ASSOCIATION BETWEEN AMOUNT OF WATER INTAKE AND QUALITY OF SLEEP IN ADULTS - JEDDAH, SAUDI ARABIA.

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Introduction:
Numerous studies have determined that the bedroom environment as well as lifestyle factors, such as smoking and drinking, can influence sleep. Obesity, hypertension, diabetes and depression, among other diseases, are associated with sleep complaints (1). Sleep has a vital effect on brain functions and many body systems, and neglect of sleep can lead to considerable disadvantages for the individual. Sleep complaints are frequently implicated in problems such as low productivity, risk of accidents and conflict in personal relationships (2,3).

Adequate sleep is required for optimal health (4). Sufficient sleep is linked to mental health, physical activity, and overall quality of life (5-8). In addition, sleep plays an important role in metabolic and emotional regulation, memory consolidation, and learning (9-11). Inadequate sleep has been associated with all-cause mortality, and morbidities (12-17). Epidemiological research suggests that the adequate sleep duration for adults falls between 7 and 8 hours of sleep (18,19). Sleep duration showed a progressive decrease and sleep complaints increased over the last 30 years, hence poor sleep quality has become a widespread problem in modern society (20,21).

A number of serious sleep disorders need to be treated in health care institutions; however, self-management is enough for the majority of cases (22). The bedroom environment and behaviors or activities before bed time are the major controllable risk factors of sleep disorder. Working before going to bed, the use of a mobile phone, noise, lighting, smoking, drinking and caffeine intake have all been implicated in sleep disorders (23-26).

Decreased daily water intake is a problem among the people in countries with hot weather, as is the situation in Saudi Arabia. In Saudi Arabia, several environmental factors, such as hot sunny weather and dry climate, can lead to excessive sweating and subsequently water loss and dehydration. In addition, some diseases may increase water loss e.g. diabetes mellitus, which is relatively common in Saudi population (27, 28).

A study on sleep duration in Saudi Arabia found that about one third of Saudi adults do not get enough sleep (sleep less than 7 hours/night) (29). An earlier study showed that people who increased their daily water intake form less than 1.2 liters up to 2-4 liters experienced increased alertness and lesser sleepiness (30). This may lead to decreased
sleep during the day, which in turn leads to better sleep at night. Hence, the current study was conducted to assess sleep quality and to identify its association with water intake levels in a sample of adults living in Jeddah.

**Methods:**
Study area/setting:
Four different malls located in the East, West, South and North of Jeddah, Saudi Arabia.

Study subjects:
- **Inclusion criteria:**
  Male and female adults living in Jeddah, Saudi Arabia, 1\textsuperscript{st} of December to 31\textsuperscript{st} of December, 2017.

- **Exclusion criteria:**
  - Participants aged less than 18 years old.
  - Participants diagnosed with sleep disorders.
  - Participants who are using diuretics.
  - Participants who are using sleep medications.

Study design:
A cross-sectional study based on a questionnaire survey.

Sample size:
Out of Jeddah city population 3,457,794, we recruited 278 participants to be 90% confident with 5% margin of error.

Sampling technique:
We used a convenience sampling technique.

Data collection methods, instruments used and measurements:
We designed a brief questionnaire to assess the amount of water intake per day in adults. The questionnaire was pilot-tested by a sample. It was then revised based on reproducibility, validity, and question value. Changes and modifications were made based on the pilot results. The survey was administered during a 1-month period via direct communication to enhance response rates. We used Pittsburgh Sleep Quality Index (PSQI) to assess sleep quality (31).

Data management and analysis plan:
Data analysis was carried out using SPSS version 22. All numerical variables were checked for normality by Shapiro Wilk test. Normally distributed variables were expressed as means ± standard deviation and differences between groups were tested by Student's unpaired T test. Abnormally distributed variables were expressed as median and interquartile range (25th - 75th percentile) and mean ranks were calculated for differences testing using Mann-Whitney test. Categorical variables were summarized as frequencies and percentages and association between variables was tested using Pearson's Chi square or Fisher-Freeman-Halton Exact Tests as appropriate. A p-value of < 0.05 was considered statistically significant.

Ethical considerations:
Ethical approval was taken from IRB of King Abdullah International Medical Research Center before carrying out the study. An informed consent was obtained from each participant before entering the study. The confidentiality of information was strictly maintained.

