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# The Nexus between the Sleeping Time, Water Consumption and the Body Mass Index

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Authors MADP and SMML carried out the measurements taking and collected data through a questionnaire. Author MADP did the complete statistical analysis under the guidance of supervisors' authors JAW and SW. Author JAW wrote the manuscript with the literature survey. Author SW performed the internal review. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** A healthy Body Mass Index (BMI) is widely regarded as important for overall health that helps to avert and control many adverse health effects. It is also known that the sleep deprivation and dehydration have a strong impact on healthy life and sleep deprivation is common among university students and has been associated with poor academic performance. We aim to study the relationship between sleep deprivation and dehydration with BMI.
**Study Design:** Data collection and statistical analysis.
**Place and Duration of Study:** University of Peradeniya, Sri Lanka, between September 2017 and March 2018.
**Methodology:** We examined the association of daily sleeping time and daily water consumption with the Body Mass Index among 452 university students of age 24-26 years and 326 females, and 126 males consented to participate in the study. A cross-tabulation analysis was used to identify the relationship between water consumption and daily sleeping time with BMI.
**Results:** Results of the chi-square test show that there is a significant association between BMI

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and sleeping time of the students as the calculated chi-square value of 13.771 was significant as p is 0.008 at 4 degrees of freedom. Results of phi and Cramer's V measures of association show that the correlation coefficient between BMI and sleeping time is 0.175 with a p-value of 0.008. Also between BMI and water consumption of the students, the calculated chi-square value of 11.538 was significant as P is 0.021 (<0.05) at 4 degrees of freedom. Results of phi and Cramer's V measures of association show that the correlation coefficient between BMI and water consumption as 0.160 with a *p*-value of 0.021.

**Conclusion:** The phi measure of symmetric coefficient shows a significant positive association; that is the students who are consuming more water are prone to fall in higher BMI category while students consume less water falls to lower BMI. The phi measure of symmetric coefficient shows a significant positive association; that is the student who gets less sleep are prone to fall in higher BMI category while students take long sleep a day falls to lower BMI.

*Keywords: BMI; water consumption; sleeping time; chi-square test; significance difference.*

## 1. INTRODUCTION

Body weight and its perception is an important aspect of health and BMI values above or below the normal range, confers an increased risk of developing cardiovascular disease, type 2 diabetes mellitus, osteoarthritis, and certain forms of cancer [1]. Although there is no agreement on interventions that are more sufficient to being in normal BMI, the approaches have made on changing lifestyle, nutritional education and promotion of physical activity [2]. Anderson et al. [3] investigated body mass index (BMI) in the university students in the final grade of a junior/senior college level course and established a significant association between BMI and the academic performance. Moreover, various research has been carried out to find a relation between social factors and obesity [4]. While there is growing literature as a part of a range of beverages and food on health in BMI maintenance, water in supporting health remains scarce.

A very limited scientific evidence is available to justify the efficacy of water intake facilitate if one attempting weight loss treatment [5]. Human magnetic resonance imaging studies have confirmed that 40 minutes after consumption, only 25% of the ingested water remains in the stomach [6]. As short-term effects, water consumption increases satiety, reduces the feeling of hunger and slightly increases energy expenditure [7]. Kant et al. [8] found that adjusted plain water consumption was higher in adults of higher BMI groups. Further studies have been proposed that energy intake is significantly lower in water drinkers compared with less water drinkers [9]. However, a mechanism for how the water consumption influencing the body weight changes are still scars and needs further exploration.

More recently, sleep has been identified as a health manner that may play a role in weight gain. Because of the time constraints and lifestyle, lack of sleep increasingly induces health risks. Yet the studies aimed to establish a relationship between the sleeping disorders and BMI is scarce in the literature. Peltzer et al. [2] investigated cross-cultural differences in the association between sleep duration and BMI, among young adults from 24 low and middle-income countries. They found that there is a significant association between short sleep duration and increased BMI. Peltzer et al. [2]'s findings were in agreement with the earlier study conducted by Bjorvatn et al. [10]. Nevertheless, Grandner et al. [11] in their study claimed that the association between sleep duration and BMI depends on age. Further, studies have shown a correlation between short sleep to type 2 diabetes, (central) obesity and metabolic syndrome [12]. Young adults leaving their family to join college experience, undergo health-related behavioural changes including unhealthy dietary habits [13]. To assess the diverse factors that students are ignorant on, there is a need for research in this area.

The primary aim of the present study is to explore the impact of the amount of water consumption below and above the usual intake, and the sleeping time per day, on the body mass index (BMI) of humans. Section 2 of this paper presents the Methodology in two subsections; key aspects in data preparation and statistical analysis. Section 3 illustrates the results of statistical analysis. Finally, section 4 provides a summary, and concluding remarks resulted from the study.

