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Urination Frequency Ranges in Healthy Women

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Ethical Conduct of Research

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Abstract

Background: Limited information on the normal range of urination frequencies in women is available to guide bladder health promotion efforts.

Objectives: This study used data from the Boston Area Community Health (BACH) Survey to (a) estimate normative reference ranges in daytime and nighttime urination frequencies in healthy women based on two operational definitions of “healthy”, and (b) compare urination frequencies by age, race/ethnicity, and fluid intake.

Methods: Secondary analysis of cross-sectional interview data collected from female participants was performed using less restrictive (“healthy”) and strict (“elite healthy”) inclusion criteria. All analyses were weighted to account for the BACH sampling design. Normative reference values corresponding to the middle 95% of the distribution of daytime and nighttime urination frequencies were calculated overall and stratified by age, race/ethnicity, and fluid intake. Generalized linear regression with a log-link was used to estimate rate ratios of daytime and nighttime urination frequencies by age, race/ethnicity, and fluid intake.

Results: Of the 2,534 women who completed the BACH follow-up interviews, 1,505 women met healthy eligibility criteria, and 300 met elite healthy criteria. Overall, reference ranges for urination frequencies were 2–10 times/day and 0–4 times/night in healthy women and 2–9 times/day and 0–2 times/night in elite healthy women. Women ages 45–64 years, but not 65+ years, reported a greater number of daytime urination than those aged 31–44 years, while women 65+ years reported a greater number of nighttime urination. Black women reported fewer daytime urination and more nighttime urinations than White women. Women who consumed less than 49 oz daily reported fewer daytime and nighttime urinations than those who drank 50–74 oz; drinking 75+ oz had only a small effect on urination frequencies.

Discussion: Normative reference values for daytime and nighttime urination frequencies were similar in women using strict and relaxed definitions of health. These results indicate a wide range of “normal” urination frequencies, with some differences by age, race/ethnicity, and fluid intake. Future research is needed to examine urination frequencies in minority women and whether fluid intake amount and type influence the development of lower urinary tract symptoms.

Keywords

bladder health; female; healthy volunteers; urination

There is growing interest in promoting bladder health and lower urinary tract symptom (LUTS) prevention, particularly in women at higher risk for LUTS and associated bladder conditions. An essential step in health promotion and prevention efforts is to estimate bladder function parameters, such as daytime and nighttime urination frequencies, in women without LUTS to define the normal reference ranges. Identification of “normal” urination frequencies can help guide health education programs and inform interpretation of patient symptoms.

Currently, there are no established reference ranges or consensus about what constitutes normal urination frequencies in healthy women. Urinary frequency, i.e., the number of voids observed in a defined period, is typically interpreted by applying criteria used for diagnosing overactive bladder, a syndrome defined by the symptoms of urinary urgency, usually accompanied by frequency (interpreted as daytime frequency) and nocturia, with or without urgency urinary incontinence, in the absence of urinary tract infection or other obvious pathology (Haylen et al., 2010). In women, the International Urogynecological Association and the International Continence Society (ICS) define the symptom of increased daytime frequency as the patient’s complaint that she voids “more frequently during waking hours than previously deemed normal by the woman” (Haylen et al., 2010) with a footnote referencing one study on 137 asymptomatic women that found that seven voiding episodes during waking hours were the upper limit of normal (Fitzgerald & Brubaker, 2003). ICS defines the symptom of nocturia or nighttime frequency as the number of times urine is passed during the main sleeping period with each void followed by sleep or the intention to sleep (Hashim et al., 2019). Epidemiological and clinical studies on overactive bladder define abnormal urination frequencies as voiding eight or more times per day and/or getting up two or more times per night (Irwin et al., 2008; Madhu et al., 2015). However, most of these definitions were derived from studies in women seeking care for bothersome LUTS, which do not consider the possible wide variations in urination frequencies that can occur in asymptomatic women.

A recent meta-analysis of 22 studies found high heterogeneity across estimates of urination frequencies in healthy women, precluding generalizing reference ranges to all healthy women (Wyman et al., 2020). Calculated reference ranges suggested that daytime frequency varies from 4 to 10 urinations and nighttime frequency ranges from 0 to 2 urinations during sleeping hours. Analyses were limited by differences in definitions of healthy women and minimal consideration of demographic characteristics and other variables known or suspected to affect bladder function, such as the amount, type, and timing of fluid intake.

Most large epidemiologic studies indicate that urination frequencies, particularly nocturia, differ by race and ethnicity (Burgio et al., 2010; Soysal et al., 2020). However, methods vary considerably based on study population and time frame (e.g., none, past 7 days, past 30 days) in which participants are asked to report on their urination frequencies. Few studies have documented racial and ethnic differences in daytime urination frequencies.

