Journal of Pelvic, Obstetric and Gynaecological Physiotherapy, Autumn 2019, **125,** 5–15

LITERATURE REVIEW

Impact of the consumption of carbonated drinks on the incidence, severity and progression of overactive bladder syndrome in women

J. Battle
Physiotherapy Department, Lewisham Hospital, Lewisham and Greenwich NHS Trust, London, UK

C. Carus
School of Allied Health Professions and Midwifery, University of Bradford, Bradford, UK

Abstract
Overactive bladder syndrome (OAB) affects approximately 20% of the adult female population. Lifestyle management, including modification of fluid consumption, is one of the first-line treatments for OAB, and the lay literature often recommends a reduction in the consumption of carbonated drinks as part of this approach. National and international guidelines on management of OAB recommend a reduction in the consumption of caffeine, but no guidance is given in relation to carbonated drinks. Consequently, it is a challenge for healthcare professionals to give patients evidence-based guidance on the importance of eliminating carbonated drinks as part of the management of OAB. Therefore, the aim of this critical review is to examine the available evidence regarding the effects of carbonated drink consumption on the incidence, severity and progression of OAB in women. A detailed literature search was undertaken and five key articles were identified. These papers varied in quality. Notable limitations included a general lack of clarity over the definition of carbonated drinks, small sample sizes and a lack of control for confounding factors in three of the five studies. However, it can be concluded that the available evidence suggests that the consumption of carbonated drinks increases the incidence of OAB, and may increase the severity and progression of its symptoms. Therefore, it would seem sensible to advise women with OAB to trial the elimination of carbonated drinks from their diet for a 1–2-week period while they self-monitor symptoms. Only when a stronger evidence base emerges would it be appropriate to develop local, national and international guidelines.

Keywords: carbonated drinks, overactive bladder, urinary frequency, urinary urgency.

Introduction
Overactive bladder syndrome (OAB) has been defined as "urinary urgency, with or without urgency urinary incontinence, usually associated with increased daytime frequency and nocturia, if there is no proven infection or other obvious pathology" (Drake 2014, p. 622). A number of studies have investigated the prevalence of OAB in adult women, and the results have ranged from 12.8% to 16.9% (Stewart *et al.* 2003; Irwin *et al.* 2006). More recently, Reisch *et al.* (2018) reported an incidence as high as 21.6% in a study of a small group of female students. Despite these variations in findings, it is clear that this is a common condition, and women with OAB frequently present for management in all healthcare settings, including women's health physiotherapy clinics.

Overactive bladder has a significant, negative impact on quality of life (QoL) (Milsom *et al.* 2017). A study of American women by Stewart *et al.* (2003) showed that those diagnosed with OAB reported significantly lower QoL scores, higher depression scores and greater sleep deprivation than those without the condition. Overactive bladder has also been associated with

Correspondence: Judi Battle, Physiotherapy Department, Lewisham Hospital, Lewisham and Greenwich NHS Trust, Lewisham High Street, London SE13 6LH, UK (e-mail: judibattle@nhs.net).

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reduced work productivity and sexual satisfaction scores (Coyne *et al.* 2008). Therefore, it is clear that efficient, evidence-based management of women presenting with OAB is key to improving QoL.

Mechanism of action of carbonated drinks on overactive bladder

A number of different mechanisms by which carbonated drinks may influence OAB have been suggested (Robinson *et al.* 2017). The artificial sweeteners present in diet carbonated drinks (e.g. aspartame and sodium saccharin) have been shown to enhance contraction of the rat detrusor muscle (Dasgupta *et al.* 2006; Elliott *et al.* 2011). It has been proposed that this is one mechanism by which carbonated drinks may influence OAB in human beings (Dasgupta *et al.* 2006; Robinson *et al.* 2017). A study by Dasgupta *et al.* (2009) demonstrated that antioxidants and preservatives (e.g. ascorbic acid and citric acid, respectively, both of which are commonly found in carbonated drinks) also enhance contraction of the rat detrusor muscle, and these authors concluded that this may also be part of the mechanism by which carbonated drinks aggravate the symptoms of OAB in humans. It has also been suggested that poor lifestyle factors causally linked to the onset of diabetes and obesity may also contribute to the onset of OAB (McGrother *et al.* 2012). Consumption of carbonated drinks has been associated with both diabetes (Nettleton *et al.* 2009) and obesity (Celis-Morales *et al.* 2018), and therefore, this is another mechanism by which carbonated drinks may have an impact on OAB.

Rationale for the literature review

The National Institute for Health and Care Excellence (NICE) recommends lifestyle modification as the first-line management for OAB (NICE 2019). The lay literature recommends a reduction in the consumption of carbonated drinks as part of this initial management (Whelan 2017; Nelson 2018). However, although the NICE and European Association of Urology (EAU) national and international guidelines on the management of urinary incontinence (EAU 2018; NICE 2019) recommend a reduction in caffeine consumption as part of first-line lifestyle management, no guidance is given in relation to carbonated drinks. Therefore, with the paucity and inconsistency of the available evidence, it is a challenge for healthcare professionals to give patients guidance on the importance of eliminating carbonated drinks as part of the management of OAB.

Thus, the aim of the present literature review is to examine the available evidence regarding the effects of carbonated drink consumption on the incidence, severity and progression of OAB in women.

In turn, this may assist healthcare practitioners in the provision and development of effective, evidence-based interventions for the management of women presenting with OAB.

