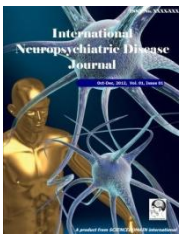

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# Effects of Sleep Deprivation on the Cardiovascular Health

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Author JK designed the study and wrote the protocol, performed the statistical analysis, managed the literature search, and wrote the first draft of the manuscript with assistance from author MK. Both authors read and approved the final manuscript.*

***Original Research Article***

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## ABSTRACT

**Aim:** Insomnia is subjective perception of dissatisfaction with sleep quality and/or duration. The present study aimed to determine the effects of sleep deprivation on cardiovascular risk factors and health.
**Design, Place and Duration of Study:** A cross-sectional study was conducted at Exservicemen Contributory Health Scheme (ECHS) Polyclinic, Sultanpur Lodhi, Kapurthala, Punjab, India from July, 2013 to Nov, 2013.
**Methodology:** All the retired defence personnel and their family members (N=351) were assessed to study physical activity, body mass index (BMI), dietary habits, alcohol, hypertension, hyperglycemia, hyperlipidemia, stress, age, gender, employment, and education as determinants of sleep deprivation. The results were analyzed by Chi Square test with statistically significance of *P* value<.05.
**Results:** The total prevalence of insomnia was 27.64% with higher frequency in females (52.57%) than males (47.42%). The prevalence increased with advancing age >50 years (81.43%), unemployment (75.25%), illiteracy (69.06%) and upper socioeconomic status (39.17%). A significant association of insomnia with hypertension (59.80%; *P*<.05) and stress (28.86%; *P*<.001) was found. Alcohol (24.40%) and active lifestyle (38.58%) had shown protective role in sleep adequacy. However, sleep deprivation had no significant

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relation with obesity, metabolic syndrome, dietary practices, blood glucose, and lipids levels.
**Conclusion:** Insomnia and its significant relation with hypertension and stress increases cardiovascular risk which requires appropriate interventions by identifying those at the risk of chronic insomnia and its associations with females, advancing age, physical inactivity, low education level and unemployment.

*Keywords: Age; females; hypertension; insomnia; stress.*

## 1. INTRODUCTION

Insomnia is a psychosomatic disorder clinically presents as a subjective perception of dissatisfaction with the sleep quality and/or duration. Difficulty falling asleep in-spite of being in bed, multiple awakenings with trouble falling back asleep, early morning awakenings or having an un-refreshing sleep constitutes insomnia [1]. Its prevalence ranges from 10-15% among the general population [2]; however, affects about 33–50% of the adult population [3] with higher rates among divorced, separated, or widowed people, older age, females, and co-morbid medical or psychiatric illness [4-6].

Sleep deprivation exerts deleterious systemic effects with detectable endocrine, immune, and metabolic changes [7,8]; which contributes to total mortality, diabetes mellitus, hypertension, obesity, respiratory disorders, and poor self-rated health [9,10]. The relationship between sleep duration and vascular events is U-shaped suggesting different mechanisms may operate at either end of the distribution of sleep duration [11]. Insomniac are more likely to visit hospitals and physicians; have increased absenteeism; make errors or have accidents at work; increased predisposition to depression, anxiety, substance abuse and suicide; and prone to fatal road accidents [12]. King et al. [13] found inverse association of sleep duration with incident coronary artery calcification over 5years follow up. Self-reported short sleep and sleep complaints have been associated with an increased cardiovascular morbidity in both epidemiological [14] and case-control studies [15]. These cardiovascular events usually follow a circadian rhythm, with a high incidence of sudden death, myocardial infarction, and stroke in the early morning [16].

Though insomnia can be an independent condition as a primary insomnia but it is often secondary to medications (beta-blockers, bronchodilators, calcium channel blockers, decongestants, antidepressants, thyroid hormones); medical disorders (asthma, hyperthyroidism, prostate hypertrophy, rhinitis); poor sleep hygiene; and disorders like sleep apnea, periodic limb movements, restless legs syndrome, or circadian rhythm disorder. Various behavioral and cognitive factors such as worrying in bed, talking on the telephone at night, watching television, using computers and internets, eating, smoking, clock watching, or having unreasonable expectations of sleep duration may further contributes to insomnia [17]. Gillin [18] believes multiple unsuccessful attempts to control thoughts, images and emotions provides an automatic nocturnal trigger for anxiety and arousal which further worsen the situation that can persist indefinitely.