**Results:**
In this study, 278 participants responded to the questionnaire. Table 1 shows the demographic data and the pattern of water intake of the respondents. The age of respondents ranged from 18 to 70 years with an average 30 ± 10 years. Slightly more than half the respondents were males (54.3%); and nearly one third had a night work (34.9%). The highest frequency of respondents drink less than 1000 ml per day (31.7%), followed by those taking 1000-1999 ml/day (29.9%), then 2000-2999 (23%), and the least frequency consumed 3000 or more daily (15.5%). The majority (79.9%) was used to drink caffeine beverages; among them 49.1% had one or less cup per day and 42.8% had 2 to 4 cups daily. The majority did not suffer from chronic diseases (93.2%). Half the respondents practiced exercise; among them 70.5% exercised for 4 hours or less weekly, 25.2% had exercise for 5 to 10 hours per week,
and only 4.3% for more than 10 hours weekly. Figure 1 shows that only 28.8% of respondents had adequate sleep duration (7 to 8 hours), while 57.9% had shortened sleep (less than 7 hours).

Table 2 demonstrates the minimum, maximum, median, and interquartile range for the seven components of PSQI questionnaire and its global score. Figure 2 illustrates that nearly half the respondents (48%) had PSQI global score 6 or more; indicating poor sleep quality.

Table 3 shows the relationship between global PSQI score and the respondents’ demographic data and water consumption pattern. The score was significantly higher in those taking less than 1000 ml/day versus 3000 or more ml/day (Median 7, 5; mean ranks 161.3, 106.6; p <0.003). There were no significant differences in global PSQI as regards different categories of gender (p = 0.889), night work (p = 0.141), caffeine intake (p = 0.154), caffeine cups/day (p = 0.085), and hours of exercise/week (p = 0.345).

Table 4 illustrates the relationship between water intake and the different components of PSQI score. Decreased water intake was significantly and adversely related to worse subjective sleep quality (p = 0.016), habitual sleep deficiency (p = 0.003), sleep disturbance (p = 0.003), and daytime dysfunction (p = 0.018).

**Discussion:**
This study addressed an important issue that was previously understudied; that is the relationship between water intake and the quality of sleep. We found that the highest percentage of adults in Jeddah, Saudi Arabia were used to take less than 1000 ml of water per day (31.7%), followed by those taking 1000-1999 ml/day (29.9%), then 2000-2999 (23%), and the least percentage consumed 3000 or more daily (15.5%). This amount is below the daily water needs of adults. An adult needs 2.5 L if sedentary; and 3.2 L if performing modest physical activity (32-35). More active adults living in a warm environment have daily water needs of about 6 L (36). Mild dehydration was reported to increase fatigue, decreased activity, and was associated with sleepiness (37-42).

In this study, only 28.8% of respondents had adequate sleep duration (7 to 8 hours), while 57.9% had shortened sleep; with average of 7 hours. This average duration of sleep is in agreement to studies in general populations in Britain and students from Palestine, Korea, Iran, Germany, China, and Nigeria that reported an average duration of night sleep < 8 hours, usually in the range of 6 to 7 hours (43-50). However, the percentage of respondents with shortened sleep duration is much higher than reported in other studies in Saudi Arabia (31 - 33.8%), and in other studies worldwide (24.1% - 41.6%) (51-55).

Nearly half the respondents (48%) in this study had poor sleep quality as indicated by global PSQI score. Poor sleep quality has been associated with poor academic achievement and health, as well as increased health care costs and absenteeism from work (56). This prevalence among the adults in Jeddah city is much higher than those reported by other studies (26–35% using the PSQI) (57-59). However, one of the limitations in our study was the non-inclusion of the respondents’ occupations in the study questionnaire; and this may have contributed to this high prevalence of poor sleep quality in our study. A proportion of the respondents may have been university students; and this category is known to suffer from stress due to the burden of studying and examinations (49, 60-62); with a prevalence of poor sleep quality in this population having been reported to range from 19.17% to 57.5% (63, 64). Despite the high prevalence of bad sleep quality among the respondents in our study, chronic diseases were reported in a small percentage only. Mental and physical disorders were associated with poor sleep quality (58).

In the present study, the PSQI score showed a tendency to decrease with the increased intake of water; with a significantly higher score in those taking less than 1000 ml/day versus 3000 or more ml/day. Decreased water intake was significantly and adversely related to worse subjective sleep quality, habitual sleep deficiency, sleep disturbance, and daytime dysfunction. Increased water intake may result in decreased sleep during the day; which in turn lead to better sleep at night. This finding is supported by previous studies that showed a positive effect of water consumption on alertness (42, 65, 66).