## 2. METHODOLOGY

University students are considered to be an important segment of the population, and a sample of 452 respondents was selected by the systematic random method. They were full-time undergraduate students in the age interval of 20 to 27. There were 326 females and 126 males. Primary data including the age, meal types, siblings, geographical area of origin, average water consumption and sleeping time were gathered through a questionnaire. Body height and the weight were measured to calculate the BMI. The BMI was derived from body weight divided by the square of body height. Participants were from ages

### 2.1 Data Preparation

The Avery weighing scale was used for the measurement of the body weight of each subject, while a standard meter ruler was used to measure the height of each subject. The data collected were arranged in line with WHO body mass classification chart [14] under the categories of < 18.5 Underweight, 18.5 – 25 Normal weight, 25 - 30 Over weight, and >30 – Obese. The data is summarized in Fig. 1. The observations reveal that the majority of students belong to normal BMI category, approximately one fourth falls below the normal BMI category and the remnant are above the normal BMI. However for the analysis of data we have considered three categories of BMI, viz., $< 18.5$ Underweight, $18.5 - 25$ Normal Weight, and $> 25$ Overweight. Fig. 2(a) and 2(b) shows the observed data in bar charts for the sleeping time, which is categorized as $< 6\ Hrs\ less, 6 - 8\ Hrs\ normal, > 8\ Hrs\ over$ . The water consumption was categorized as $< 500ml, 500ml - 1l, and > 1l$ respectively.

As shown in the bar-charts students fall in normal BMI range when they have long slept a day, and also students who take less sleep tend to fall into abnormal BMI category. Further, the students who are having higher the water consumption then the BMI falls within abnormal range.

### 2.2 Statistical Analysis

The statistical analysis of the data was performed independently using Statistical Packages for Social Sciences (SPSS). The data were analyzed with descriptive statistics, chi-square, and Cramer's V test analysis at .05 alpha levels. To this end we set the null and alternative hypotheses, $H_0$ : There is no statistically significant association between two variables among college students and $H_1$: There is a statistically significant association between two variables among college students. In the first case of this hypothesis, the dependent variable is BMI, and the independent variable is sleeping time. That is, the two variables form a $3 \times 3$ contingency table or 9 cells. In the second case of this hypothesis, the dependent variable is BMI, and the independent variable is daily water consumption. That is, the two variables form a $3 \times 3$ contingency table or 9 cells, and thus we use the chi-square test of association to examine the effect of water consumption on students' BMI and also for a sleeping time on students' BMI. Set alpha at 0.05 and reject $H_0$ only if p<= 0.05. No more than 20 percent of cells should have expected frequencies of less than five cases per cell. Table 1(a) and 1(b) displays the observed and expected counts and 100 percent of expected frequencies are greater than five in both cases. A total of 452 participated in well-being study thus exceeding the minimum requirement. The Chi-square test of association was utilized to examine the association between,

The case I: BMI and sleeping time,

Case II: BMI and water consumption, among a sample of 452 university students.

However, there can be various reasons for the water consumption and sleeping time which in turn replicate the BMI change. Hence, as a major factor for the water consumption we analyzed the water consumption relation with exercise time per day. The cross-tabulation of water consumption and exercise time is given in Table 2.

