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Association between body mass index and urinary tract infections: A cross-sectional investigation of the PERSIAN Guilan cohort study

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Abstract

Introduction: There is a relationship between excess body weight and the risk of a number of infectious diseases, including urinary tract infections (UTIs). This study aimed to investigate the correlation between body mass index (BMI) and UTIs among Prospective Epidemiological Research Studies of the Iranian Adults (PERSIAN) Guilan Cohort Study (PGCS) population.

Methods: This cross-sectional study was conducted on 10,520 individuals aged 35–70 years from PGCS. The demographical data and clinical characteristics of the participants were recorded. Microscopic examination of the urine samples was performed to detect the presence of bacteria or white blood cells (WBC) as indicators of infection. UTI was defined as the presence of bacteria in the urine (Few, moderate, and many) and a value of ≥10 WBC/high power field (HPF) by light microscopy.

Results: The prevalence of UTIs in this study was 8.8%, with a higher incidence in females compared to males (12.2% vs. 4.7%, $p < 0.001$). Among participants, the prevalence of UTIs across different weight categories was as follows: underweight/normal weight, 7.1%; overweight, 8.1%; and obesity, 10.9%. According to the unadjusted model, subjects with obesity were at significantly higher odds for UTIs than subjects with underweight/normal BMI (OR = 1.62, 95% CI: 1.35–1.93, $p < 0.001$). However, this association was no longer significant after adjusting for demographic and clinical variables.

Conclusion: The findings of this study provide evidence supporting a higher prevalence of UTIs among individuals with obesity.

KEYWORDS

bacteriuria, BMI, Pyuria, urinary tract infections

1 | INTRODUCTION

Obesity is a detrimental health condition that negatively affects overall well-being and quality of life.[1] Projected trends suggest a significant increase in the rates of obesity and overweight in developing countries, particularly in the Middle East. As a result, the Middle Eastern population faces a substantial burden of non-communicable diseases.[2] Obesity is a major public health concern that is strongly associated with a range of chronic conditions, such as cardiovascular diseases, diabetes, arthritis, gallbladder disorders, and specific cancers.[3,4] Notably, a high body mass index (BMI) is linked to an increased risk of acquiring infectious diseases, such as skin infections, bloodstream infections, respiratory infections, and urinary tract infections (UTIs).[5,6] Additionally, elevated BMI is associated with higher incidences of septic shock, ventilator-related pneumonia, and catheter-related sepsis.[7,8] Individuals with uncontrolled BMI are thought to be more vulnerable to infections due to adverse effects on the immune system, respiratory function, pharmacokinetics, and pharmacodynamics.[9,10]

UTIs are a common clinical problem, accounting for about 1%–6% of medical consultations. These infections can affect the bladder and kidneys.[11] UTIs may present with symptoms or remain unnoticed, in a condition known as asymptomatic bacteriuria, where individuals show no specific symptoms.[12] UTIs can range from mild, easily treatable conditions to severe, life-threatening diseases, such as pyelonephritis, which can lead to sepsis and renal failure.[13,14] UTIs and their associated complications are responsible for an estimated 150 million deaths globally each year.[15] However, the widespread use of antibiotics has led to the emergence of antibiotic resistance, a global health crisis that threatens the effectiveness of these life-saving drugs.[16,17] Moreover, antibiotics are not without side effects, including gastrointestinal disturbances, allergic reactions, and the disruption of normal microbiota, which can lead to further health complications.[18,19] Investigating the risk factors associated with UTIs is crucial for developing effective prevention strategies.[20]

Recognized risk factors for UTIs include age, sexual activity, family history, medical comorbidities, and a personal history of UTIs.[21] However, the relationship between BMI and UTIs has not been thoroughly studied, with several aspects of this connection remaining uncharted. Epidemiological research has investigated the potential link between obesity and an elevated risk of UTIs, but the findings have been inconsistent and contradictory.[22,23] Furthermore, many of these studies did not sufficiently control for various confounding variables. In light of the significant impact of obesity on public health and the established correlation between elevated BMI and increased risk of infectious diseases, including UTIs, there is a pressing need to further elucidate the relationship between BMI and UTIs. Understanding this relationship is not only crucial for the development of targeted prevention strategies but also for the broader management of UTIs and the judicious use of antibiotics. By examining the role of BMI in the context of UTIs, this research has the potential to inform clinical practice, public health policies, and future research directions in the field of infectious diseases and obesity. Therefore, this study investigates the association between UTIs, BMI, and the relevant risk factors in the PGCS population.