Materials and methods

A thorough, systematic literature search was undertaken. Table 1 defines the population, intervention, comparator, outcome, study type and time frame (PICOST; Schardt *et al.* 2007), and search terms that were used to structure the literature search, along with the rationale for their selection. The Allied and Complementary Medicine Database, Cumulative Index to Nursing and Allied Health Literature, Cochrane Library, Medline, Physiotherapy Evidence Database, PubMed and Scopus databases were systematically searched in association with a number of grey literature sources, including the Bielefeld Academy Search Engine, Current Awareness Service for Health, Copac, Electronic Theses Online Service, Networked Digital Library of Theses and Dissertations, and NICE evidence search.

The inclusion criteria were: studies must involve women aged 18 years or over, investigate the effects of consumption of carbonated drinks as compared to not consuming carbonated drinks, use a validated outcome measure of OAB symptoms, and be published in or after the year 2000.

The exclusion criteria were: any texts not in English, case reports (Greenhalgh 2014), systematic reviews and meta-analyses, and any texts not available in full (despite all reasonable attempts to obtain these).

Search results were processed in line with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram (Moher *et al.* 2009) shown in Figure 1.

The Critical Appraisal Skills Program and Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) critical appraisal tools (STROBE 2007; Vandenbroucke *et al.* 2007; CASP 2018) were used in combination to facilitate detailed critical appraisal of the studies that were identified.

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Table 1. Search criteria: (OAB) overactive bladder; (LUTS) lower urinary tract symptoms; and (ICIQ-OAB) International Consultation on Incontinence Questionnaire Overactive Bladder Module (ICI 2019)

Criterion	Search	Search terms/keywords	Reasoning
Population	Any adult women	Women, adults	The present authors' current clinical practice does not involve the treatment of males or children
Intervention	Consumption of carbonated drinks	Carbonated drinks, carbonated beverages, fizzy drinks, fizzy beverages, soda, Coke, Coca-Cola, cola, lemonade	The aim of the present literature review was to investigate the impact of the consumption of any form of carbonated drink
Comparison	Not consuming carbonated drinks	–	–
Outcomes	Assessment of OAB using any standardized outcome measure	Overactive bladder, overactive bladder syndrome, OAB, urinary urgency, urinary incontinence, urge urinary incontinence, urge incontinence, detrusor instability, detrusor overactivity, lower urinary tract symptoms, LUTS	Initially, the ICIQ-OAB was selected because of the high validity, reliability and responsiveness of this outcome measure, and its availability in numerous languages; however, because of the paucity of evidence that included the ICIQ-OAB, this search was expanded to include any validated outcome measure of OAB
Study type	Not systematic reviews, meta-analyses or case reports; English-language and full-text literature only	–	Case reports are considered to be at the bottom of the hierarchy of evidence (Greenhalgh 2014), the first author (J.B.) wanted to focus on primary research and the full text of any publication was required for thorough critical appraisal
Time	2000–2019 (February 2019)	2000–2019	Initially, this period was for 10 years, but it was expanded to 2000 onwards because of the paucity of evidence

Results

Five studies were identified through the above searches, and the application of the inclusion and exclusion criteria (Table 1).

Of the five studies included for critical review (summarized in Table 2), three were cross-sectional surveys (Yeniel *et al.* 2012; Eğilmez, 2014; Reisch *et al.* 2018), one was a large-scale prospective cohort study (Dallosso *et al.* 2003), and one was a combined large-scale prospective cohort study and cross-sectional survey achieved via the collection of acute carbonated drinks consumption data at the final follow-up stage (Maserejian *et al.* 2013). Three studies investigated the impact of the consumption of carbonated drinks on the incidence of OAB, and found a positive relationship (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Reisch *et al.* 2018). Two studies examined the impact of the consumption of carbonated drinks on the severity of OAB, and found conflicting results (Maserejian *et al.* 2013; Eğilmez 2014). One study investigated the impact of the consumption of carbonated drinks on the progression of OAB, and found a positive relationship between increasing consumption of carbonated drinks and the progression of OAB (Maserejian *et al.* 2013). When pooled, the entire sample size was 10 148. Detailed critical appraisal of the studies (as summarized in Table 2) revealed a number of limitations.

Study participants

All five studies used heterogenous samples, which makes a comparison across studies difficult (Greenhalgh 2014). Dallosso *et al.* (2003) included community-dwelling women aged 40 years or older without OAB at baseline. Maserejian *et al.* (2013) included community-dwelling women aged 30–79 years with and without OAB from a variety of ethnic backgrounds. Yeniel *et al.* (2012) and Reisch *et al.* (2018) used samples of young, female healthcare professional students with and without OAB with a mean age of 22 and 25 years, respectively. Eğilmez (2014) included women aged 18–76 years presenting to a urogynaecology clinic with a diagnosis of OAB, but excluded all those who were taking any bladder medications. Medications for OAB are recommended when first-line, conservative strategies fail (EAU 2018; NICE 2019). Consequently, it is feasible that, by excluding women taking