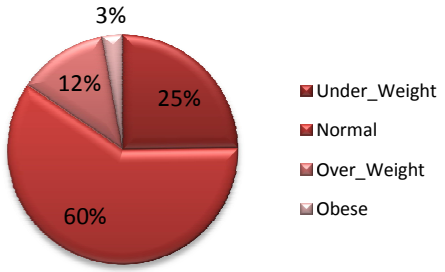


**Fig. 1. The BMI as a percentage of the sample size**

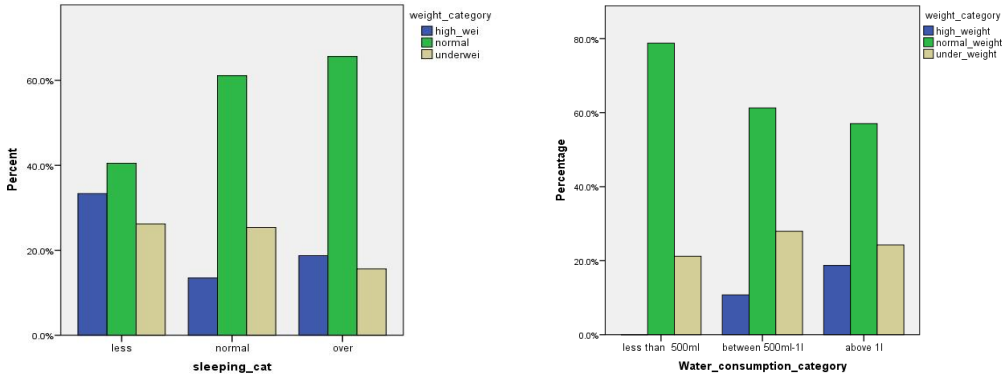


**Fig. 2. (a) Sleeping time, and (b) Water Consumption, as a percentage of sample size for three weight categories**

**Table 1. Cross tabulation showing expected count is 100% over five. (a) Sleeping time, and (b) water consumption**

| Water_consumption_category x weight_category crosstabulation | | | | | |
|---|---|---|---|---|---|
| Water consumption | | Weight_category | | | Total |
| | | High | Normal | Under | |
| > 1 l | Count | 61 | 186 | 79 | 326 |
| | Expected Count | 51.2 | 194.0 | 80.8 | 326.0 |
| | % of Total | 13.5% | 41.2% | 17.5% | 72.1% |
| 500 ml-1 l | Count | 10 | 57 | 26 | 93 |
| | Expected Count | 14.6 | 55.3 | 23.0 | 93.0 |
| | % of Total | 2.2% | 12.6% | 5.8% | 20.6% |
| <500 ml | Count | 0 | 26 | 7 | 33 |
| | Expected Count | 5.2 | 19.6 | 8.2 | 33.0 |
| | % of Total | 0.0% | 5.8% | 1.5% | 7.3% |
| Total | Count | 71 | 269 | 112 | 452 |
| | Expected Count | 71.0 | 269.0 | 112.0 | 452.0 |
| | % of Total | 15.7% | 59.5% | 24.8% | 100.0% |

(a)

| Sleeping_cat x weight_category crosstabulation | | | | | |
|---|---|---|---|---|---|
| Sleeping time | | Weight_category | | | Total |
| | | High | Normal | Under | |
| less | Count | 14 | 17 | 11 | 42 |
| | Expected Count | 6.6 | 25.0 | 10.4 | 42.0 |
| | % of Total | 3.1% | 3.8% | 2.4% | 9.3% |
| normal | Count | 51 | 231 | 96 | 378 |
| | Expected Count | 59.4 | 225.0 | 93.7 | 378.0 |
| | % of Total | 11.3% | 51.1% | 21.2% | 83.6% |
| over | Count | 6 | 21 | 5 | 32 |
| | Expected Count | 5.0 | 19.0 | 7.9 | 32.0 |
| | % of Total | 1.3% | 4.6% | 1.1% | 7.1% |
| Total | Count | 71 | 269 | 112 | 452 |
| | Expected Count | 71.0 | 269.0 | 112.0 | 452.0 |
| | % of Total | 15.7% | 59.5% | 24.8% | 100.0% |

(b)

## 3. RESULTS AND DISCUSSION

Inspection shows that 0 cells have an expected frequency less than 5 in each case. Results of the chi-square test presented in Table 3 show that there is a significant association between BMI and sleeping time of the students as the calculated chi-square value of 13.771 was significant as *p* is 0.008 (<0.05) at 4 degrees of freedom. This implies that water consumption relates to the BMI of the population. Results of phi and Cramer's V measures of association show that the correlation coefficient between BMI and sleeping time is 0.175 with a p-value of 0.008. Also, the results reveal that there is a significant difference in the students as the calculated Cramer's V value of 0.123 was significant as $p < 0.05$. The phi measure of symmetric coefficient shows a significant positive association; that is a student who gets less sleep are prone to fall in higher BMI category while students take long sleep a day falls to lower BMI. However, the sleeping time accounted for only about 3 percent of the variance in BMI, thus indicating a weak relationship between the two variables.

Inspection shows that those 0 cells have an expected frequency less than 5 in each case. Results of the chi-square test are presented in Table 4 show that there is a significant association between BMI and water consumption of the students as the calculated chi-square value of 11.538 was significant as P is 0.021 (<0.05) at 4 degrees of freedom. This implies that water consumption relates to the BMI of the population. Results of phi and Cramer's V measures of association show that the correlation coefficient between BMI and water consumption as 0.160 with a *p*-value of 0.021. Also, the results indicate that there is a significant difference in the students as the calculated Cramer's V value of 0.113 was significant as $p < 0.05$. The phi measure of symmetric coefficient shows a significant positive association; that is the students who are consuming more water are prone to fall into higher BMI category while students consume less water falls to lower BMI. However, the water consumption accounted for only about 3 percent of the variance in BMI, pointing to a weak relationship between the two variables.

