ORIGINAL ARTICLE

ASSOCIATION BETWEEN WATER INTAKE AND ANTHROPOMETRIC MEASUREMENTS: A CROSS SECTIONAL STUDY AMONG A SAMPLE POPULATION OF PAKISTANI DENTAL STUDENTS

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Background: Role of water is well known as an essential nutrient in human health. Lifestyle medicine researches have shown high prevalence of inadequate hydration habits globally. In this study, the relationship of daily water intake with anthropometric measurements in young adults of a particular geographical location were observed. **Methods:** This cross-sectional study was conducted on 259 undergraduate students of Islamic International Dental College (IIDC), from September 2021 to February 2022. To assess daily water intake, an online questionaire was filled, whereas anthropometric measurements were done according to the recommendations of the International Standards for Anthropometric Assessment. Associations of Body Mass Index (BMI) with Waist Circumference (WC), Waist/Hip Ratio (WHR), Abdominal Circumference (AC), and Daily Water Intake (DWI) were analyzed by multiple linear regression analysis. One-way ANOVA was also used to determine the relationship of DWI with BMI, WC, AC and WHR, and considered significant at $p \leq 0.05$. **Results:** One-way ANOVA analysis showed statistically significant differences in the mean values of BMI (F=6.0, p=0.001) and WC (F=7.5, p<0.001) and no significant difference was found in the mean value of WHR (F=2.0, p=0.10) between the different DWI groups. Post hoc Tukey's test followed by ANOVA revealed that BMI, WC, and WHR were statistically lower among students having adequate daily water intake (21.0±3.8 Kg/m^2, p=0.001; 79.2±9.7 Cm, p<0.001; and 0.78±0.04, p=0.013 respectively). **Conclusion:** Significant association was found between adequate daily water intake and lower values of BMI, WC and WHR.

Keywords: Obesity, General obesity, Central obesity, Daily water intake, Body Mass Index, Waist circumference, Waist/Hip ratio, Abdominal circumference, Obesity, Water intake, Body mass index

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INTRODUCTION

Worldwide incidence of overweight and obesity has been rising significantly in the past 30 years, contributing to several co-morbidities and several deaths.[1,2] Pakistan has been ranked at 9th position in obesity in the world.[3]

Various anthropometric parameters such as body mass index (BMI), waist circumference (WC), abdominal circumference (AC) and waist/hip ratio (WHR) are consistent predictors of obesity.[4] General obesity can be defined as an elevated BMI ≥30 Kg/m^2 and central obesity measured by considering WC and WHR >102 Cm and ≥0.90 in men, and >88 Cm and ≥0.85 in women.[5] BMI is the most common measure of general obesity. However, BMI alone is an insufficient biomarker to properly assess and manage abdominal obesity-related health risk that's why inclusion of additional anthropometric parameters of central obesity are recommended by international health organizations.[6] Central obesity is recognised as an independent risk factor for cardio-metabolic diseases and a better predictor of a wide range of risk factors and related health conditions.[7] WC and WHR are an inexpensive method of measurement that is considered a rational marker of intra-abdominal fat and central obesity contributes to shortened life span and several health conditions.[8]

A recent study from Karachi, demonstrated the rising incidence of obesity among medical students.[9] Abdominal circumference measurements have been slowly emerging as a promising way to size up your overall health and an effective method to diagnose patients with metabolic syndrome.[10] Drinking adequate water is an important tool to maintain body weight and body fat distribution.[8] Water accounts for 60–70% of total body mass and drinking proper amount of water is essential for healthy weight maintenance in adult females with sedentary activity level as well as physical and mental performance.[11] Significant daily water intake should be 2.5–3 L in adults.[12] Chronic dehydration is associated with significant deterioration of cognitive and physical performance, as well as general health among students. Adequate hydration status may increase the rate of lipolysis and energy expenditure leading to weight loss.[13] Moreover, recent studies documented unfavourable outcomes of dehydration on cognitive performances.[14]

The aims of this study were to explore the associations between water intake and anthropometric variables and secondly, to assess adequate water intake

(2–3 L/day) and hypohydration status among students of Islamic International Dental College, Pakistan to bring awareness of keeping ourselves well hydrated.