Various studies found an association of insomnia with chronic diseases; with the complaint in 33% of patients with diabetes, 45% with gastro-esophageal reflux disease, 50% with congestive heart failure, 44% with cancer, 74% to 98% with Parkinson disease, 65% with major depression, 61% with panic disorder, and 44% with generalized anxiety disorder

[19,20]. The causative mechanisms relating short sleep to adverse health outcomes include reciprocal changes in circulating leptin and ghrelin levels which would increase appetite, calorie intake, reduce energy expenditure, and facilitate the development of obesity and impaired glycemic control with increased cardiovascular risk [7,8,14,15]. Sympathetic activation, increased cortisol secretion, altered growth hormone metabolism and low-grade inflammation is further activated during short sleep which may induce endothelial dysfunction not only for cardiovascular diseases but also for other chronic conditions including cancer [8]. However, evidence suggests insomnia is mostly under-recognized, under-diagnosed and under-treated [2]. Hence, the present study was an attempt to study the prevalence of insomnia and its effects on the cardiovascular health of the study participants.

## 2. MATERIALS AND METHODS

### 2.1 Design Overview

This cross-sectional study was undertaken to determine the relationship between self-reported usual sleep adequacy and the cardiovascular parameters in a community-based Ex-Servicemen residing in the region of Sultanpur Lodhi, Kapurthala, Punjab (India). This survey was conducted at Ex-Servicemen Contributory Health Scheme (ECHS) Polyclinic which provides free at-the-point-of-access primary care and follow up services for all kind of acute and chronic diseases solely to the registered retired defence personnel. The study population was representative of the primary care attendees of the selected primary care clinic in the Northern India who had been retired from the defence services; their family members comprising spouse, children and parents; registered with ECHS Polyclinic; and had attended the polyclinic from July, 2013 to Nov, 2013. Institutional ethical committee approval was obtained prior to the start of study and informed written consent was taken from all the recruited subjects. Chi Square test was used for statistical analysis with a statistically significance of $P$ value<.05.

### 2.2 Diagnosis of Insomnia

Symptoms of insomnia were obtained from responses on a 4-point Likert scale to the items “Have trouble falling asleep?,” “Wake up during the night and have difficulty getting back to sleep?,” “Wake up too early in the morning and be unable to get back to sleep?,” and “Take sleeping pills or other medication to help you sleep?” Insomnia was diagnosed as an inadequate sleep with “frequent” responses to any of these 4 questions.

### 2.3 Survey Questionnaires

A structured in-person interview was conducted to record socio-demographic variables and cardiovascular risk factors. The regular aerobic physical activity (e.g., brisk walking) of at least 30minutes per day for most days of the week was considered adequate [21]. Men alcohol intake is limited to <2 drinks per day; and for women and lighter weight persons, it is limited to <1 drink per day (1 drink=1/2oz or 15ml ethanol (e.g., 12oz beer, 5oz wine, 1.5oz 80-proof whiskey)) [21]. Subjects who exceed their limit were classified under “Current” group. Job strain, social constraints, financial un-stability, health issues, and family distress were included under “stress” which significantly affects the daily life activities. The family history was defined as positive if a first-degree male relative (e.g. father, brother) and female relative have cardiovascular disease (e.g., heart attack, high BP, stroke) before the age of 55 or 65 years respectively [21]. It is considered as “negative” if the interviewed person

reported the absence of a specific condition, and/or didn't know whether any relatives had ever been affected with cardiovascular disease. The modified National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATPIII) guidelines [22] were considered, where-in presence of any three following traits in the same individual would meet the metabolic syndrome criteria:-abdominal obesity: waist circumference (WC) ≥102cm (>40in) in men or ≥88cm (>35in) in women; serum triglycerides (TGs): ≥150mg/dl (≥1.7mmol/L); High Density Lipoprotein Cholesterol (HDL-C):<40mg/dl (<1.03mmol/L) in men or <50mg/dl (<1.29mmol/L) in women; fasting blood glucose level: ≥100mg/dl (≥5.6mmol/L); blood pressure (BP):≥130/85mmHg. It further includes those previously diagnosed with hypertension, hyperlipidemia, impaired fasting glucose, impaired glucose tolerance or type 2 diabetes mellitus and being on treatment for these disorders [22]. However, the current study used a correspondence of a WC of 102cm to body mass index (BMI) of ≥29.40kg/$m^2$ defined in a linear regression analysis which is similar to BMI cut-offs used in previous modified NCEP definitions [23].