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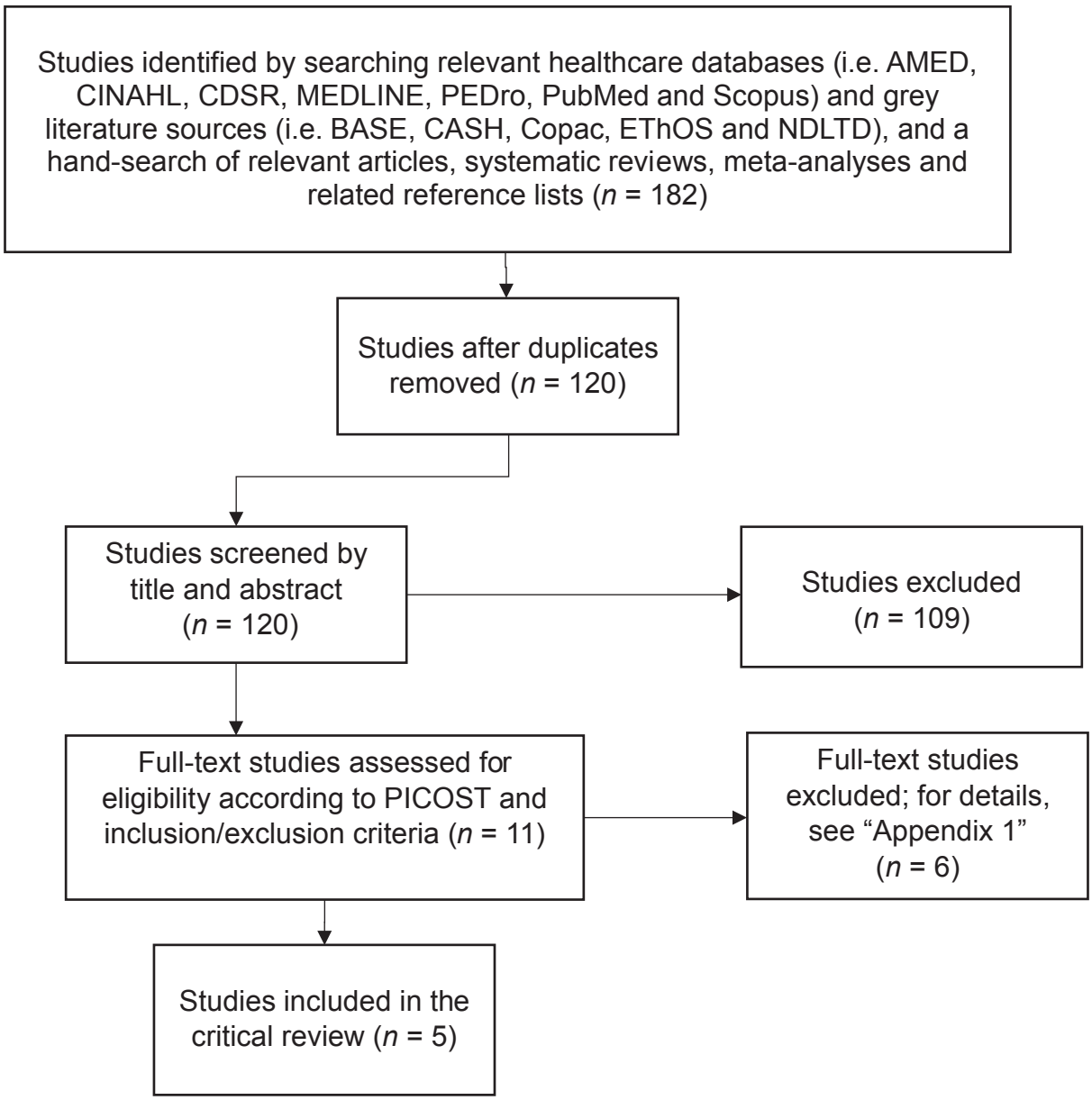

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow chart (modified from Moher *et al.* 2009) detailing the literature search strategy: (AMED) Allied and Complementary Medicine Database; (CINAHL) Cumulative Index to Nursing and Allied Health Literature; (CDSR) Cochrane Database of Systematic Reviews; (MEDLINE) Medical Literature Analysis and Retrieval System Online; (PEDro) Physiotherapy Evidence Database; (BASE) Bielefeld Academy Search Engine; (CASH) Current Awareness Service for Health; (EThOS) Electronic Theses Online Service; (NDLTD) Networked Digital Library of Theses and Dissertations; and (PICOST) population, intervention, control, outcomes, study design and time frame.

bladder medications, Eğilmez (2014) excluded more-severe cases from their study. Therefore, all studies but one (Maserejian *et al.* 2013) investigated specific populations, and thus, limited the generalizability of the results (Greenhalgh 2014).

Sample size and selection

None of the studies included in the present literature review offered details about power calculations, and as shown in Table 2, the sample sizes varied widely (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Maserejian *et al.* 2013; Eğilmez 2014; Reisch *et al.* 2018). The small sample sizes used by Yeniel *et al.* (2012) and Eğilmez (2014) may have adversely influenced the validity of the results of these studies. The conclusions of Yeniel *et al.* (2012) were based on a subgroup of students who drank three or more cans of carbonated drinks per day. However, only three subjects (1.1%) fell into this category. While this small sample provides an interesting result, it is clearly a weakness in this study's methodology and conclusions. In the paper by Eğilmez (2014), only seven subjects (7%) drank more than one carbonated drink per week. Therefore, it is possible that this study was also underpowered, and

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Table 2. Critical analysis of the studies included in the present literature review: (OAB) overactive bladder syndrome; (HCP) healthcare professional; (FFQ) food frequency questionnaire; (N/A) not applicable; (CDs) carbonated drinks; (OR) odds ratio; (95% CI) 95% confidence interval; (β) standard error; (ρ) Spearman's rank correlation coefficient; and (χ^2) chi squared