As sleep quality is likely to be affected by other factors, we evaluated the effect of gender, night work, caffeine beverages, and exercise on the PSQI global score. We found that the majority of respondents were used to drink caffeine containing drinks; about half of them had one or less cup/day and 42.8% had 2 to 4 cups daily. Caffeine is a methylxanthine that acts as a mild CNS stimulant. It exerts its central effects mainly by inhibiting adenosine, resulting in increased alertness (67-69). Caffeine administration is usually achieved by drinking beverages such as...
tea, coffee, and energy drinks. The caffeine content varies among the different beverages, according to plant source and method of preparation (70). In this study, there were no significant differences in global PSQI as regards caffeine intake or the number of caffeine cups/day. This result agrees with Engleman et al. who found that regular caffeine intake during the day, with the last dose before bedtime by adequate period, did not significantly affect sleep (71). On the other hand, some studies reported that caffeinated coffee increases sleep onset latency, decreases total sleep time and adversely affects sleep quality (62, 72-76). However, most of these studies have evaluated the effects of caffeine that has been consumed just before bedtime; which does not resemble the actual, everyday pattern of caffeine consumption (77). Moreover, habitual intake of caffeine, as is the case in a considerable proportion of Saudi adults, is reported to result in tolerance to caffeine effects (78). Hindmarch et al. found some indication that those individuals whose sleep was most disrupted had the lowest habitual caffeine consumption levels; and concluded that infrequent use of caffeine was likely to enhance sensitivity to caffeine effects (75).

In this study, half the respondents practiced exercise; among them 70.5% exercised for 4 hours or less weekly, 25.2% had exercise for 5 to 10 hours per week, and only 4.3% for more than 10 hours weekly. The sleep quality was not significantly affected by the hours of exercise weekly, a finding that was reported also by other studies (79-82). The absence of significant relationship between sleep quality and hours of exercise/week may be due to the low level of exercise practice among Saudis which was elicited in this study as well as previous studies (83). Other studies have shown that active adolescents were more likely to get high sleep duration compared with inactive peers (7, 84-87).

In this study, there was no effect of gender on sleep quality. This contradicts previous studies that showed poorer quality of sleep of females in university and young adults (62, 88-92). Other studies in Saudi Arabia showed either no effect of gender or higher risk of poor sleep in males (93). This difference between the results conducted in Saudi Arabia and other countries is probably due to the conservative nature of Saudi society where females are not allowed to stay late outside home.

**Conclusion:**
It appears that the quality of sleep improves with increased water intake per day. The quality of sleep was not significantly affected by gender, night work, caffeine intake and amount, and hours of exercise per week. The general public should be educated about the benefits of adequate water intake daily, particularly those who suffer from sleep disturbances.

**Strengths:**
This study possessed many points of strengths. We used the PSQI tool to decrease the subjectivity in rating of sleep quality. The sample size was adequate and explored the adult population, which was not studied previously, particularly in Saudi Arabia.

**Limitations:**
This study was subject to some limitations. There was difficulty in specifying the type of caffeinated beverage and the usual times of their intake during the day. Different types of beverages have variable content of caffeine and each type can affect the quality of sleep differently. The effects of some lifestyle factors that affect the quality of sleep - such as the occupation of the respondents, cigarette smoking, heavy drinking, and excessive Internet usage - were not investigated, which may throw light on the causes of high prevalence of poor sleep quality.

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**Table 1:** Demographic data of respondents and water intake (total N = 278).

| Age (years)       | Minimum - Maximum | 18 - 70 | 30 ± 10 |
|-------------------|-------------------|---------|---------|
| Gender            |                   |         |         |
| Male              | 151               | 54.3%   |         |
| Female            | 127               | 45.7%   |         |
| Night work        |                   |         |         |
| No                | 181               | 65.1%   |         |
| Yes               | 97                | 34.9%   |         |
| Water per day (ml)|                   |         |         |
| < 1000            | 88                | 31.7%   |         |
| 1000 - 1999       | 83                | 29.9%   |         |
| Caffeine intake (e.g., tea, coffee, energy drinks) | Yes | 222 | 79.9% |
| Caffeine Cups/day | ≤ 1 | 109 | 49.1% |
| | 2 - 4 | 95 | 42.8% |
| | ≥ 5 | 18 | 8.1% |
| Chronic diseases | None | 259 | 93.2% |
| | Allergic rhinitis | 1 | 0.4% |
| | Anemia | 1 | 0.4% |
| | Asthma | 2 | 0.8% |
| | Diabetes mellitus | 3 | 1.2% |
| | Hypertension | 1 | 0.4% |
| | Dyslipidemia | 1 | 0.4% |
| | Gout | 1 | 0.4% |
| | Hypothyroidism | 4 | 1.6% |
| | IBS | 1 | 0.4% |
| | Sinusitis | 2 | 0.8% |
| Exercise per week (hours) | None | 139 | 50.0% |
| Yes | ≤ 4 | 139 | 50.0% |
| | 5 - 10 | 98 | 70.5% |
| | > 10 | 35 | 25.2% |

SD: standard deviation; IBS: irritable bowel syndrome.