## 2.4 Measurements

Height was determined using a wall mounted, non extendable measuring tape with subjects standing in an erect barefoot position, arms by side and feet together. The subjects were weighed by standing at the centre of the weighing scale in light clothing with no shoes and socks. BMI was classified into normal (≤24.99kg/$m^2$), overweight (25.00–29.39kg/$m^2$), and obesity (≥29.40kg/$m^2$) [22]. BP was measured using a standard mercury sphygmomanometer and suitable calibrated cuff in the right arm with the subject rested for 5 minutes. An antecubital sample was obtained after 8–10 hours of fasting to measure blood glucose levels using Erba glucose kit (GOD-POD method, end point); TGs by Erba triglyceride Des-kit (GPO-Trinder method, end point); and HDL-C with cholesterol kit (Phosphotungstic acid method, end point).

## 3. RESULTS

The total prevalence of insomnia was 27.64% in the current study; where all subjects (N=351) were divided into two groups on the basis of insomnia symptoms: subjects with inadequate (N=97) and adequate sleep (N=254). Table 1 shows 01.03%, 17.52%, 42.26% and 39.17% of insomniac were in 20-35 years, 36-50 years, 51-65 years and >65 years of age group; and those with adequate sleep had 04.72%, 24.40%, 38.58% and 32.28% for the same age groups, respectively. This shows sleep adequacy declines as the age progresses with a higher prevalence of insomnia (81.43%) among the subjects >50 years (Fig. 1).

Among both sexes, females (52.57%) were reported with a higher frequency of insomnia than males (47.42%). Individuals with no/little, primary, secondary and graduation had 36.08%, 32.98%, 26.80% and 04.12% of insomnia; and 29.13%, 29.52%, 36.22% and 05.11% of them had a normal sleep for the same education categories, respectively. It shows a positive relation between level of education and sleep adequacy. Subjects belonging to upper social class (39.17%) had a higher frequency of insomnia than the middle class subjects. Furthermore, unemployed subjects (75.25%) had been more frequently reported with insomnia as compared to employed subjects (24.74%).

Sedentary lifestyle (16%), hypertension (13%), vegetarian dietary habits (13%), overweight and obesity (12%), non vegetarian dietary habits (9%), family history (8%), stress (7%),

hyperlipidemia (6%), hyperglycemia (6%) and alcohol (4%) were reported in the decreasing order among insomniac (Fig. 2).

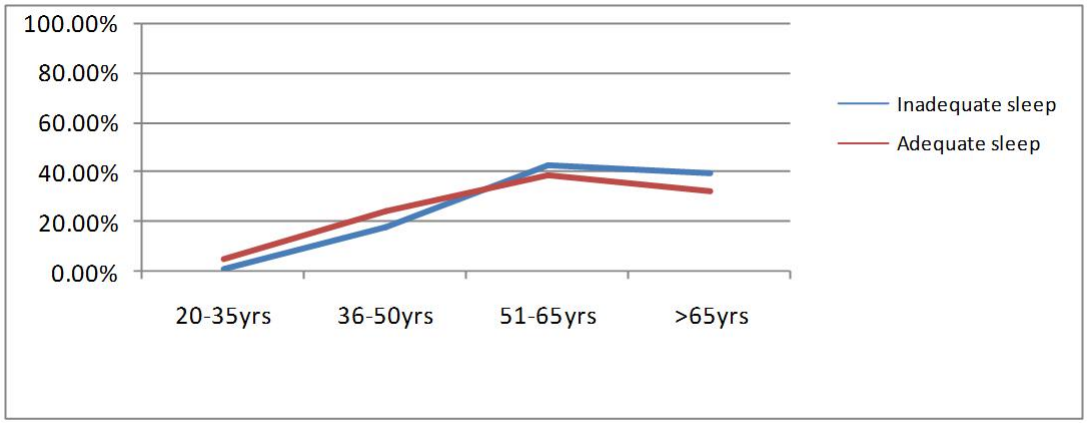


**Fig. 1. Graphical presentation of age specific prevalence of insomnia Inadequate sleep: Sleep duration (<6 hours), trouble falling sleep, multiple and early awakenings, and use of sleeping pills**

