.416	r_s = -0.226, p= 0.096
SIT	r_s = -0.240, p= 0.076	r_s = 0.121, p= 0.037	r_s = -0.326, p= 0.014	r_s = 0.290, p= 0.031	r_s = 0.212, p= 0.119	r_s = -0.199, p= 0.144	r_s = 0.071, p= 0.603	r_s = -0.023, p= 0.865	r_s = -0.230, p= 0.091
SD	r_s = 0.004, p= 0.975	r_s = -0.049, p= 0.720	r_s = 0.102, p= 0.457	r_s = -0.127, p= 0.035	r_s = 0.414, p= 0.027	r_s = -0.145, p= 0.288	r_s = -0.044, p= 0.749	r_s = -0.046, p= 0.733	r_s = -0.046, p= 0.737
SE	r_s = 0.008, p= 0.949	r_s = 0.076, p= 0.579	r_s = 0.033, p= 0.805	r_s = -0.042, p= 0.757	r_s = 0.213, p= 0.031	r_s = 0.059, p= 0.666	r_s = -0.098, p= 0.475	r_s = -0.017, p= 0.896	r_s = 0.099, p= 0.469

Table 3 shows significant differences in Heart rate variability and electrocardiography in three groups. HF, Total Power and RR interval were more in group 1 as compared to group 3, whereas VLF and HR were less in group 1 as compared to group 3. LF/HF ratio and HR were more in group 3 as compared to group 2, whereas HF was more in group 2 as compared to group 3.

Table 4 shows Spearman's rank correlation between PSQI components and HRV and ECG of all three group of adults. There was statistically significant negative correlation between GPSQI and Total power, SMS and HF, SIT and HF, SD and LF/HF ratio, whereas statistically significant positive correlation between SMS and LF, SMS and LF/HF ratio, SIT and LF, SIT and LF/HF ratio, SD and total power as well as SE and total power.

As shown in (Table 1) the mean ages (in years) of three groups under study were as follows: Group 1= 21.76± 3.65; Group 2= 36.11±5.23 and Group 3= 51.45±6.40. The Group 3 participants were older adults. Their BMI were also high, many participants belong to overweight category having BMI >25 kg/m2 whereas most of the Group 1 and 2 participants belong to normal weight category, i.e. BMI between 18.5 to 24.99 Kg/ m2. As shown in (Table 2) the global PSQI score (GPSQIS) were more in group 2 and 3 as compared to group 1. Most of the group 2 and 3 participants belong to poor sleeper category (GPSQIS>5), whereas younger participants in group 1 were good sleepers. GPSQI was also more in group 3 as compared to group 2. SSQS, SDS and SMS were observed more in group2 and 3 as compared to group1, whereas SD and SE were more in group1 as compared to group 2 and 3. SD was more in group 2 as compared to group 3.

As shown in (Table 3), the frequency domain parameters like high frequency (HF), and Total Power were more in group 1 as compared to group 3, whereas very low frequency (VLF) were less in group 1 as compared to group 3. HF was more in group 2 as compared to group 3. These finding indicated that group 1 participants had overall higher parasympathetic activity as compared to group 3. The HF range is from 0.15 Hz to 0.4 Hz, which equates to rhythms with periods that occur between 2.5 and 7 s. HF band reflects parasympathetic or vagal activity and is frequently called the respiratory band because it corresponds to the HR variations related to the respiratory cycle known as respiratory sinus arrhythmia. LF/HF ratio were more in group 3 as compared to group 2. The high LF: HF ratio may indicate higher sympathetic activity relative to parasympathetic activity. Normally it is observed when people engage in meeting a task that requires constant stress and efforts and increased sympathetic activation.

(Table 4) shows that there was statistically significant negative correlation between GPSQI and Total power, SMS and HF, SIT and HF, SD and LF/HF ratio, whereas statistically significant positive correlation between SMS and LF, SMS and LF/HF ratio, SIT and LF, SIT and LF/HF ratio, SD and total power as well as SE and total power. This indicates that sleep quality indices were correlated in some or other ways with autonomic functions. The above results shows that poor sleep quality impose stress in the healthy people which ultimately influences the sympathetic activity.

DISCUSSION

The present study was conducted to evaluate the effect of subjective sleep quality on autonomic functions in different age groups of adults. The relationship between frequency domain parameters of HRV and select ECG characteristics with different components of PSQI sleep quality indices was studied. Our study demonstrated that younger adults have better sleep quality indicators as compared to middle aged and older adults.

The findings in our study were in accordance with the previous studies, who reported older adults having sleeping related problem as waking up before expected timings, disturbed or “light” sleep, increase in wakefulness time during night hours, reduced total sleep time.[11-13] Another study in the Austrian Population also reported significantly poor sleep quality (PSQI) and associated worse quality of life index (QLI) in elderly people as compared to young adults.[14] The results in the present study demonstrated that younger adults had more parasympathetic activities and lesser sympathetic activities as compared to middle aged and older adults. These findings in our study matched with other previous studies. Bertel, O et al, demonstrated that there is decreased beta adrenoreceptor responsiveness as related to age, blood pressure, and plasma catecholamines in patients with essential hypertension.[15] A positive correlation between age and muscle sympathetic nerve activity is shown in normal subjects who are 18-75 years-of-age in the study by Iwase S et al.[16] In the studies related to the effect of aging on vagus nerve activities and the cholinergic receptor functions, it had been demonstrated that vagal component of heart rate variability decreases with age and that heart rate changes in response to muscarinic acetylcholine receptor blocking agents are blunted.[17,18]

Despite evidences linking associations between sleep deprivation and autonomic reactivity, the impact of sleep quality on autonomic nervous system is not available in review of literature.[19-21] Takase et al, demonstrated chronic stress associated with sleep deprivation causes autonomic imbalance represented by decreased parasympathetic and increased sympathetic activity, as reflected in their study by low HRV indices and high norepinephrine levels.[22] Our data suggest that short sleep and poor sleep quality and decreased efficiency of sleep may be more of a concern in older adults. The increased sympathetic activity and decreased parasympathetic activity in older adults are because of poor sleep quality and reduced sleep efficiency in them.

The limitation of this study is because of being a cross sectional design, we cannot exclude the possibility of reverse causality, autonomic dysfunction may be the primary cause of poor sleep quality. Further research will be needed to establish whether the connection between sleep duration and autonomic functions consistently varies with age, whether this connection can be demonstrated with other health measures, and whether the relationship is that is, poor sleep quality led to autonomic dysfunction in different age group of adults.

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