2 | MATERIALS AND METHODS

2.1 | Participants and study design

This cross-sectional study was carried out on 10,520 individuals from the PGCS population in Guilan, Iran.[24,25] The pregnancy, history of hospitalization or surgery in the last 4 months, a disorder in the urinary system such as cytopathic or recent manipulation of the urinary system, a history of taking antimicrobial medications in the last 2 weeks, a history of taking corticosteroid medication in the last 3 months, any immunodeficiency problems, and individuals using urinary bags were excluded from the study. Demographic and clinical data, including age, gender, marital status, education level, employment status, wealth score index (WSI) habitat, smoking, opium, use of alcohol, physical activity, BMI, and number of underlying diseases, were surveyed. Physical activity was assessed using metabolic equivalent of task (MET) values and categorized into three tertiles: low (<36.1 MET-hours/day), medium (36.1–42.8 MET-hours/day), and high (>42.8 MET-hours/day). This classification was based on the total number of hours per day spent on activities such as walking, work-related tasks, and exercise.

In addition, standard anthropometric measurements were taken, including weight (kg) and height (cm). BMI was then calculated and used to classify participants into the following categories: underweight (BMI <18.5 kg/m_2), normal weight (BMI 18.5–24.99 kg/m^2), overweight (BMI 25–29.9 kg/m^2), and obese (BMI ≥30 kg/m^2). Following a fasting period of 12–14 h overnight, a blood sample was obtained between 7 and 9 in the morning to assess fasting blood sugar (FBS). Blood glucose levels were determined at the central laboratory of the cohort using a Biotecnica auto-analyzer (BT1500). Diabetes was defined as FBS ≥126 mg/dL or a history of diagnosis with diabetes or taking medication. Additionally, fasting morning urine samples were collected from all participants (except for the first urine sample of the day) to obtain midstream urine. The urine samples were under a microscope (Olympus CX21) for bacteria or white blood cells (WBC), which are signs of infection. UTI was defined as the presence of bacteria in the urine (Few, moderate, and many), and a value of ≥10 WBC/high power field (HPF) by light microscopy.[26,27]

2.2 | Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were reported as frequency (percentage). Differences in continuous and categorical variables between participants with and without UTIs were assessed using independent *t*-tests and chi-square tests, respectively. Logistic regression analysis was performed to examine the associations between BMI and UTI. Separate analyses were performed, treating BMI as a continuous variable (per 1-point increase) and categorical variable. Odds ratio (OR) and 95% confidence interval (CI) were calculated. O.R.s were also adjusted for demographic characteristics. Model 1 was unadjusted; Model 2 was adjusted for sex; Model 3 was adjusted for sex, age, marital status, education, employment, habitat, WSI, physical activity, smoking, alcohol consumption, and number of morbidities. All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp.). The significance level was set at 0.05. The study protocol was approved by the ethics committee of the Guilan University of Medical Sciences [I.R.GUMS.REC.1402.381], and all participants provided informed consent.

3 | RESULTS

3.1 | Characteristics of the participants

Table 1 presents the demographic and clinical characteristics of the study participants. The mean age was 51.52 ± 8.90 years, and 53.6% were female. The majority (90.6%) were married, 6.1% had a university education, 54.5% were employed, and 56.2% were rural residents. Regarding health-related factors, 32.7% had a BMI greater than 30 kg/m^2, 24.6% were current smokers, 13.3% consumed alcohol, and 71.9% had at least one chronic disease. The mean total BMI was 28.14 ± 5.09 kg/m^2 and were 28.06 ± 5.06 kg/m^{2,} and 29.03 ± 5.25 kg/m^2 in individuals with and without UTIs, respectively.