**Table 1. Comparisons of socio-demographic variables in all the subjects***

| Category | Inadequate sleep (97) | Adequate sleep (254) | $\chi^2$ value |
|---|---|---|---|
| Age (years) | | | |
| 20-35 | 01.03(01) | 04.72(12) | 5.32 |
| 36-50 | 17.52(17) | 24.40(62) | |
| 51-65 | 42.26(41) | 38.58(98) | |
| >65 | 39.17(38) | 32.28(82) | |
| Sex | | | |
| Male | 47.42(46) | 50.39(128) | .27 |
| Female | 52.57(51) | 49.60(126) | |
| Education | | | |
| No/Little | 36.08(35) | 29.13(74) | 3.38 |
| Primary | 32.98(32) | 29.52(75) | |
| Secondary | 26.80(26) | 36.22(92) | |
| Graduation | 04.12(04) | 05.11(13) | |
| Socio economic status | | | |
| Middle | 60.82(59) | 64.96(165) | .54 |
| Upper | 39.17(38) | 35.03(89) | |
| Occupation | | | |
| Unemployed | 75.25(73) | 68.50(174) | 1.54 |
| Employed | 24.74(24) | 31.49(80) | |

*parentheses represent absolute number of subjects*

Table 2 depicts a statistically significant stress had predisposed the subjects to insomnia (28.86%; *P*<.001) than adequate sleep (15.35%; *P*<.001). Similarly, sedentary lifestyle had shown contribution to insomnia (71.14%) than sound sleep (61.41%). Furthermore, insomniacs (37.11%) were more frequently reported with a positive family history as

compared to subjects with adequate sleep (32.28%). However, subjects under the effects of alcoholic beverages had reported more sound sleep (24.40%) than insomnia (17.52%).

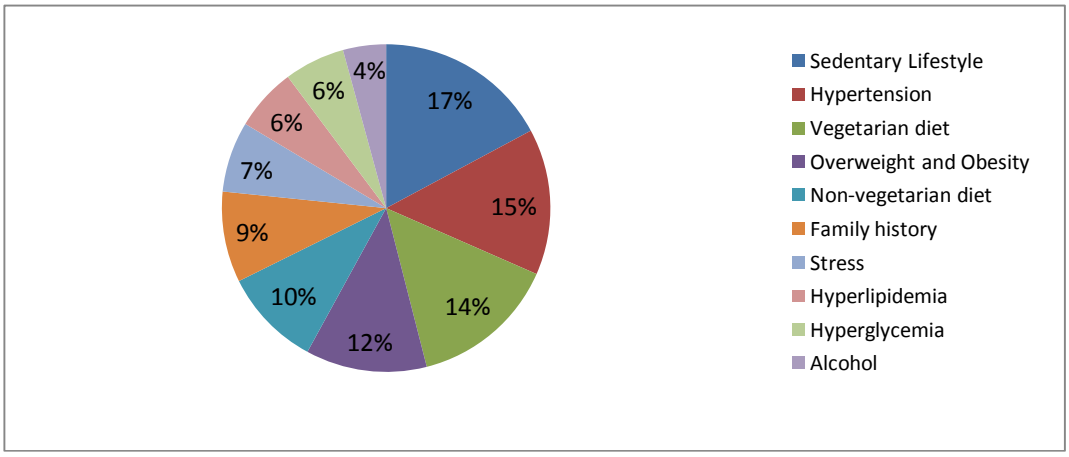


**Fig. 2. Prevalence of cardiovascular risk factors in insomniac**

**Table 2. Comparison of risk factors in subjects with inadequate and adequate sleep***

| Category | Inadequate Sleep (97) | Adequate Sleep (254) | $\chi^2$ value |
|---|---|---|---|
| Body mass index (kg/m$^2$) | | | |
| Normal | 50.51(49) | 40.55(103) | 4.30 |
| Overweight | 27.84(27) | 39.38(100) | |
| Obesity | 21.65(21) | 20.08(51) | |
| Alcohol consumption | | | |
| Current | 17.52(17) | 24.40(62) | 1.93 |
| Never/Ex | 82.47(80) | 75.59(192) | |
| Dietary habits | | | |
| Vegetarian | 59.80(58) | 60.63(154) | .02 |
| Nonvegetarian | 40.20(39) | 39.38(100) | |
| Stress levels | | | |
| Significant | 28.86(28) | 15.35(39) | 8.31 |
| Insignificant | 71.14(69) | 84.64(215) | (<.001) |
| Physical activity | | | |
| Adequate | 28.86(28) | 38.58(98) | 2.90 |
| In adequate | 71.14(69) | 61.41(156) | |