	Study				
Variable	Dallosso *et al.* (2003)	Yeniel *et al.* (2012)	Maserejian *et al.* (2013)	Eğilmez (2014)	Reisch *et al.* (2018)
Study design	Prospective cohort study	Cross-sectional survey	Prospective cohort study and cross-sectional survey	Cross-sectional survey	Cross-sectional survey
Population	Community-dwelling women, age ≥ 40 years, without OAB at baseline ($n = 7046$)	Female HCP students, mean age = 22 years, with and without OAB ($n = 265$)	Community-dwelling women, age = 30–79 years, with and without OAB at baseline ($n = 2534$)	Women presenting to a urogynaecology clinic with OAB, age = 18–76 years ($n = 100$)	Female HCP students, mean age = 25 years, with and without OAB ($n = 203$)
Exposure variable:					
definition	"Carbonated drinks"*	"Carbonated drinks"*	"Carbonated drinks"/"soda"*	"Carbonated drinks"*	"Carbonated drinks"*
method of assessment	Validated FFQ	Questionnaire (validation not stated)	Validated FFQ/face-to-face interview	Not stated	Bladder diary
Outcome measure for OAB (validation)	Leicester Urinary Symptom Questionnaire (incomplete)	Overactive Bladder Awareness Tool (complete)	International Prostate Symptom Score (complete)	Boyarsky symptom score (incomplete)	Bladder diary (complete)
Follow-up (years)	1	N/A	5	N/A	N/A
Main results	Onset of OAB more likely with daily intake of CDs versus intake of less than once a week (OR = 1.14; 95% CI = 1.02–1.95; $P = 0.03$)	Of those drinking ≥ 3 cans of CDs per day, more had OAB than did not; of those drinking ≤ 1 can of CD per day, more did not have OAB than did ($P = 0.045$)	Increasing CD intake was associated with progression of OAB (OR = 1.4; 95% CI = 1.02–1.91; $P < 0.05$) The relationship between CD consumption and OAB was strongest for diet caffeinated CDs (> 1 cup per day versus none; β = 0.6; 95% CI = 0.1–1.1)	No relationship between the severity of irritative bladder symptoms (e.g. urgency, frequency, nocturia and dysuria) and CD intake (ρ = 0.14; $P = 0.158$)	Subjects with OAB consumed more CDs than those without ($P = 0.047$)
Statistical analysis power calculation	No	No	No	No	No
Test applied	Multivariate logistic regression model, 95% CI stated	χ^2 test, 95% CI not stated	Multivariate logistic regression model, 95% CI stated	Spearman's rank correlation coefficient, 95% CI not stated	χ^2 test, 95% CI not stated
Control for confounding	Yes	No	Yes	No	No
Sampling	Random	Convenience	Random	Consecutive	Convenience
Bias:					
response	Investigated, not present	Not investigated	Not investigated	N/A	Not investigated
recall	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated
Applicability	Good, patient population as per first author's (J.B.'s) other than age	Low, population very specific, results based on very high intake of CDs	Good, patient population as per first author's (J.B.'s)	Moderate, relatively specific population (excluded those taking bladder medications)	Low, population very specific

*No further definition.

thus, unable to detect a relationship between the consumption of carbonated drinks and OAB. The potential for a small sample size to compromise the validity of research was highlighted by Vandenbroucke *et al.* (2007).

A variety of sample selection methods were used in the studies included in the present literature review: a consecutive sample was used in one study (Eğilmez 2014); a convenience sample of young healthcare professional students was used in two (Yeniel *et al.* 2012; Reisch *et al.* 2018); and random sampling was used in two others (Dallosso *et al.* 2003; Maserejian *et al.* 2013). According to Mathieson (2014), while the use of consecutive sampling reduces the risk of response bias, external validity may be compromised if the sample size is small, as per the study by Eğilmez (2014). Response bias can occur with both convenience and random sampling (Greenhalgh 2014), and can significantly affect the internal validity of studies (Vandenbroucke *et al.* 2007). Dallosso *et al.* (2003) were the only authors to investigate response bias, but they found that there was little indication of this. In the other studies that used random or convenience sampling (Yeniel *et al.* 2012; Maserejian *et al.* 2013; Reisch *et al.* 2018), it is feasible that subjects with OAB and those with a higher consumption of carbonated drinks were more and less motivated to respond, respectively, because of their awareness of the unhealthy nature of these drinks. This may be particularly true of the samples of healthcare professional students selected by Yeniel *et al.* (2012) and Reisch *et al.* (2018). Therefore, the use of convenience sampling by Yeniel *et al.* (2012) and Reisch *et al.* (2018), and random sampling by Maserejian *et al.* (2013) may have introduced a significant response bias into the results of these studies (Greenhalgh 2014). Internal validity may have been compromised as a result (Vandenbroucke *et al.* 2007).

Definition of carbonated drinks

None of the studies reviewed in the present paper explicitly stated what types of drinks were included under the umbrella term "carbonated drinks", i.e. caffeinated/non-caffeinated, diet/non-diet and/or alcoholic/non-alcoholic (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Maserejian *et al.* 2013; Eğilmez 2014; Reisch *et al.* 2018). Maserejian *et al.* (2013) stated that decaffeinated, caffeinated, diet and non-diet drinks were included under the term "carbonated drinks", and these authors used the term "soda" interchangeably with "carbonated drinks". The term "soda" is generally used for non-alcoholic beverages (Smith 2019), which suggests that Maserejian *et al.* (2013) did not include alcoholic drinks under the term "carbonated drinks". The other studies made no attempt to define the term "carbonated drinks", and did not even state whether or not carbonated alcoholic drinks were included in the analyses (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Eğilmez 2014; Reisch *et al.* 2018). This lack of clarity limits the clinical application of the findings from these four studies.