METHODOLOGY

This cross-sectional study involved 259 medical students, aged 17–23 years, and was conducted between September 2021 and February 2022 at Biochemistry and Physiology Laboratories of the Islamic International Dental College, Riphah International University, Islamabad, Pakistan. Prior approval was obtained from the Institutional Ethical Review Committee of Riphah International University Islamabad. All participants provided informed written consent prior to study enrolment.

A well designed 'hydration status questionnaire' was used online to assess their daily water intake. The inclusion criteria was mentally and physically healthy medical students of age 18–24 years. Students who suffered from any abnormalities related to hydration status were excluded.

Anthropometric evaluation included height (CM), weight (Kg), BMI, waist circumference (Cm), abdominal circumference (Cm), and waist hip ratio using standardised methods. The anthropometric measures were executed according to the International Standards for Anthropometric Assessment (ISAK).[15] Body mass index (BMI) was calculated as weight in kilograms divided by the square of the body height in meters (Kg/m^2), and classified as underweight (<18.5 Kg/m^2), normal (18.5–24.9 Kg/m^2), over-weight (25–29.9 Kg/m^2), and obese (30 Kg/m^2 or above)[16].

WC was measured using a non-stretch tape measure and taken at the midpoint between the costal margin and iliac crest of the subject. According to WHO criteria, central obesity was defined as WC ≥94 Cm for men and ≥80 Cm for women and WHR ≥0.90 in men and ≥0.85 in women. WHR was measured by dividing WC (Cm) with hip circumference (HC in Cm). HC was taken at the level of the trochanter major. AC was measured as a horizontal circumference at the midpoint between the lower border of the rib cage and iliac crest.

Data analysis was carried out using SPSS-25. Descriptive statistics of continuous variables (Mean±SD) were analyzed on Student's *t*-test. Association between categorical study and outcome variables were analyzed using Pearson Chi-square test, and $p<0.05$ was considered statistically significant. Multiple regression was performed to determine correlation of BMI with hydration status, age, along with other anthropometric variables. For the descriptive variables, one-way analysis of variance model was used to estimate the unadjusted means in each category of daily fluid intake. The associated *p*-values were derived from the ANOVA F-statistics.

RESULTS

A total of 259 medical students, 179 (69.1%) females with a mean age of 19.41±1.2 (18–23) years and 80 (30.9%) males with a mean age of 19.93±1.2 (18–23) years, participated in the study. The degree of relationship between general obesity (defined by BMI) and central obesity (defined by WC, WHR and AC) along with daily water intake was assessed among males, females and in total subjects (Table-1).

The prevalence of general obesity (overweight and obese) was 23.9%, the prevalence of central obesity (WC, WHR and AC) was 18.5%, 25.9% and 23.2% respectively. There were 56.4% medical students who were drinking water inadequately.

There was a significant association of gender with BMI ($x^2(3)=11.2$, $p=0.01$), WHR ($x^2(3)=22.3$, $p<0.005$), WC ($x^2(3)=6.2$, $p=0.04$), AC ($x^2(3)=20.2$, $p=0.005$) and DWI ($x^2(3)=8.0$, $p=0.04$) (Table-2). Indicator of general obesity, BMI was at higher level (29.6%) in females as compared to males (11.3%) ($p=0.01$). This difference is more pronounced for central obesity (WC, WHR and AC), where its prevalence among females was more than double that of males (22.3% *vs* 10%, $p=0.04$; 33% *vs* 10.1%, $p<0.005$; and 26.8% *vs* 12.8%, $p<0.005$).

The multiple regression model was successful in predicting BMI outcome with predictors WC, AC, age and hydration status (Table-3). Multiple correlation coefficient between BMI and predictor variables was $R=0.62$ and $R^2=0.39$. The positive β coefficient indicates that for every one-unit increase in the AC and WC, the BMI will increase by 0.80 Kg/m^2 and 0.11 Kg/m^2 respectively. Students who were inadequately hydrated had a mean BMI of 1.29 Kg/m^2 (95% CI: 0.44–2.14, $p=0.003$) more than adequately hydrated students, on average. Similarly, older students also had higher BMIs and were more likely to be obese than younger students.

Table-4 provides descriptive statistics for medical students according to their daily water intake (DWI). Students were divided into 4 different groups according to their DWI (Group 1: 0.5–1 L, Group 2: 1–1.5 L, Group 3: 1.5–2 L, Group 4: 2–3 L).