Comparisons of characteristics between individuals with and without UTIs are presented in Table 1. Patients with UTIs tended to be younger, predominantly female, more frequently divorced, and more often unemployed. They reported less frequent smoking and lower consumption of alcohol, a lower level of education, a higher BMI, and engaged in less physical activity. Additionally, patients with UTIs were more likely to have underlying chronic medical conditions.

3.2 | BMI distribution and prevalence of UTIs

The distribution of BMI was as follows: underweight, 141 (1.3%); normal, 2746 (26.1%); overweight, 4198 (39.9%); and individuals with obesity, 3435 (32.7%). BMI was significantly higher in females compared to males ($p < 0.001$). The overall prevalence of UTIs in this study population was 8.7%, but the condition was markedly more prevalent among females versus males (12.2% vs. 4.7%, $p < 0.001$) (Table 2).

3.3 | Prevalence of UTIs by BMI categories

As presented in Table 3, the prevalence of UTIs among participants with underweight/normal, overweight, and obesity was 7.1%, 8.1%, and 10.9%, respectively. The prevalence of UTIs increased with increasing BMI ($p < 0.001$).

3.4 | Treating BMI as a continuous variable

As presented in Table 3, the unadjusted model (Model 1) showed that for every 1-unit increase in BMI, the odds of having a UTI increased by 4.0% (OR = 1.04, 95% CI: 1.02–1.05, $p < 0.001$). However, this association between higher BMI and increased UTI risk was no longer statistically significant after adjusting for sex in Model 2 (OR = 1.00, 95% CI: 0.99–1.02, $p = 0.673$). These results indicate that the variable 'sex' is likely acting as a confounder in the relationship between 'BMI' and 'UTI'. Furthermore, after adjusting for a broader set of demographic and clinical variables in the fully adjusted Model 3, there was no significant independent association detected between BMI and UTI risk (OR = 1.00, 95% CI: 0.99–1.02, $p = 0.860$).

3.5 | Treating BMI as a categorical variable

The unadjusted model (Model 1) showed that individuals with obesity (BMI>30 kg/m^2) had significantly higher odds of having a UTI than those with underweight or normal BMI (OR = 1.62, 95% CI: 1.35–1.93, $p < 0.001$). However, this association between obesity and increased UTI risk was no longer statistically significant after adjusting for the variable of sex in the model (OR = 1.04, 95% CI: 0.86–1.26, $p = 0.650$). The non-significant relationship was also obtained after adjusting for demographic and clinical variables (see Table 3).

4 | DISCUSSION

This study aims to explore the association between obesity and UTIs in Northern Iran among a large population of PGCS. One of the main findings of this study was the association between UTIs and obesity, so an upward trend in the prevalence of UTIs was observed with increasing BMI. In the current study, the overall prevalence of UTIs in the population was 8.7%. According to the Meta-Analysis study of Khatony et al., the overall prevalence of UTIs in older Iranians was 26.8% compared to the study population.[28] The prevalence of UTIs was higher in the cities of Tehran (34.0%) and Kermanshah (19.5%)[29,30] but lower among the population of Kashan (7.6%).[31] However, it is important to note that the prevalence of UTIs can vary significantly based on factors such as population characteristics, diagnostic criteria, or genetics.[32]

The findings demonstrated a higher prevalence of UTIs in women than in men. This gender difference has been extensively reported and is often explained by anatomical distinctions. Women have a shorter urethra that is situated nearer to the anus, which facilitates

TABLE 1 Demographic and clinical characteristics of the participants in the PERSIAN Guilan Cohort Study.