Further the statistical analysis of water consumption and exercise time revealed that there is no correlation between them as $p > 0.05$ as shown in Table 5.

Therefore the exercise time is not considered as a factor of water consumption and hence its indirect affect on BMI. Further analysis revealed that 76% students live in-campus and therefore treated to be under similar diet and all students are taking three meals a day and hence meal plan can be treated to be same and under similar life-style.

**Table 2. Cross tabulation is showing water consumption and exercise time**

| Exercise category * water_consumption_category crosstabulation | | | | | |
|---|---|---|---|---|---|
| Exercise_category | | Water_consumption_category | | | Total |
| | | Above 1 l | Bet 500 ml-1l | Less 500 ml | |
| greater 1hr | Count | 24 | 9 | 2 | 35 |
| | % Exercise_category | 68.6% | 25.7% | 5.7% | 100.0% |
| | % Water_cons_cat | 7.4% | 9.7% | 6.1% | 7.7% |
| | % of Total | 5.3% | 2.0% | 0.4% | 7.7% |
| less 1hr | Count | 42 | 14 | 7 | 63 |
| | % Exercise_category | 66.7% | 22.2% | 11.1% | 100.0% |
| | % Water_ cons_cat | 12.9% | 15.1% | 21.2% | 13.9% |
| | % of Total | 9.3% | 3.1% | 1.5% | 13.9% |
| No | Count | 260 | 70 | 24 | 354 |
| | % Exercise_category | 73.4% | 19.8% | 6.8% | 100.0% |
| | % Water_cons_cat | 79.8% | 75.3% | 72.7% | 78.3% |
| | % of Total | 57.5% | 15.5% | 5.3% | 78.3% |
| Total | Count | 326 | 93 | 33 | 452 |
| | % Exercise_categor | 72.1% | 20.6% | 7.3% | 100.0% |
| | % Water_cons _cat | 100.0% | 100.0% | 100.0% | 100.0% |
| | % of Total | 72.1% | 20.6% | 7.3% | 100.0% |

**Table 3. A chi-square test of association and symmetric measures of the association of BMI and sleeping time**

| | Value | Df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson chi-square | 13.771[a] | 4 | .008 |
| Likelihood ratio | 12.258 | 4 | .016 |
| N of valid cases | 452 | | |
| a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.03. | | | |

| | | Value | Approx. Sig. |
|---|---|---|---|
| Nominal by nominal | Phi | .175 | .008 |
| | Cramer's V | .123 | .008 |
| N of valid cases | | 452 | |

**Table 4. A chi-square test of association and symmetric measures of the association of BMI and water consumption**

| | Value | Df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 11.538[a] | 4 | .021 |
| Likelihood Ratio | 16.601 | 4 | .002 |
| N of Valid Cases | 452 | | |
| a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.18. | | | |

| | | Value | Approx. Sig. |
|---|---|---|---|
| Nominal by Nominal | Phi | .160 | .021 |
| | Cramer's V | .113 | .021 |
| N of Valid Cases | | 452 | |

**Table 5. A chi-square test of association and symmetric measures of the association of exercise time and water consumption**

**Chi-square tests**

| | Value | Df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 2.555[a] | 4 | .635 |
| Likelihood Ratio | 2.367 | 4 | .669 |
| N of Valid Cases | 452 | | |
| a. 2 cells (22.2%) have expected count less than 5. The minimum expected count is 2.56. | | | |

**Symmetric measures**

| | | Value | Approx. Sig. |
|---|---|---|---|
| Nominal by Nominal | Phi | .075 | .635 |
| | Cramer's V | .053 | .635 |
| N of Valid Cases | | 452 | |

## 4. CONCLUSIONS

In the present study, an attempt was made to examine the effect of daily average water consumption and daily sleeping time on BMI. To our knowledge, this is the first investigation of this theme to be reported in the literature. Moreover, age-related weight gain which may cause due to a reduction in energy expenditure [15] need not to be addressed as the sample is between the ages (24-27 years). Data analysis revealed that the majority of students (~60%) were in normal BMI category, about one fourth fell below the normal BMI, and the remnant stayed above the normal BMI. Moreover, the normal BMI percentage increases with sleeping time and decreases with water consumption. Therefore a statistical analysis was conducted to test the hypothesis that the BMI has an association with water consumption and the sleeping time. Results from the statistical analysis implicated that the increase in sleeping time would be associated with the decrease in standardized BMI and, short sleeping time would be associated in with increased standardized BMI. Furthermore, this study establishes the influence of excessive water drinking to weight gain. Although the increased water consumption is known to help a healthier life, the outcome of this study shows this may lead to overweight.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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