We took advantage of data from the Boston Area Community Health (BACH) Survey, which comprehensively assessed daytime and nighttime urination frequencies, medical conditions, and fluid intake at the first follow-up interview to (a) estimate normative reference ranges in daytime and nighttime urination frequencies in healthy women based on two operational definitions of “healthy”, and (b) compare urination frequencies by age, race/ethnicity, and intake of total and individual types of fluid (carbonated, caffeinated, and alcohol).

The BACH Survey

The BACH Survey was a longitudinal study of community-based adults residing in Boston, MA, designed to explore health risks in minority populations focusing on a broad range of urologic symptoms and conditions. A multistage, stratified sample was randomly selected with 24 design cells defined by age category (30–39, 40–49, 50–59, and 60–79 years), sex (male and female), and race/ethnicity (equally distributed across Black, Hispanic, and White; McKinlay & Link, 2007; Piccolo et al., 2014). The baseline survey (BACH I) conducted from 2002–2005 recruited 5,502 adults (3,201 women and 2,301 men). Two follow-up surveys were conducted approximately 5 and 7 years later (BACH II, 2008; BACH III, 2010: National Institute of Diabetes and Digestive and Kidney Diseases Central Repository, n.d). Following consent, participants completed an in-home interview (> 2 hr) conducted by a trained bilingual interviewer and a self-administered questionnaire (BACH I and II only), supplied an early-morning blood sample, and had their height, weight, hip and waist circumference, and vital signs measured. Information collected via standardized interviews included sociodemographic characteristics, urological symptoms, medical conditions, health status, lifestyle and psychosocial factors, and health care access/utilization. Validated instruments or scales, whenever possible, were used. Details of the study methods have previously been reported (McKinlay & Link, 2007; Piccolo et al., 2014).

Methods

Study Design

A secondary analysis of cross-sectional data collected from female participants who completed the BACH II survey (2008–2010) was performed. The BACH II Survey was selected as it contained information on how participants perceived individual LUTS as problematic, which was used as part of the current study’s eligibility criteria. Permission and data access were obtained from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK, n.d.) central repository to access the data. The BACH Survey was approved by the New England Research Institute Institutional Review Board, and all participants provided written informed consent. We conceptualized this analysis based on the research model for the BACH Survey, which treated age, race/ethnicity, and gender as independent variables, lifestyle experiences as intervening variables or mediating influences (e.g., fluid intake, type, and timing), and signs and symptoms (e.g., urination frequencies) as dependent variables (McKinlay & Link 2007).

Study Population

The study population was created in three steps. We first selected female participants who participated in the BACH II Survey (n = 2,534; 79.5% retention rate). Next, we chose nonpregnant women who were considered "healthy," without urinary tract abnormalities, urinary incontinence (UI; Sandvik Index > 0; Sandvik et al., 2000), bladder conditions (e.g., interstitial cystitis, bladder pain syndrome, chronic catheter use, or reported greater than minor bladder problems), progressive neurological disorders (e.g., multiple sclerosis, Parkinson's disease, Alzheimer's disease or other dementia), did not use LUTS medications, and had data on urination frequencies. These criteria resulted in the following exclusions: 35 women who were pregnant, 145 because of a congenital urinary tract abnormality, 500 because of UI, 309 because of a self-reported bladder problem greater than minor, 88 because of current LUTS medication use, 31 because of a bladder condition (e.g., interstitial cystitis, bladder pain syndrome), 38 because of catheter use, 96 because of a problem with bladder emptying as a result of a nerve or muscle problem, and 26 because of a progressive neurological disease. We then created two groups of healthy female participants using less restrictive ("healthy") and strict ("elite healthy") selection criteria (Table 1). There were 1,505 participants (59.4%) who met the healthy definition and a subsample of 300 participants (11.8%) who met the stricter elite healthy definition.

Data Collection

Demographic data were assessed by self-report at baseline (BACH I). All other variables were collected at the first follow-up (BACH II) during an at-home interview using a validated questionnaire on urologic symptoms, comorbidities, prescribed and over-the-counter medications, lifestyle factors, alcohol use, and fluid intake (McKinlay & Link, 2007).

Daytime and Nighttime Urinations—Daytime and nighttime urination frequencies were assessed by a standardized interviewer-administered questionnaire based on modifying the American Urological Association's Symptom Index (Barry et al., 1992). Participants were asked to report the average number of daytime and nighttime urinations over the last 7 days (Hall et al., 2008). For daytime urination, participants were asked to indicate the number of times that they had to "go the bathroom to empty your bladder during the day, meaning from the time you woke up in the morning until you fell asleep at night?" Nighttime urination was assessed by asking participants to report the number of times that "you had to go to the bathroom to empty your bladder during the night after falling asleep?"