Measurement of the consumption of carbonated drinks

The studies by Dallosso *et al.* (2003), Yeniel *et al.* (2012), Maserejian *et al.* (2013) and Reisch *et al.* (2018) all relied on self-reported measures of the consumption of carbonated drinks. Eğilmez (2014) did not state how consumption was assessed. Only one study used a participant-completed bladder diary to assess the consumption of carbonated drinks (Reisch *et al.* 2018). Three studies (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Maserejian *et al.* 2013) used self-reported questionnaires to assess the consumption of carbonated drinks. In the studies by Dallosso *et al.* (2003) and Maserejian *et al.* (2013), these were validated food frequency questionnaires. In addition, Maserejian *et al.* (2013) also used a face-to-face interview to assess the consumption of carbonated drinks at one stage of their study. Yeniel *et al.* (2012) gave no details about the nature or validation of the questionnaire that they used to assess the consumption of carbonated drinks. It has been demonstrated that study participants tend to over-report dietary consumption when using food frequency questionnaires (Tollosa *et al.* 2017), and thereby, introduce recall bias into the results (Shim *et al.* 2014).

Overactive bladder outcome measures

Each study used a different outcome measure to assess bladder symptoms (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Maserejian *et al.* 2013; Eğilmez 2014; Reisch *et al.* 2018). The Leicester Urinary Symptom Questionnaire (LUSQ; Shaw *et al.* 2002) was used by Dallosso *et al.* (2003). The LUSQ was validated by Shaw *et al.* (2002) for both men and women, and with a broad spectrum of bladder symptoms, as an interviewer-administered, patient-completed questionnaire. Dallosso *et al.* (2003) used it as a self-administered questionnaire rather than an interviewer-administered one, and therefore,

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potentially influenced the validity of their results (Chang & Krosnick 2010). Eğilmez (2014) used the Boyarsky symptom score (Boyarsky *et al.* 1976), as modified and validated by Bolognese *et al.* (1992). However, Bolognese *et al.* (1992) validated this outcome measure for use in its full format in men with benign prostatic hyperplasia. It has not been validated for women or OAB, or for the independent use of its subsections, as done by Eğilmez (2014), which may have reduced both the internal and external validity of their results (Greenhalgh 2014). Maserejian *et al.* (2013) used the International Prostate Symptom Score (IPSS; Barry *et al.* 1992). Although this was initially designed for use in men with benign prostatic hyperplasia, it has subsequently been validated for use in women with a broad spectrum of bladder symptoms (Scarpero *et al.* 2003; Okamura *et al.* 2009). Yeniel *et al.* (2012) applied the Overactive Bladder Awareness Tool (OABAT; Coyne *et al.* 2005) to assess bladder symptoms associated with OAB. This outcome measure has been validated for use in women with OAB (Coyne *et al.* 2005), and in the Turkish population (Acquadro *et al.* 2006). Only one study used a bladder diary, as opposed to a questionnaire, to assess bladder symptoms (Reisch *et al.* 2018). Bladder diaries are considered to be a valid and reliable method of assessing the symptoms of OAB (Starkman & Dmochowski 2008), and may be subject to less recall bias than questionnaires because these diaries are filled out as each event occurs (Reisch *et al.* 2018). Reisch *et al.* (2018) considered the use of a bladder diary to assess bladder symptoms to be a major strength of their study. In summary, a variety of outcome measures were used to assess bladder symptoms in the five studies included in the present literature review (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Maserejian *et al.* 2013; Eğilmez 2014; Reisch *et al.* 2018). While each outcome measure had been validated, as stipulated in the search strategy (Table 1), analysis of this validation revealed several limitations, especially in the study by Eğilmez (2014).

Data analysis used

Consideration and analysis of confounding factors is crucial in observational studies (Mann 2003; Vandenbroucke *et al.* 2007). Eğilmez (2014), Yeniel *et al.* (2012) and Reisch *et al.* (2018) used very simplistic statistical analyses. Spearman's rank correlation coefficient (ρ; Lund & Lund 2018) was employed by Eğilmez (2014), while the χ^2 test (Parab & Bhalerao 2010) was utilized by Yeniel *et al.* (2012) and Reisch *et al.* (2018). These simplistic statistical analyses do not allow for control of confounding factors, and therefore, compromised the validity of the results of these three studies (Vandenbroucke *et al.* 2007). Dallosso *et al.* (2003) and Maserejian *et al.* (2013) used more-complex statistical analyses with thorough control for confounding factors, i.e. multivariate logistic regression models (McDonald 2015), and thus, increased the validity of their results (Vandenbroucke *et al.* 2007).

Findings of the studies

Three studies (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Reisch *et al.* 2018) investigated the impact of the consumption of carbonated drinks on the incidence of OAB.

The cohort study by Dallosso *et al.* (2003) demonstrated that a diagnosis of OAB, via the LUSQ (Shaw *et al.* 2002), was a more-likely occurrence with daily consumption of carbonated drinks compared to consumption less than once a week [odds ratio (OR) = 1.14; 95% confidence interval (CI) = 1.02–1.95; $P = 0.03$]. Follow-up was over 1 year, and this study had many strengths, such as a large sample size, thorough statistical analysis including control for confounding factors and a lack of non-response bias.