One-way ANOVA showed statistically significant difference in the mean value of BMI ($F(3,255)=6.9$, $p=0.001$), WC ($F(3,255)=6.5$, $p<0.001$) and WHR ($F(3,255)=3.6$, $p=0.013$), but no significant differences were found in the mean value of AC ($F(3,255)=0.65$, $p=0.582$ between different DWI groups. Tukey's post hoc test revealed that BMI and WC were lower among both DWI Group 4 (21.0±3.8 Kg/m^2, $p=0.05$ and 78.8±8.6 Cm, $p=0.012$ respectively) and Group 3 (20.7±3.1 Kg/m^2, $p=0.008$ and 79.2±9.1 cm, $p=0.005$ respectively) but WHR was lower in DWI Group 4 only (0.78±0.04, $p=0.03$).

Table-1: Demographic and Anthropometric characteristics of the medical students

Variables	All subjects (n=259)	Males (n=80)	Females (n=179)	*p*
Age (Yr)	19.58±1.3 (18–23)	19.9±1.2 (18–23)	19.4±1.2 (18–23)	<0.005
Height (Cm)	165.5±4.4 (154.4–172.6)	168±3.2 (166.4–172.6)	156.2±2.8 (154.4–158.8)	<0.005
Weight (Kg)	60.23±8.72 (46.2–68.7)	64.42±5.50 (59.2–68.7)	49.75±5.24 (46.2–54.7)	<0.005
BMI (Kg/m^2)	21.85±3.6 (14–31)	22.3±3.3 (16–30)	21.6±3.08 (14–31)	<0.005
WC (Cm)	81.9±9.9 (61–108)	85.5±8.4 (70–108)	80.3±10.2 (61–108)	<0.005
AC (Cm)	1.6±1.2 (0.0–6.4)	1.4±1.3 (0.0–6.2)	1.5±1.0 (0.0–6.4)	<0.005
WHR	0.80±0.5 (0.60–0.96)	0.86±0.03 (0.80–0.96)	0.78±0.04 (0.60–0.88)	<0.005

Table-2: Association of gender with various categories of anthropometric parameters along with daily water intake [n (%)]

Variables		Total (n=259)	Males (n=80)	Females (n=179)	value	Sig. (2-sided)
BMI* (Kg/m^2)	Under weight	58 (22.4)	18 (22.5)	40 (22.3)	11.2	0.01
	Normal	139 (53.7)	53 (66.3)	86 (48.0)		
	Overweight	51 (19.7)	7 (8.8)	44 (24.6)		
	Obese	11 (4.2)	2 (2.5)	09 (5.0)		
WC (Cm)	Low Risk	46 (17.8)	18 (22.5)	28 (15.6)	5.2	0.04
	Moderate Risk	165 (63.7)	54 (67.5)	111 (62.0)		
	High Risk	48 (18.5)	8 (10.0)	40 (22.3)		
AC (Cm)	Very Low	114 (44.0)	50 (62.5)	62 (34.6)	17.9	<0.001
	Low risk	85 (32.8)	20 (25)	69 (38.5)		
	High Risk	60 (23.2)	10 (12.5)	48 (26.8)		
WHR	Normal	59(22.8)	30 (37.5)	29 (16.2)	22.3	<0.001
	Low risk	133 (51.4)	42 (52.5)	91 (50.8)		
	Moderate risk	58 (22.4)	7 (8.8)	51 (28.5)		
	High risk	09 (3.5)	1 (1.3)	08 (4.5)		
DWI	0.5–1 L	17 (6.6)	1 (1.3)	16 (8.9)	8.0	0.04
	1–1.5 L	129 (49.8)	40 (50)	89 (49.7)		
	1.5–2 L	83 (32.0)	32 (40)	51 (28.5)		
	2–3 L	30 (11.6)	7 (8.8)	23 (12.8)		

Table-3: Multiple regression model with BMI as the dependent variable

Anthropometric parameters	*p*	β (95% CI)
WC (Cm)	<0.001	0.11 (0.06–0.16)
AC	<0.001	0.83 (0.45–1.21)
WHR	0.11	5.82 (-1.43–13.08)
Inadequate hydration	0.003	1.29 (0.44–2.14)
Age	0.01	0.37 (0.09–0.66)