Covariates—Demographic variables included age, race, and ethnicity. Clinical variables included measured height and weight to calculate BMI, self-reported health status, hormone status (e.g., premenopausal and using hormonal contraceptives, premenopausal and not using hormonal contraceptives, menopausal, cigarette smoking status (e.g., never, ex-smoker, current smoker), and sleep problems. Participant responses to the following item assessed medical comorbidities: "Have you ever been told by a health care provider that you have . . . ?" (Hall et al., 2008). Comorbidities assessed were depression or anxiety, diabetes, hypertension, joint diseases, cardiovascular disease (e.g., history of myocardial infarction, angina, coronary bypass surgery, arrhythmia, or heart failure), stroke, or pulmonary disease

(e.g., asthma, chronic lung diseases such as chronic bronchitis, COPD, or emphysema). Self-report of most comorbidities has correlated well with medical record confirmed diagnoses (Okura et al., 2004).

Types and amounts of nonalcohol and alcohol fluid intake were evaluated using an investigator-modified item from the Block Food Frequency Questionnaire (Block et al., 1986; Maserejian et al., 2013). Participants were asked to indicate the number of servings (8 oz each) consumed each day in the past 7 days for water, juice, milk, soda or carbonated beverages with caffeine, soda or carbonated beverages without caffeine, herbal tea or decaffeinated tea, tea with caffeine, including green tea, coffee with caffeine, decaffeinated coffee, other caffeinated beverages (other than soda or coffee), and other noncaffeinated, noncarbonated beverages. Participants also indicated their alcohol use within the past 30 days by reporting whether they had drunk beer or lite beer, wine, wine coolers, sangria, or champagne, and hard liquors such as tequila, gin, vodka, scotch, rum, whiskey, or liquor, either alone or mixed. For any affirmative answers, participants were asked how often they drank each alcohol type (daily, 5–6 days, 3–4 days, 1–2 days, or less frequently than weekly, and the amount of intake for each type). Categories for amount varied by type of alcohol, but servings were also indicated with ounces. In addition, participants responded to an investigator-designed question on the time of day that the majority of fluid intake was consumed, using three categories: before noon, noon–5 p.m., and after 5 p.m.

Average daily intakes of carbonated, caffeinated, and alcoholic beverages were calculated separately. Average daily intake of total fluids, including alcohol, was calculated by summing the responses to all fluid types in ounces. Based on the Institute of Medicine's (IOM) dietary reference intake recommendation for daily fluid intake for adult women (IOM, 2005), we converted milliliters to ounces and categorized total fluid intake into three categories: ≤ 49 oz (less than daily recommendation), 50–74 oz (meeting daily recommendation), and ≥ 75 oz (exceeding daily recommendation). Intake of individual fluids was divided into three or four categories. Caffeinated drinks were divided into the following four categories: 0 oz, 1–16 oz, 17–60 oz, and ≥ 61 oz (Hannestead et al., 2003). Carbonated drinks were divided into three categories: 0–7 oz, 8–15 oz, and 16+ oz. Alcohol intake was divided into three categories: 0 oz, 1–24 oz, and ≥ 25 oz.

Statistical Analysis

All analyses were weighted to account for the BACH sampling design and performed using R Statistical Software (v3.6.1; R Core Team, 2021). Descriptive statistics were used to report demographic and clinical characteristics and daytime and nighttime urination frequencies for each definition of healthy women, overall and stratified by age (ages 31–44, 45–64, 65+ years), race/ethnicity (Black, White, Hispanic), and total fluid intake. Normative reference values were identified by the 2.5th and 97.5th percentiles (i.e., the middle 95%) of the distributions of urination frequencies for the two definitions (Ekelund, 2018; Horn & Pesce, 2003). Reference values were also calculated by age, race/ethnicity, amount, type, and timing of fluid intake.

Generalized linear regression with a log-link and robust variance estimation was used to estimate the unadjusted and adjusted rate ratios of daytime and nighttime urination

frequencies by age, race/ethnicity, and total and individual fluids intake. Models were adjusted for variables found in previous studies as associated with urinary frequencies such as BMI, hormonal status, smoking status, total fluid intake (for analyses of individual fluids), sleep problems, depression or anxiety, hypertension, cardiovascular disease, diabetes, and joint problems (Asplund & Åberg, 2004; Dallosso et al., 2003; Dutoglu et al., 2019; Hsieh et al., 2010; Jones et al., 2016; Madhu et al., 2015; Maserejian et al., 2013; Moon et al., 2019). Multiple imputations were not performed because of the low missing data (2.3%) across all variables. A significance level was set at $p < .05$.

To determine the sensitivity of the results to our definitions of "healthy," we repeated the analyses using a third intermediate or semistrict definition (e.g., healthy women without UI who met all relaxed criteria as well as several of the elite healthy women inclusion criteria (e.g., no reported bladder problem, self-reported good to excellent health, no use of protective pads or previous UI treatment, no bladder or UI surgery, no history of genitourinary cancer or current treatment of non-skin cancer, not using insulin or pills for "sugar," "blood pressure or fluid pills," or "antidepressants," no pulmonary disease, heart failure or stroke, and no health-related activity limitations rated as "a lot."). Results for this semistrict definition were similar to those for strict and relaxed definitions; therefore, only results for the strict and relaxed healthy definitions are presented.