The cross-sectional survey by Yeniel *et al.* (2012) demonstrated that, of those participants consuming three or more cans of carbonated drinks per day, more had OAB than did not, as diagnosed by the OABAT (Coyne *et al.* 2005). Of those subjects consuming one or less carbonated drinks per day, more did not have OAB than did ($P = 0.045$). This led these authors to conclude that excessive consumption of carbonated drinks is statistically significantly associated with an increased incidence of OAB. However, the validity of the results of this study were significantly compromised by a small sample size, and the lack of control for confounding factors.

The cross-sectional survey by Reisch *et al.* (2018) also investigated the relationship between the consumption of carbonated drinks and the incidence of OAB, and demonstrated that subjects with OAB, as diagnosed via a bladder diary, consumed more carbonated drinks than those without the condition ($P = 0.047$). While this study had the advantage of using a bladder diary to assess bladder symptoms, the validity of results was compromised by the lack of control for confounding factors.

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However, when combined, the three studies (Dallosso *et al.* 2003; Yeniel *et al.* 2012; Reisch *et al.* 2018) suggest that increased consumption of carbonated drinks is associated with a higher incidence of OAB.

Two studies investigated the impact of the consumption carbonated drinks on the severity of the symptoms of OAB (Maserejian *et al.* 2013; Eğilmez 2014).

The results of the cross-sectional survey by Eğilmez (2014) demonstrated that there was no relationship between the severity of irritative bladder symptoms (i.e. urgency, frequency, nocturia and dysuria), and the consumption of carbonated drinks ($\rho = 0.14$; $P = 0.158$). However, once again, the validity of the results of this study were significantly compromised by a small sample size and the lack of control for confounding factors. Furthermore, the outcome measure used by Eğilmez (2014), the Boyarsky symptom score (Boyarsky *et al.* 1976), had not been fully validated for use as described in his study.

The cross-sectional survey by Maserejian *et al.* (2013) also investigated the impact of the consumption of carbonated beverages on the severity of the symptoms of OAB, and was the only study to investigate the impact of drinking different types of carbonated drinks on these symptoms. The results showed that the consumption of carbonated drinks was associated with urinary frequency and urgency, as assessed using the IPSS (Barry *et al.* 1992), regardless of caffeine content. The relationship was stronger for caffeinated diet carbonated drinks (less than one cup per day versus none: $\beta = 0.6$; 95% CI = 0.1–1.1) than for caffeinated non-diet carbonated drinks ($\beta = 0.1$; 95% CI = –0.3–0.5). Detailed critical appraisal showed that Maserejian *et al.*'s (2013) study had many strengths, including a large sample size with good generalizability and thorough statistical analysis, and therefore, this increased the validity and reliability of their results.

Therefore, it can be concluded that the available evidence suggests that increased consumption of carbonated drinks may increase the severity of the symptoms of OAB. Only one study investigated the impact of carbonated drink consumption on the progression of OAB symptoms (Maserejian *et al.* 2013). Maserejian *et al.* (2013) reported that, although baseline consumption of carbonated drinks was not related to the progression of the symptoms of OAB (OR = 1.08; 95% CI = 0.75–1.57; $P > 0.05$), as assessed via the IPSS (Barry *et al.* 1992), increasing consumption was related to the progression of symptoms (OR = 1.4; 95% CI = 1.02–1.91; $P < 0.05$). This study had many strengths, including a large sample size with good generalizability, thorough statistical analysis with control for confounding factors and long-term follow-up over 5 years.

Therefore, it can further be concluded that the available evidence suggests that increasing the consumption of carbonated drinks may cause the progression of the symptoms of OAB.

Discussion

Limitations

The present literature review has a number of limitations. First, all critical appraisal was undertaken independently by a single reviewer (the first author, J.B.), and therefore, an element of bias may be present in this process. Secondly, a standardized quality measure for cohort or cross-sectional surveys could not be identified, and therefore, none was applied to the studies included in this literature review. Finally, no formal meta-analysis was applied because of the non-homogenous nature of the studies that were identified.

Application of the findings to theories of the mechanism of action of carbonated drinks on the overactive bladder

As previously stated, the artificial sweeteners that are present in diet carbonated drinks have been shown to enhance contraction of the rat detrusor muscle (Dasgupta *et al.* 2006; Elliott *et al.* 2011), and it has been proposed that this is one mechanism by which these beverages may influence OAB in human beings (Dasgupta *et al.* 2006; Robinson *et al.* 2017). This theory is supported by the findings of the cross-sectional survey by Maserejian *et al.* (2013), in which caffeinated diet carbonated drinks had a stronger association with frequency and urgency than caffeinated non-diet carbonated drinks.

Implications for clinical practice

In terms of clinical practice, it would seem sensible to suggest that women presenting with OAB are advised to trial eliminating carbonated beverages, even though this is not mentioned in either the NICE or EAU guidelines on the management of urinary incontinence (EAU 2018; NICE 2019). Studies investigating the impact of reducing caffeine consumption on bladder symptoms (Swithinbank *et al.* 2005; Wells *et al.* 2014) have used a 1–2-week elimination period, and therefore, a similar time frame may be

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recommended for phasing out carbonated drinks while patients self-monitor their symptoms to assess their response.