		UTIs		
	Total *n* (%) *n* = 10,520	No *n* (%) *n* = 9601	Yes *n* (%) *n* = 919	*p*
Age (years)				<0.001
35–44	3139 (29.8)	2808 (29.2)	331 (36.0)	
45–54	3854 (36.6)	3558 (37.1)	296 (32.2)	
≥65	3527 (33.5)	3235 (33.7)	292 (31.8)	
Mean ± SD	51.52 ± 6.63	51.61 ± 8.86	50.57 ± 9.21	<0.001
Sex				<0.001
Male	4887 (46.5)	4657 (48.5)	230 (25.0)	
Female	5633 (53.5)	4944 (51.5)	689 (75.0)	
Marital status				0.020
Single	305 (2.9)	276 (2.9)	29 (3.2)	
Married	9527 (90.6)	8710 (90.7)	817 (88.9)	
Widow	566 (5.4)	513 (5.3)	53 (5.8)	
Divorced	122 (1.1)	102 (1.1)	20 (2.2)	
Education (years)				0.007
Illiterate	1738 (16.5)	1589 (16.6)	149 (16.2)	
1–5	3312 (31.5)	2996 (31.2)	316 (34.4)	
6–12	4832 (45.9)	4412 (46.0)	420 (45.7)	
University	638 (6.1)	604 (6.3)	34 (3.7)	
Mean ± SD	6.63 ± 4.52	6.65 ± 4.54	6.34 ± 4.28	0.047
Employment				<0.001
Unemployed	4781 (45.4)	4238 (44.1)	543 (59.1)	
Employed	5739 (54.6)	5363 (55.9)	376 (40.9)	
Habitat				0.187
Urban	4613 (43.8)	4229 (44.0)	384 (41.8)	
Rural	5907 (56.2)	5372 (56.0)	535 (58.2)	
Wealth score index				0.199
Tertile 1	3507 (33.3)	3191 (33.2)	316 (34.4s)	
Tertile 2	3506 (33.3)	3185 (33.2)	321 (34.9)	
Tertile 3	3507 (33.3)	3225 (33.6)	282 (30.7)	
Mean ± S.D. (z score)	0 ± 1	0.01 ± 1.00	−0.08 ± 0.97	0.013
BMI (kg/m2)				<0.001
Underweight	141 (1.3)	134 (1.4)	7 (0.8)	
Normal	2746 (26.1)	2549 (26.6)	197 (21.4)	
Overweight	4198 (39.9)	3859 (40.2)	339 (36.9)	
Obese	3435 (32.7)	3059 (31.9)	376 (40.9)	
Mean ± SD	28.14 ± 5.09	28.06 ± 5.06	29.03 ± 5.25	<0.001
Physical activity (using MET)				0.004
Tertile 1	3507 (33.3)	3163 (32.9)	344 (37.4)	
Tertile 2	3506 (33.3)	3196 (33.3)	310 (33.7)	
Tertile 3	3507 (33.3)	3242 (33.8)	265 (28.8)	

TABLE 1 (Continued)

	Total n (%) n = 10,520	UTIs No n (%) n = 9601	UTIs Yes n (%) n = 919	p
Mean ± SD	41.26 ± 8.88	41.36 ± 8.93	40.22 ± 8.30	<0.001
Smoking	2584 (24.6)	2452 (25.5)	132 (14.4)	<0.001
Hookah smoking	1515 (13.3)	1309 (13.6)	86 (9.4)	<0.001
Number of morbidity				0.014
0	2952 (28.1)	2725 (28.4)	227 (24.7)	
1	3263 (31.0)	2986 (31.1)	277 (30.1)	
2	2276 (21.5)	2061 (21.5)	206 (22.4)	
≥3	2038 (19.4)	1829 (19.1)	209 (22.7)	

Abbreviations: BMI, Body Mass Index; KSD, Kidney Stone Disease; SD, Standard Deviation.

TABLE 2 Distribution of body mass index and prevalence of urinary tract infection among the participants in the PERSIAN Guilan Cohort Study.

	BMI category				Prevalence of UTIs
	Underweight n (%)	Normal n (%)	Overweight n (%)	Obesity n (%)	n (%)
Total	141 (1.3)	2746 (26.1)	4198 (39.9)	3435 (32.7)	919 (8.7)
Sex					
Male	110 (2.3)	1894 (38.8)	2095 (42.9)	788 (16.1)	230 (4.7)
Female	31 (0.6)	852 (15.1)	2103 (37.3)	2647 (47.0)	689 (12.2)
p	<0.001				<0.001

Note: p-value is based on the chi-square test.
Abbreviations: BMI, Body Mass Index; UTIs, Urinary Tract Infections.