Table-4: Correlation Analysis of daily water intake and anthropometric parameters

Variables	DWI 0.5–1 L (n=35)	DWI 1–1.5 L (n=69)	DWI 1.5–2 L (n=110)	DWI 2–3 L (n=45)	F	*p*
BMI (Kg/m^2)	23.7±3.5	22.4±3.9	21.4±3.0	21.0±3.8	6.0	0.001
95% CI	21.9–25.6	21.4–22.8	20.3–21.6	19.9–22.8		
WC (Cm)	87.8±7.8	82.9±10.1	80.1±9.5	79.2±9.7	6.5	<0.001
95% CI	83.8–91.9	81.1–84.7	78.0–82.2	75.6–82.9		
AC (Cm)	1.6±0.9	1.6±1.2	1.4±1.0	1.5±1.0	0.6	0.582
95% CI	1.1–2.1	1.3–1.8	1.2–1.6	1.2–1.9		
WHR	0.82±0.05	0.81±0.05	0.79±0.05	0.78±0.04	3.6	0.013
95% CI	0.80–0.85	0.80–0.82	0.78–0.81	0.76–0.79		

DISCUSSION

We determined BMI along with WC, WHR and AC as a screening tool and for predicting overweight, general and central obesity, and compared these anthropometric parameters with daily water intake in a local sample of the Pakistani medical students. The findings revealed that among the study population, 4.2% were obese, 19.7% were overweight. Similarly, 18.5% and 23.2% of total subjects were having high WC and AC showing increase tendency towards central obesity. The results are in line with previous studies conducted at different cities of Pakistan, such as Lahore (i.e., 21% overweight or obese medical students)[17], Karachi (14.8% overweight and 18.4% obese medical students)[9], and Peshawar (29.6 overweight and 8.0% obese).[18]

BMI is a predictor of cardiovascular disease and mortality being the most common parameter to estimate general obesity.[19] According to our results, the prevalence of overweight and general obesity defined by BMI, is more pronounced among females (29.6%) as compare to males (11.3%). A similar study showed that adult females have higher rates of obesity as compare to males (13.6% *vs* 9.5%).[20]

WC and AC are an effective parameter to assess obesity and has been proven to be a strong predictor of BMI.[21] In line with the findings of previous research[22], this study showed that the prevalence of central obesity among females (22.3%, 33% and 26.8% based on WC, WHR and AC) was higher than in males (10%, 10.1% and 12.5%). This means that in a general population of young adults, WC, WHR and AC arte more correlated to metabolic disturbances and cardiovascular disease in females than in males. Abdominal circumference could be just as important as WC and WHR to signify visceral adiposity and increased cardiometabolic risk.[23]

This study described the effect of daily water intake on body measurements of the subjects. Based on the adequacy of consumption, 105 (58.6%) female students had inadequate daily intake of water as compare to 41 male students (51.3%). Students who did not meet the hydration criteria had statistically significant higher BMI, WC, and WHR as inadequacy of water may be responsible for higher body fat accumulation and central adiposity. Furthermore, insufficient water intake may also lead to learning difficulties and poor concentration.[24] Our results indicate that increased water consumption is associated with increased sensations of fullness which is translated as satiety induced reduction in body mass index, waist circumference and waist/hip ratio. This effect may be due to in part to an acute meal reduction following water consumption.[25]

A similar cross-sectional study was conducted in Spain with a sample size of 188. They also found statistically significant association of higher water intake with BMI, body fat and waist circumference.[26]

In our study, correlation analyses showed that adequate water intake was directly associated with overall obesity and central obesity irrespective of gender. These findings may bring to light the important role of

water consumption to reduce the risk of weight gain in both genders.

Our study has a few specific limitations; the collected data was cross-sectional and cannot be used to infer causation, sample size was small, it was a single-centred study, the time of water consumption like before, during, or after meals and the temperature of consumed water (warm or cold) was not taken into account.

CONCLUSION

Significant inverse association of water intake, more pronounced in female students, was found with BMI, WC, and WHR; no significant association was found with AC. Since anthropometric measurements are related to metabolic syndrome and other related chronic disorders, this correlation at an early age highlights the significance of adequate WI. Further work on role of hydration status in maintaining optimal body mass index and body fat accumulation in healthy young adults is recommended.

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