Future research

Further large-scale cohort studies investigating the effect of the consumption of carbonated drinks on the incidence, severity and progression of OAB would enhance the confidence with which healthcare professionals can offer their patients advice about these matters. Furthermore, in preparation for the present paper, a detailed literature search was undertaken to investigate the impact of the elimination of carbonated beverages on urinary symptoms in women with OAB. This search did not identify any relevant clinical trials. Consequently, there is a need for randomized controlled trials investigating this area. Patients with OAB are often reluctant to change their drinking habits. In a study by Miller *et al.* (2016), only 16% of women with OAB followed advice about the complete elimination of certain drinks. Psychological theories of behaviour change, such as that proposed by Maddux (1993), suggest that having a clear understanding of the potential benefits of a behavioural change is key to motivating it. Therefore, it is vital that healthcare professionals are able to give clear, evidence-based advice to patients about the effects of the consumption of carbonated drinks on OAB in an effort to motivate a change in dietary habits.

Conclusions

The aim of the present literature review was to investigate the impact of the consumption of carbonated drinks on the incidence, severity and progression of OAB in women in order to provide evidence-based guidance to healthcare professionals and patients. The available evidence suggests that the consumption of carbonated beverages increases the incidence OAB, and may increase the severity and progression of its symptoms. It would seem sensible to advise women with OAB to trial the elimination of carbonated drinks for a 1–2-week period while they self-monitor their symptoms. Future research may focus on considering whether a reduction in the consumption of carbonated drinks results in a reduction in, or even cessation of the symptoms associated with OAB. It will only be appropriate to develop local, national and international guidelines when a clearer evidence base emerges.

References

Acquadro C., Kopp Z., Coyne K. S., *et al.* (2006) Translating overactive bladder questionnaires in 14 languages. *Urology* **67** (3), 536–540.

Barry M. J., Fowler F. J., Jr, O'Leary M. P., *et al.* (1992) The American Urological Association symptom index for benign prostatic hyperplasia. *The Journal of Urology* **148** (5), 1549–1557.

Bolognese J. A., Grino P. B., Stoner E., *et al.* (1992) Validation of a symptoms questionnaire for benign prostatic hyperplasia. *The Prostate* **21** (3), 247–254.

Boyarsky S., Jones G., Paulson D. F. & Prout G. R., Jr (1976) A new look at bladder neck obstruction by the food and drug administration regulators: guidelines for investigation of benign prostatic hypertrophy. *Transactions of the American Association of Genito-Urinary Surgeons* **68,** 29–32.

Bradley C. S., Kennedy C. M. & Nygaard I. E. (2005) Pelvic floor symptoms and lifestyle factors in older women. *Journal of Women's Health* **14** (2), 128–136.

Celis-Morales C., Livingstone K. M., Affleck A., *et al.* (2018) Correlates of overall and central obesity in adults from seven European countries: findings from the Food4Me Study. *European Journal of Clinical Nutrition* **72** (2), 207–219.

Chang L. & Krosnick J. A. (2010) Comparing oral interviewing with self-administered computerized questionnaires: an experiment. *Public Opinion Quarterly* **74** (1), 154–167.

Coyne K. S., Zyczynski T., Margolis M. K., Elinoff V. & Roberts R. G. (2005) Validation of an overactive bladder awareness tool for use in primary care settings. *Advances in Therapy* **22** (4), 381–394.

Coyne K. S., Sexton C. C., Irwin D. E., *et al.* (2008) The impact of overactive bladder, incontinence and other lower urinary tract symptoms on quality of life, work productivity, sexuality and emotional well-being in men and women: results from the EPIC study. *BJU International* **101** (11), 1388–1395.

Critical Appraisal Skills Program (CASP) (2018) *CASP Checklist: 12 Questions to Help You Make Sense of a Cohort Study.* [WWW document.] URL https://casp-uk.net/wp-content/uploads/2018/01/CASP-Cohort-Study-Checklist_2018.pdf

Dallosso H. M., McGrother C. W., Matthews R. J., Donaldson M. M. K. & Leicestershire MRC Incontinence Study Group (2003) The association of diet and other lifestyle factors with overactive bladder and stress incontinence: a longitudinal study in women. *BJU International* **92** (1), 69–77.

Dasgupta J., Elliott R. A., Doshani A. & Tincello D. G. (2006) Enhancement of rat bladder contraction by artificial sweeteners via increased extracellular Ca^{2+} influx. *Toxicology and Applied Pharmacology* **217** (2), 216–224.

Dasgupta J., Elliott R. A. & Tincello D. G. (2009) Modification of rat detrusor muscle contraction by ascorbic acid and citric acid involving enhanced neurotransmitter release and Ca^{2+} influx. *Neurourology and Urodynamics* **28** (6), 542–548.

Drake M. J. (2014) Do we need a new definition of the overactive bladder syndrome? ICI-RS 2013. *Neurourology and Urodynamics* **33** (5), 622–624.

Eğilmez M. T. (2014) The risk factor and the severity of symptoms relation in women with overactive bladder.

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Journal of Clinical and Analytical Medicine **6** (102), 683–687.

Elliott R. A., Kapoor S. & Tincello D. G. (2011) Expression and distribution of the sweet taste receptor isoforms T1R2 and T1R3 in human and rat bladders. *The Journal of Urology* **186** (6), 2455–2462.