TABLE 3 Relationship between body mass index and urinary tract infection among the participants in the PERSIAN Guilan Cohort Study.

	Prevalence of UTIs		Model 1 (unadjusted)		Model 2		Model 3	
	n/N	%	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
BMI (per 1-point increase)			1.04 (1.02–1.05)	<0.001	1.00 (0.99–1.02)	0.673	1.00 (0.99–1.02)	0.860
BMI category								
Underweight/Normal	204/2887	7.1	1 (ref.)		1 (ref.)		1 (ref.)	
Overweight	339/4198	8.1	1.16 (0.96–1.38)	0.117	0.94 (0.78–1.13)	0.528	0.93 (0.77–1.12)	0.441
Obesity	376/3435	10.9	1.62 (1.35–1.93)	<0.001	1.04 (0.86–1.26)	0.650	1.02 (0.84–1.24)	0.836

Note: Two separate analyses were performed: (1) treating BMI as a continuous variable (per 1-point increase) and (2) BMI as a categorical variable. Model 1: Unadjusted model. Model 2: Adjusted for sex. Model 3: Adjusted for sex and age, marital status, education, place of residency, occupation, wealth score index, physical activity, smoking, alcohol consumption, and number of morbidities.
Abbreviations: BMI, Body Mass Index; CI, Confidence Interval; OR, Odds Ratio; UTIs, Urinary Tract Infections.

the entry of bacteria into the urinary tract.[33,34] Hormonal factors and the presence of vaginal flora also contribute to a higher susceptibility to UTIs in women.[11] These findings align with various studies that have consistently shown a higher prevalence of UTIs in women compared to men.[35,36] Moreover, the highest prevalence of UTIs was observed in individuals with obesity, and the risk of UTI increased by 4.0% for each unit increase in BMI compared to individuals with normal or lower weight. These results are in line with emerging evidence that suggests obesity may be a risk factor for UTIs. Some studies have reported findings similar to those of the current study, showing a positive association between obesity and UTIs.[37,38] These studies have suggested several mechanisms to explain this relationship. Obesity is linked to altered immune function, chronic low-grade inflammation, and changes in the urinary microbiome, which may heighten susceptibility to UTIs.[39,40] However, it is important to acknowledge that not all studies have consistently demonstrated a strong association between obesity and UTIs.

Nassaji et al. did not find an association between BMI and UTI and do not support obesity as a risk factor for UTIs in adult patients.[23] Saliba et al. demonstrated that obesity is independently associated with UTIs in men, suggesting a significant dose-response relationship. In women, there was a non-significant trend toward increased odds of UTIs, which was confined to BMIs of 50 kg/m^2 or higher.[41] Additionally, Ribera et al. found that obesity is linked exclusively to UTIs in males.[41] This study presents a significant advantage by investigating the association between UTIs and obesity in a large population cohort. Additionally, it explores the influence of demographic and clinical confounding variables using a distinct model. However, one of the study limitations is the lack of urine culture analysis among the participants, which is recommended for future studies to investigate the prevalence of bacterial UTIs and the pattern of antimicrobial resistance. In addition, the related risk factors for the severity of UTI were evaluated.

5 | CONCLUSION

In conclusion, the current study supports a higher prevalence of UTIs among individuals with BMI ≥30 kg/m^2, so the prevalence of UTIs showed an ascending trend with the increase in BMI. Additionally, BMI is seemingly linked to a heightened susceptibility to UTIs. Nevertheless, additional investigation is warranted to ascertain whether this association signifies a cause-and-effect relationship. However, these findings hold potential relevance for healthcare practitioners attending to individuals with obesity.

AUTHOR CONTRIBUTIONS

Sonbol Taramian, Fariborz Mansour-Ghanaei and Saman Maroufizadeh participated in the research concept and design. Sonbol Taramian, Farahnaz Joukar and Fateme Sheida participated in writing the first draft. Sonbol Taramian and Farahnaz Joukar participated in the performance of the research and analytic tools. Saman Maroufizadeh and Soheil Hassanipour participated in data analysis. All authors reviewed and confirmed the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

CONSENT FOR PUBLICATION

Not applicable.

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