**parentheses represent absolute number of subjects*

50.51%, 27.84% and 21.65% of insomniac were in normal, overweight and obesity ranges; and those with a normal sleep had 40.55%, 39.38% and 20.08% for the same groups, respectively. It shows sleep inadequacy among normal weight, adequate sleep in overweight and no significant differences in obese subjects. Moreover, vegetarians had approximately the same frequency of inadequate and adequate sleep; and the same trend was reported among non-vegetarians. It shows no relation of sleep deprivation with obesity and dietary habits (Table 2).

(Table 3) reveals a statistically significant relation between insomnia and hypertension (59.80%; *P*<.05). Contrarily, the prevalence of metabolic syndrome, hyperglycemia, hyperlipidemia and obesity was approximately the same in both compared groups which shows no effects of sleep deprivation on these variables.

**Table 3. Comparison of the metabolic syndrome and its components in all the subjects***

| Category | Inadequate sleep (97) | | Adequate sleep (254) | | $\chi^2$ value |
|---|---|---|---|---|---|
| | Normal | Diseased | Normal | Diseased | |
| Metabolic Syndrome | 80.42(78) | 19.59(19) | 77.96(198) | 22.05(56) | .24 |
| Hypertension | 40.20(42) | 59.80(55) | 54.72(139) | 45.27(115) | 5.30(<.05) |
| Hyperglycemia | 75.25(73) | 24.74(24) | 76.37(194) | 23.62(60) | .06 |
| Obesity | 78.36(76) | 21.65(21) | 79.93(203) | 20.08(51) | .10 |
| Hyperlipidemia | 74.22(72) | 25.77(25) | 72.04(183) | 27.95(71) | .19 |

**parentheses represent absolute number of subjects*

## 4. DISCUSSION

This survey appears to be the first attempt to comprehensively analyze sleep deprivation in the study area with representative population sample >20 years old. The total prevalence of insomnia was 27.64% in the current study which is found similar to LeBlanc et al. (30.70%) [24]. However, Wong et al. [5] and Beck et al. [25] have found a prevalence of 39.4% and 15.80% in their study population, respectively. This variation might be regarded to differing definitions and timeframes used for the estimation of insomnia among the study population. Furthermore, biases related to diagnostic criteria, interviewing techniques or methodology aspects might have accounted for the gaping discrepancy between the study findings.

An increase in insomnia (Table 1) as age advances from >50 years was found supported by Xiang et al. [4]. Stressful life events related to retirement, supporting children and taking care of parents, progressive physical inactivity, social life dissatisfaction, and concurrent medical and psychiatric problems might be responsible for this rising trend [6,10]. Higher prevalence of insomnia in females than males in the current study has been found consistence to Wong et al. [5] which might be contributed to the differences in the prevalence of psychiatric morbidities, symptom endorsement, gonadal steroids, socio-cultural factors, and coping strategies among both sexes. Ohayon [26] proposed the female/male ratios for insomnia reached their peak after 45 years of age with an underlying menopausal state and increased chronic physical conditions. However, Cappuccio et al. [27] analyzed no gender differences in association with sleep durations and cardiovascular outcomes.

A relation of insomnia with low education level in the present study has been persistence to other studies [4,28]. However, various factors like sedentary jobs, physical inactivity, high mental stress, rich diet, smoking and medical conditions predispose the upper social class to a higher prevalence of insomnia as observed in the current study. Gellis et al. [28] indicated individuals of lower household and education was significantly more likely to experience insomnia even after accounted for ethnicity, gender, and age. Furthermore, Moore et al. [29] observed higher education level was associated with higher income, higher sleep quality, lower psychological distress and better physical health after controlling for age, gender, ethnicity, and prior health status.