Figure 1: Sleep duration in the respondents. Adequate duration is 7 to 8 hours, shortened sleep is < 7 hours, and prolonged sleep > 8 hours.

Table 2: Components and global score of Pittsburgh Sleep Quality Index (PSQI).

| Component | Minimum | Maximum | Median | IQR |
|-----------|---------|---------|--------|-----|
| Subjective sleep quality | 0 | 3 | 1 | 0 - 1 |
| Sleep latency | 0 | 3 | 1 | 0 - 2 |
| Sleep duration | 0 | 3 | 1 | 0 - 2 |
| Habitual sleep deficiency | 0 | 3 | 0 | 0 - 1 |
| Sleep disturbance | 1 | 3 | 2 | 2 - 2 |
| Use of sleep medications | 0 | 0 | 0 | 0 - 0 |
Component 7 daytime dysfunction

Global PSQI score

IQR: interquartile range

Figure 2: Sleep quality of the respondents according to PSQI score (poor sleep quality ≤ 6).

Table 3: Relationship of global PSQI score and demographic and water consumption pattern.

|                      | Global PSQI score |
|----------------------|-------------------|
|                      | Median | Mean ranks | p       |
| Gender               |         |            |         |
| Male                 | 6.00   | 138.9      | 0.889   |
| Female               | 6.00   | 140.2      |         |
| Night work           |         |            |         |
| No                   | 6.00   | 134.3      | 0.141   |
| Yes                  | 7.00   | 149.1      |         |
| Water ml/day         |         |            |         |
| < 1000               | 7.00   | 161.3      | 0.003*  |
| 1000 - 1999          | 6.00   | 137.9      | Significant difference between <1000 & ≥ 3000 |
| 2000 - 2999          | 6.00   | 133.8      |         |
| ≥ 3000               | 5.00   | 106.6      |         |
| Caffeine intake      |         |            |         |
| No                   | 6.00   | 125.9      | 0.154   |
| Yes                  | 6.50   | 142.9      |         |
| Caffeine cups/day    |         |            |         |
| ≤ 1                  | 6.00   | 102.1      | 0.085   |
| 2 - 4                | 7.00   | 121.9      |         |
| ≥ 5                  | 7.00   | 113.6      |         |
| Hours of exercise/ week |       |            |         |
| None                 | 6.00   | 145.6      | 0.345   |
| ≤ 4                  | 6.00   | 130.9      |         |
| 5-10                 | 7.00   | 145.4      |         |
| > 10                 | 5.00   | 104.2      |         |

*significant at p <0.05.

Table 4: Effect of water intake on components of Pittsburgh Sleep Quality Index score.

| Water intake (ml/day) | Component 1 Subjective sleep quality | Component 2 Sleep |
|----------------------|-------------------------------------|-------------------|
|                      | Median | Mean ranks | Median | Mean ranks | Median | Mean ranks | Median | Mean ranks | p     |
| < 1000               | 1      | 157.0 | 1 | 133.2 | 1 | 140.3 | 1 | 114.7 | 0.016** |
| 1000 - 1999          | 1      | 137.5 | 1 | 137.4 | 1 | 154.5 | 1 | 128.4 | 0.259   |
| Component | 3 Sleep latency | 1  | 145.7 | 1  | 139.3 | 1  | 129.8 | 1  | 141.5 | 0.652 |
|-----------|----------------|----|--------|----|--------|----|--------|----|--------|-------|
| Component | 4 Habitual sleep deficiency | 0  | 150.3 | 0  | 143.5 | 0  | 137.1 | 0  | 113.2 | 0.020** |
| Component | 5 Sleep disturbance | 2  | 159.8 | 2  | 131.1 | 2  | 134.5 | 2  | 121.7 | 0.003* ab |
| Component | 6 Use of sleep medications | 0  | 139.5 | 0  | 139.5 | 0  | 139.5 | 0  | 139.5 | 1.000 |
| Component | 7 Daytime dysfunction | 1  | 154.3 | 1  | 145.6 | 1  | 128.4 | 1  | 114.1 | 0.018* a |

*significant at p <0.05; a: significant differences between <1000 & ≥ 3000; b: significant differences between <1000 & 1000 - 1999.

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