Results

Characteristics of the sample are summarized in Table 2. Participants ranged in age from 31 to 84 years ($M = 54.1$, $SD = 13.7$). The majority of participants were aged 31 64 years (75.2%), overweight or obese (68.8%), premenopausal and not using hormonal contraceptives (56%), parous (79.4%), and non- or former smokers (79.5%). Most women (85.3%) consumed at least the daily recommended amount of fluid intake (50–74 oz/day; 35.6%) or higher (75+ oz/day; 43.8%). Compared to women in the healthy group, elite healthy women were younger ($M = 48.4$ years), more likely to rate their health as excellent, normal weight, premenopausal and using hormonal contraceptives, nonsmokers, and less likely to have a medical condition. Fluid intake patterns were generally similar in both groups of healthy women, although healthy women were less likely to consume alcohol.

Normative Reference Ranges for Daytime and Nighttime Urination Frequencies

Overall, reference ranges for women who met the relaxed healthy definition were 2–10 daytime urinations ($M = 5.1$, $SD = 2.2$, minimum–maximum = 0–20) and 0–4 nighttime urinations ($M = 1.1$, $SD = 1.1$, minimum–maximum = 0–10), whereas those for elite healthy women were 2–9 daytime urinations ($M = 5.0$, $SD = 1.9$, minimum–maximum = 1–15), and 0–2 nighttime urinations ($M = 0.7$, $SD = 0.8$, minimum–maximum = 0–4).

In unadjusted analyses, women meeting the relaxed, healthy criteria ages 45–64 years reported a slightly higher daytime urination frequency (13%) than younger women. In contrast, women ages 65 years and older reported a somewhat lower frequency (5% [Table 3]). For nighttime urination, women ages 65 years and older meeting the relaxed criteria had a higher nighttime urination frequency than women ages 31–44 years (39%), whereas no difference was observed for women ages 45–64 years. In general, findings in elite healthy

women were similar in magnitude to those in healthy women but tended not to reach statistical significance because of the smaller sample size. Comparable results were also noted in adjusted analyses (Supplemental Table 1).

Concerning race and ethnicity, Black and Hispanic women meeting the relaxed, healthy criteria reported slightly fewer daytime urinations (7% and 8%, respectively) and greater nighttime urinations (51% and 48%, respectively) compared to White women (Table 3). Findings of similar magnitude were observed for elite healthy women; in adjusted analyses, the statistical significance of these findings differed because of smaller sample sizes (Supplemental Table 1).

For total fluid intake, women meeting relaxed, healthy criteria who consumed ≤ 49 oz/ day reported slightly fewer daytime urination (7%) than those who consumed 50–74 oz/day, whereas healthy women who consumed 75+ oz/day reported slightly more daytime urination (6%; Table 3). Generally, similar findings were observed for ≤ 49 oz/day consumption and nighttime urination in healthy women (13% fewer urinations). Overall, results were similar in magnitude in elite healthy women as in healthy women but were less likely to be statistically significant because of the smaller sample size. Finally, no associations were observed in healthy women concerning timing of fluid intake and nighttime urination frequency. Still, a null inverse association was observed in elite healthy women who consumed most of their fluid after 5 p.m. (38% fewer urinations). Similar findings were noted in adjusted analyses for amount and timing of fluid intake (Supplemental Table 1).

Influence of Fluid Types and Timing of Fluid Consumption on Urination Frequencies

Considering intake of different types of fluids, findings were variable across fluid types and between daytime and nighttime urinations (Table 4 and Supplemental Table 2). With respect to carbonated drinks, healthy and elite healthy women who consumed 8–15 oz/day and 16+ oz/day of carbonated drinks had similar daytime urination frequencies as women who consumed 0–7 oz/day, but their nighttime urination frequencies were higher. Healthy women who consumed 8–15 oz/day and 16+ oz/day had 19% and 40%, respectively, higher nighttime urination frequencies than women who drank 0–7 oz/day, and elite healthy women had 71% and 24% higher frequencies, respectively.

For caffeinated drinks, nonlinear associations were observed with daytime and nighttime urination. In healthy women, consuming 1–16 oz/day was associated with fewer nighttime urination (20%) than drinking 0 oz/day, while no association was observed for greater consumption levels. This same nonlinear pattern was also seen in elite healthy women.

Finally, with respect to alcoholic drinks, intake of 1–24 oz per day was associated with a greater frequency of daytime urination in healthy and elite healthy women (10% and 21%, respectively). For nighttime urination frequencies, any alcohol intake was associated with fewer nighttime urination in women. Healthy women who drank 1–24 oz/day and 25+ oz/day had fewer nighttime urinations than those who did not consume alcohol drinks (30% and 27%, respectively), with elite healthy women having 40% and 34% fewer nighttime urination, respectively. A generally similar pattern was observed in adjusted analyses (Supplemental Table 2).