A predisposition of unemployment, including retirement, to insomnia in the present study was found supported by Lallukka et al. [30]. The associations between sleep and retirement are complex due to the removal of work-related stressors; however sleep adequacy among disability retirees is poor before and after retirement [30]. Conversely, Utsugi et al. [31] indicated occupational stress as a possible risk factor for insomnia and short sleep. Furthermore, Dahlgren et al. [32] demonstrated a workweek with a high workload and stress increases work hours and sleepiness, impairs sleep, and affects the diurnal cortisol secretion pattern which subsequently result in unwinding; difficulty falling asleep even on feeling sleepier; transient insomnia; and possibly, to chronic insomnia in the long term.

A statistically significant association was found between insomnia and hypertension (59.80%; $P<0.05$) in the current study (Table 3). Similarly, Gottlieb et al. [33] found usual sleep duration above or below the median of 7-8 hours per night is associated with an increased prevalence of hypertension, particularly at the extreme of <6 hours per night.

The current study (Table 2) observed a protective role of alcohol against insomnia which is found consistent to Xiang et al. [4]. Contrarily, Wong et al. [5] found significant association of insomnia with 4-7 times per week alcohol consumption. Furthermore, behavioural studies [34] suggest that up to 2 to 3 standard drinks before bedtime initially promotes sleep, but these effects diminish in as few as 3 days of continued use. Alcohol consumed at bedtime, after an initial stimulating effect, may decrease the time required to fall asleep, however disrupt the second half of the sleep period by multiple awakening from dreams and returning to sleep with difficulty which results in daytime fatigue and sleepiness.

A statistically significant stress had predisposed the present study subjects to insomnia (28.86%; $P<0.001$). Similarly, Charles et al. [35] found that perceived stress was inversely associated with sleep duration and positively associated with poor sleep quality. Furthermore, Joo et al. [36] has shown acute 24 hours sleep deprivation induces increases in the stress hormones, and suggests deprivement itself is the stress-eliciting situation. Sedentary lifestyle had lead to a higher prevalence of insomnia in the present study. Similarly, Silva et al. [37] indicated physical exercise contributed positively to the mood profiles and sleep patterns. Contrarily, Sutton et al. [38] demonstrated no relationship between a sedentary lifestyle and insomnia in their survey.

The present study had found no significant relation of sleep deprivation to metabolic syndrome, obesity, dietary practices, blood glucose, and lipids levels. However, Gottlieb et al. [9] has estimated that short sleep durations were associated with the components of metabolic syndrome through elevated BMIs, higher non-fasting levels of cholesterol and TGs, and higher systolic and diastolic BP. Sutton et al. [38] has further found no association between BMI and sleep. Conversely, Spaeth et al. [39] shows sleep-restriction promotes weight gain through extra calories consumption during days with a delayed bedtime. Furthermore, Santana et al. [40] noticed that individuals with short sleep showed a preference for high energy-density fatty food which further explains the relationship between short sleep and the development of metabolic abnormalities. Moreover, Gislason et al. [41] reported diabetes was associated with near frequent complaints of difficulty in initiating and maintaining sleep, and excessive daytime sleepiness. On the other hand, Andersen et al. [42] demonstrated partial sleep deprivation induced a significant increase in HDL-C and LDL-C, and reduction in TGs and VLDL-C levels. Contrarily, Kaneita et al. [43] showed sleeping <5 hours or >8 hours per night were associated with high TGs or low HDL-C among women. However, the results of no significant relation of sleep deprivation to dietary

practices, blood glucose, and lipids levels in the current study are not consistent with previous findings, and hence must be further explored.

## 5. CONCLUSION

Insomnia and its significant relation with hypertension and stress increases cardiovascular risk which further explains the relation found in other epidemiological studies. Hence, individuals consistently reporting sleeping ≤6 hours per night should be regarded in a higher risk group and appropriate interventions should be commenced by identifying its associations with females, advancing age, sedentary lifestyle, low education level and unemployment.

## 6. STRENGTH AND LIMITATIONS

The cross-sectional design had shown a significant association between insomnia, stress and hypertension but unable to establish the causal link. Insomnia is defined as respondent subjective complaints which may have some elements of recall and self-report bias. The longitudinal prospective designs would help to establish the direction of a cause-effect relationship and minimize the recall bias. However, the prevalence found is valuable to capture the breadth of the insomnia experience outside the clinical purview.

## CONSENT

Authors declare that written informed consent was obtained from all the recruited subjects.

## ETHICAL APPROVAL

Authors declare that this work have been examined and approved by the appropriate ethics committee, and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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