Discussion

In this large sample of well-characterized, healthy women, we report new findings related to daytime and nighttime urination frequencies across age, race/ethnicity, and fluid amount and type. The normative reference range for daytime urination frequency was similar using strict and less restrictive healthy definitions, whereas nighttime urinations differed. Findings suggest that voiding up to 10 times/day and 4 times/night may be "within normal limits" for most nonpregnant healthy women, whereas women with elite health void up to 9 times/day and 2 times/night. We also found greater daytime urination frequency in middle-aged women and those who consumed 75+ oz of total fluids/day or 1–24 oz of alcohol/day and lower daytime frequency in older, Black, and Hispanic women, and those who drank less fluid than the IOM (2005) recommended daily amount (50–74 oz/day). Greater nighttime frequency was observed in women aged 65+ years, Black and possibly Hispanic women, women who consumed 8+ oz of carbonated fluids/day, and lower nighttime frequency was observed for women who consumed any alcohol.

Our results support the prior meta-analysis concluded that there is a wide range of normality in healthy women regarding urination frequencies (Wyman et al. 2020). The results from this study and the earlier meta-analysis differ somewhat concerning the upper boundary of the estimated reference values because of the use of a middle 95% versus 90% reference interval to calculate reference ranges. However, when data from the meta-analysis were recalculated using the middle 95% reference interval, the upper bounds of daytime and nighttime urinations were similar. Daytime urinations in asymptomatic/healthy women were 11 times/day in the meta-analysis versus 9 to 10 times/per day in elite healthy and healthy women, respectively, in this analysis. In the meta-analysis, nighttime urinations in asymptomatic/healthy women were 3 times/night versus 2 to 4 times/night in elite healthy and healthy women, respectively (J. Zhou, personal communication, April 22, 2019). While some of these findings may be related to convenience voiding (e.g., urinating for convenience or social reasons and not for physiological necessity; Darling & Neilson, 2005), the results challenge the current consensus definition used in most epidemiological studies of overactive bladder with respect to 24-hr urination frequency (> 8 times/24 hr) and nocturia (≥ 2 times/night). None of the elite healthy women in the BACH study described "any bladder problem," and those in the less restrictive healthy group reported no more than "a minor bladder problem."

The results indicated that urination frequencies were mostly consistent between the "healthy" women groups. This suggests that the relaxed inclusion criteria for healthy women (e.g., excluding any self-reported LUTS as a minor problem, pad use, history of gynecological conditions or surgery, bladder or UI surgery or treatment, history of recurrent urinary tract infections, medical comorbidities known to affect bladder function, or taking medications for diabetes, heart failure, depression, or pelvic pain) may be sufficient in determining normative reference ranges for urination frequencies. The relaxed inclusion criteria were used to identify the more typical "healthy" woman who would be seen in clinical practice, taking into consideration that they may have had treatment previously for gynecological (e.g., pelvic organ prolapse, pelvic inflammatory disease, hysterectomy, etc.) and urological conditions (e.g., urinary incontinence, recurrent urinary tract infections) and

not currently reporting urinary incontinence. This reference ranges also reflect that healthy woman may note some LUTS as a minor problem such as urinary urgency and nocturia but not consider them bothersome enough to require treatment.

As expected, daytime urination frequencies varied by age group, although not consistently in a linear fashion even when controlling for covariates. Middle-aged women (ages 45–64 years) had higher daytime urination frequencies than those who were younger (31–44 years), whereas older women (65+) had fewer daytime urination. Nighttime urination frequencies linearly varied by age, consistent with prior research that indicates the prevalence of nocturia increases with age and that 70% of women over the age of 60 reports at least one nighttime urination in unadjusted (Bosch & Weiss, 2013; Clemens et al., 2020; Coyne et al., 2003) and adjusted analyses (Soysal et al., 2020). Aging is associated with a decreased ability to maintain sleep (e.g., increased number of nocturnal awakenings; Li et al., 2018) and an inadequate secretion of the antidiuretic hormone arginine vasopressin that can lead to nocturnal polyuria (Bosch & Weiss, 2013). It may be that older women who have more nighttime awakenings choose to preemptively void when they wake up.

Race and ethnicity also appeared to influence urination frequencies. In the current study, Black women had fewer daytime urinations than White women but had more nighttime urinations. Hispanic women also had a similar pattern; however, not all the individual estimates reached significance. This finding for Black women and nighttime urinations is consistent with previous studies (Burgio et al., 2010; Soysal et al., 2020). The racial difference might be explained by potential genetic factors, lifestyle behaviors, or sociocultural factors that were not captured in our analyses. Also, a higher prevalence of medical conditions known to contribute to nocturia (e.g., diabetes mellitus, obesity, and cardiovascular disease) may be more prevalent in some racial/ethnic groups. Although these conditions were included in the multivariable analysis, it is possible that other comorbidities and factors not included in the analysis contributed to the differences in urination frequencies. For example, in a recent study using National Health and Nutrition Survey data, cardiovascular disease (e.g., coronary heart disease, myocardial infarction, angina pectoris, and all medications for cardiovascular disease) was associated with more severe nocturia (Moon et al., 2021). Our study did not adjust for these variables. Finally, recent research has suggested that the social context and lived experiences that affect toileting behaviors, including suboptimal toileting environments (e.g., toilets that are not safe or accessible), may be more critical than the biologic construct of bladder function and may explain racial differences (Newman et al., 2021). Exploring factors that influence toileting decisions might reveal reasons for racial/ethnic differences in urination frequencies.

This study adds new information regarding the effects of fluid intake amount and types on urination frequencies in healthy women without LUTS. As expected, women with restricted fluid intake (less than the IOM recommended daily amount) had decreased daytime and nighttime urination. Otherwise, the total fluid intake, either within or exceeding IOM daily recommended amounts, had only a small effect on urination frequencies. We also found varied effects of carbonated, caffeinated, and alcoholic beverages on daytime or nighttime urination frequencies. These findings differ from those in two systematic reviews that found some evidence of associations between increased fluid intake, caffeine intake, and modest

alcohol intake and greater daytime or nighttime urinations in adults with LUTS (Bradley et al., 2017; Robinson et al. 2017). They also conflict with a study examining fluid intake and voiding parameters in 115 asymptomatic Turkish women that found that maximum fluid intake was a significant predictor of total number of voidings (Haliloglu et al., 2012). Similar to a previous study (Johnson et al., 2005), we found that drinking most daily fluids after 5 p.m. had little effect on nighttime urination. However, this finding should be viewed cautiously because of the wide confidence intervals and the considerable amount of missing data on this variable (15%). Our results suggest that making recommendations on the amount, type, or timing of fluid intake is not essential in healthy women who do not have bothersome LUTS. Others have suggested that fluid and caffeine manipulations may help improve overactive bladder symptoms symptoms (Hashim & Al Mousa, 2009). Also, our study does not focus on whether fluid intake recommendations would help reduce the future risk of LUTS.

Compared to previous analyses of normative urination frequency estimates (Wyman et al., 2020), our study was considerably larger, had a representative sample, and included greater characterization of participants. This allowed us to perform analyses in two groups of healthy women while holding other known risk factors constant. The diverse population sampled, including equal proportions of select racial and ethnic minorities, enabled us to identify urination reference values in these groups. In addition, the similar recall periods for both urinary frequency and fluid intake helped to reduce misclassification in analyses of fluid intake and urination frequency.

The study had several limitations, including reliance on self-reported interview data on daytime and nighttime urination frequencies and fluid intake types and amounts. Previous research indicates that approximately 47% of women overestimate daytime urinary frequency but are more accurate in reporting nighttime urinary frequency when compared to data collected by bladder diary (Stav et al., 2009). Reports of 10 or more urinations during the daytime may be overestimated. A simplified intake instrument assessed fluid intake, which may have also introduced some degree of misclassification. Also, findings on the timing of fluid consumption were limited by missing data. Using a bladder diary that includes fluid intake might improve both these estimates, as would collecting urinary frequency and fluid intake data via real-time assessment techniques, such as through a mobile app.

Although the BACH study was conducted over 10 years ago, we believe the data are still relevant because biologically bladders should not have changed during this period. Although some lifestyle factors have changed, such as a greater focus on drinking water rather than carbonated beverages, an increase in caffeine consumption with coffee and tea drinks, and an increase in body weight with higher BMIs in adult women, our study either adjusted for these factors or presented estimates separately by these factors to make them more relevant for today’s population. The representative sample further aids with generalization of study findings. A study of this nature in today’s funding environment would be difficult and costly to replicate.

Conclusion

Normative reference values for daytime and nighttime urination frequencies in healthy women without LUTS indicate a wide variation in what is considered “normal,” with important variations by age and race/ethnicity. Nurses and other public health experts can use this information to develop health promotion programs focused on bladder health, an under-addressed area. Clinicians can use this information in counseling women about what is considered “normal” bladder function and how it changes with aging and assist in clinician decision-making about when bladder issues warrant further assessment and intervention. Future research is needed to clarify reference ranges in minority women, the role of convenience voids versus voids for physiological necessity, and the importance of bother in quantifying urination frequency. Longitudinal studies are also recommended to clarify whether fluid intake amount, type, and timing affect the development of LUTS.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Selection Criteria for Healthy and Elite Healthy Women Subgroups

Criteria	Healthy Women	Elite Healthy Women
Not pregnant	•	•
No urinary tract abnormalities	•	•
No bladder emptying problem as a result of nerve or muscle problem	•	•
No report of greater than minor bladder problem	•	
No report of any bladder problem		•
No lower urinary tract symptoms in past 30 days with any symptom rated as a problem[1]		•
No urinary incontinence (Sandvik score > 0)	•	•
No use of pads or previous urinary incontinence treatment		•
No bladder or urinary incontinence surgery		•
No use of lower urinary tract medications	•	•
No chronic pain of bladder origin, pelvic pain, or medication for pelvic pain		•
No interstitial cystitis or bladder pain syndrome	•	•
No chronic catheter use	•	•
No recurrent urinary tract infections in past year		•
No gynecological condition, e.g., endometriosis, pelvic inflammatory disease, polycystic ovarian syndrome		•
No gynecological surgeries, e.g., hysterectomy, pelvic organ prolapse repair, or cancer		•
No current treatment of cancer other than skin cancer		•
No progressive neurological disorder, e.g., multiple sclerosis, Parkinson's disease, Alzheimer's disease, or other dementias		•
No stroke		•
No pulmonary disease, e.g., asthma, COPD		•
No heart failure		•
No irritable bowel syndrome		•
Not taking insulin or pills for blood sugar, blood pressure or fluid pills, or antidepressants		•
Reported "Good" to "Excellent" self-rated health		•
No reported health-related limitations in activity rated as "a lot"		•

Note. Based on items measured by the American Urological Association's Symptom Index (e.g., incomplete emptying, frequency, intermittency, urgency, weak stream, straining, and nocturia), Barry et al., 1992.

Table 2

Demographic and Clinical Characteristics of Healthy and Elite Healthy Women in the Boston Area Community Health Survey, 2008–2010

	Healthy Women (*n* = 1,505)	Elite Healthy Women (*n* = 300)
Age (Years, Mean, SD)	54.1 (13.7)	48.4 (11.1)
Age range	31.7–84.5	34.4–84.5
Age groups (%)		
31–44	35.2	49.4
45–64	40.0	38.1
65+	24.8	12.5
Race/ethnicity (%)		
White	55.4	60.8
Black	31.6	28.7
Hispanic	12.9	10.6
BMI (kg/m^2, %)		
< 24.9	30.9	43.6
25–29.9	32.6	30.0
30+	36.2	26.3
Hormonal status (%)		
Premenopausal, not using hormonal contraceptives	56.0	56.5
Premenopausal, using hormonal contraceptives	6.4	15.2
Menopausal	37.4	28.3
Parity		
Never pregnant	20.6	18.8
1–3 pregnancies	46.4	49.9
4+ pregnancies	32.9	31.3
Missing	0.1	0.0
Medical conditions (%)		
Cardiovascular disease	10.8	2.4
Hypertension	33.7	6.1
Diseases causing joint pain	36.6	17.9

	Healthy Women (*n* = 1,505)	Elite Healthy Women (*n* = 300)
Type 1 or 2 Diabetes	11.3	1.3
Depression/Anxiety	46.8	34.4
Sleep Problems	50.1	32.9
Self-Rated health (%)		
Excellent	16.0	32.3
Very good	33.7	42.3
Good	33.2	25.3
Fair	15.4	0.0
Poor	1.7	0.0
Smoking Status (%)		
Never smoked	52	60.2
Former smoker	27.5	22.7
Current smoker	17.5	13.8
Missing	3.0	3.2
Total daily fluid intake (%)		
≤ 49 oz	19.7	23.1
50–74 oz	35.6	36.1
75+ oz	43.8	39.9
Daily carbonated fluid intake (%)		
0–7 oz	65.6	71.1
8–15 oz	15.8	14.9
16+ oz	18.4	13.0
Daily caffeinated fluid intake (%)		
0 oz	15.5	14.7
1–16 oz	45.1	44.0
17–60 oz	36.4	39.2
61+ oz	2.8	1.1
Daily alcohol intake (%)		

	Healthy Women (*n* = 1,505)	Elite Healthy Women (*n* = 300)
0 oz	56.4	41.5
1–24 oz	37.9	53.7
25+ oz	5.7	4.8
Time of day most fluids consumed (%)		
Before noon	39.9	39.5
Noon to 5 p.m.	33.9	32.2
After 5 p.m.	11.1	6.6
Missing	15.0	21.7

Note. Groups are not mutually exclusive. *SD* = standard deviation.

Table 3

95% Reference Ranges and Unadjusted Rate Ratios of Daytime and Nighttime Urination Frequencies by Demographic Characteristics and Fluid Intake in Healthy Women and Elite Healthy Women in the Boston Area Community Health Survey, 2008–2010

	Daytime Urination Frequency				Nighttime Urination Frequency			
	Healthy Women (*n* = 1505)		Elite Healthy Women (*n* = 300)		Healthy Women (*n* = 1505)		Elite Healthy Women (*n* = 300)	
	95% reference range	Unadjusted RR (95% CI)	95% reference range	Unadjusted RR (95% CI)	95% reference range	Unadjusted RR (95% CI)	95% reference range	Unadjusted RR (95% CI)
Age group								
31–44	2–10	1.00 (-,-)	2–8	1.00 (-,-)	0–3	1.00 (-,-)	0–3	1.00 (-,-)
45–64	2–12	1.13 (1.07,1.18)	2–9	1.12 (0.91,1.38)	0–2	1.17 (0.89,1.55)	0–2	0.86 (0.57,1.29)
65+	2–9	0.95 (0.89,1.00)	2–8	0.91 (0.53,1.56)	0–2	1.39 (1.08,1.79)	0–2	1.57 (1.10,2.22)
Race/ethnicity								
White	2–10	1.00 (-,-)	2–9	1.00 (-,-)	0–2	1.00 (-,-)	0–2	1.00 (-,-)
Black	2–10	0.93 (0.88,0.98)	2–8	0.92 (0.77,1.10)	0–3	1.51 (1.31,1.74)	0–3	1.61 (0.96,2.69)
Hispanic	2–10	0.92 (0.88,0.96)	2–10	0.92 (0.77,1.10)	0–3	1.48 (0.98,2.24)	0–3	1.28 (0.57,2.20)
Fluid intake								
≤ 49 oz	2–10	0.93 (0.87,1.00)	2–7	0.77 (0.61,0.97)	0–2	0.87 (0.64,1.18)	0–2	0.78 (0.53,1.17)
50–74 oz	2–9	1.00 (-,-)	2–9	1.00 (-,-)	0–3	1.00 (-,-)	0–3	1.00 (-,-)
75+ oz	2–12	1.06 (1.00,1.13)	3–10	1.00 (0.79,1.27)	0–2	0.99 (0.77,1.27)	0–2	1.03 (0.54,1.95)
Time of most fluid intake								
Before 5 p.m.						1.00 (-,-)		1.00 (-,-)
After 5 p.m.						1.08 (0.86,1.36)		0.62 (0.28,1.37)

Note. RR = rate ratio; CI = confidence interval.

Table 4.

95% Reference Ranges and Unadjusted Rate Ratios of Daytime and Nighttime Urination Frequencies Type of Fluid Intake in Healthy Women and Elite Healthy Women in the Boston Area Community Health Survey, 2008–2010

	Daytime Urinations				Nighttime Urinations			
	Healthy Women (n = 1,505)		Elite Healthy Women (n = 300)		Healthy Women (n = 1,505)		Elite Healthy Women (n = 300)	
	95% Reference Range	Unadjusted RR (95% CI)	95% Reference Range	Unadjusted RR (95% CI)	95% Reference Range	Unadjusted RR (95% CI)	95% Reference Range	Unadjusted RR (95% CI)
Carbonated drinks								
0–7 oz	2–10	1.00 (-,-)	2–9	1.00 (-,-)	0–4	1.00 (-,-)	0–2	1.00 (-,-)
8–15 oz	2–9	0.98 (0.93, 1.02)	3–8	0.93 (0.82,1.05)	0–3	1.19 (1.03,1.36)	0–2	1.71 (1.13,2.58)
16+ oz	2–10	0.98 (0.92, 1.04)	2–8	0.87 (0.75,1.02)	0–4	1.40 (1.15,1.71)	0–2	1.24 (0.77,1.98)
Caffeinated drinks								
0 oz	2–10	1.00 (-,-)	2–9	1.00 (-,-)	0–4	1.00 (-,-)	0–3	1.00 (-,-)
1–16 oz	2–10	1.01 (0.90, 1.13)	2–9	1.12 (0.90,1.40)	0–4	0.80 (0.66,0.98)	0–2	0.78 (0.48,1.28)
17–60 oz	2–10	1.04 (0.91, 1.18)	2–8	1.12 (0.97,1.30)	0–4	0.90 (0.74,1.09)	0–2	0.80 (0.42,1.50)
61+ oz	2–11	0.92 (0.80, 1.05)	4–8	1.02 (0.89,1.16)	0–6	1.10 (0.61,1.97)	0–4	1.30 (0.56,3.01)
Alcohol drinks								
0 oz	2–10	1.00 (-,-)	2–8	1.00 (-,-)	0–4	1.00 (-,-)	0–3	1.00 (-,-)
1–24 oz	2–10	1.10 (1.02, 1.19)	2–9	1.21 (1.07,1.40)	0–3	0.70 (0.59,0.82)	0–2	0.60 (0.40,0.92)
25+ oz	3–10	1.04 (O.94, 1.16)	3–6	0.97 (0.88,1.07)	0–3	0.73 (0.63,0.83)	0–1	0.66 (0.42,1.05)

Note. RR = rate ratio; CI = confidence interval.