European Association of Urology (EAU) (2018) *EAU Guidelines: Urinary Incontinence.* [WWW document.] URL https://uroweb.org/guideline/urinary-incontinence/

Greenhalgh T. (2014) *How To Read a Paper: The Basics of Evidence-Based Medicine*, 5th edn. John Wiley & Sons, Chichester.

International Consultation on Incontinence (ICI) (2019) *International Consultation on Incontinence Questionnaire Overactive Bladder Module (ICIQ-OAB).* [WWW document.] URL http://www.iciq.net/iciq-oab

Irwin D. E., Milsom I., Hunskaar S., *et al.* (2006) Population-based survey of urinary incontinence, overactive bladder, and other lower urinary tract symptoms in five countries: results of the EPIC study. *European Urology* **50** (6), 1306–1315.

Korytkowski M. T. (2013) Lessons from the Look Action for Health in Diabetes Study. *Indian Journal of Endocrinology and Metabolism* **17** (Suppl. 3), S650–S653.

Lund A. & Lund M. (2018) *Spearman's Rank-Order Correlation*. [WWW document.] URL https://statistics.laerd.com/statistical-guides/spearmans-rank-order-correlation-statistical-guide.php

McDonald J. H. (2015) *Multiple Logistic Regression.* [WWW document.] URL http://www.biostathandbook.com/multiplelogistic.html

McGrother C. W., Donaldson M. M. K., Thompson J., *et al.* (2012) Etiology of overactive bladder: a diet and lifestyle model for diabetes and obesity in older women. *Neurourology and Urodynamics* **31** (4), 487–495.

Maddux J. E. (1993) Social cognitive models of health and exercise behaviour: an introduction and review of conceptual issues. *Journal of Applied Sports Psychology* **5** (2), 116–140.

Mann C. J. (2003) Observational research methods. Research design II: cohort, cross sectional, and case-control studies. *Emergency Medicine Journal* **20** (1), 54–60.

Maserejian N. N., Wager C. G., Giovannucci E. L., *et al.* (2013) Intake of caffeinated, carbonated, or citrus beverage types and development of lower urinary tract symptoms in men and women. *American Journal of Epidemiology* **177** (12), 1399–1410.

Mathieson K. (2014) Making sense of biostatistics: types of nonprobability sampling. *Journal of Clinical Research Best Practices* **10** (10), 1–2.

Mendive J. M., Rebollo P. & Pérez M. (2012) *Epidemiological Study on Urinary Incontinence and Overactive Bladder in Primary Care, and the Prevalence of Risk Factors (URO-RISK Study)*. [WWW document.] URL http://dx.doi.org/10.3834/uij.1944-5784.2012.06.10

Miller J. M., Garcia C. E., Becker Hortsch S., Guo Y. & Schimpf M. O. (2016) Does instruction to eliminate coffee, tea, alcohol, carbonated, and artificially sweetened beverages improve lower urinary tract symptoms? A prospective trial. *Journal of Wound, Ostomy and Continence Nursing* **43** (1), 69–79.

Milsom I., Altman D., Cartwright R., *et al.* (2017) Epidemiology of urinary incontinence (UI) and other lower urinary tract symptoms (LUTS), pelvic organ prolapse (POP) and anal incontinence (AI). In: *Incontinence*, 6th edn (eds P. Abrams, L. Cardozo, A. Wagg & A. Wein), pp. 1–141. International Continence Society, Bristol.

Moher D., Liberati A., Tetzlaff J. & Altman D. G. (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Medicine* **6** (7): e1000097. DOI: 10.1371/journal.pmed.1000097.

National Institute for Health and Care Excellence (NICE) (2019) *Urinary Incontinence and Pelvic Organ Prolapse in Women: Management.* NICE Clinical Guideline 123. National Institute for Health and Care Excellence, London.

Nelson J. K. (2018) *Diet and Overactive Bladder: Are There Dietary Changes I Can Make to Deal with Overactive Bladder?* [WWW document.] URL https://www.mayoclinic.org/diseases-conditions/overactive-bladder/expert-answers/diet-and-overactive-bladder/faq-20322774

Nettleton J. A., Lutsey P. L., Wang Y., *et al.* (2009) Diet soda intake and risk of incident metabolic syndrome and type 2 diabetes in the multi-ethnic study of atherosclerosis (MESA). *Diabetes Care* **32** (4), 688–694.

Okamura K., Nojiri Y., Osuga Y. & Tange C. (2009) Psychometric analysis of international prostate symptom score for female lower urinary tract symptoms. *Urology* **73** (6), 1199–1202.

Parab S. & Bhalerao S. (2010) Choosing statistical test. *International Journal of Ayurveda Research* **1** (3), 187–191.

Reisch R., Rutt R., Dockter M. & Sanders S. (2018) Overactive bladder symptoms in female health profession students: bladder diary characteristics and impact of symptoms on health-related quality of life. *Journal of Women's Health* **27** (2), 156–161.

Robinson D., Hanna-Mitchell A., Rantell A., Thiagamoorthy G. & Cardozo L. (2017) Are we justified in suggesting change to caffeine, alcohol, and carbonated drink intake in lower urinary tract disease? Report from the ICI-RS 2015. *Neurourology and Urodynamics* **36** (4), 876–881.

Scarpero H. M., Fiske J., Xue X. & Nitti V. W. (2003) American Urological Association Symptom Index for lower urinary tract symptoms in women: correlation with degree of bother and impact on quality of life. *Urology* **61** (6), 1118–1122.

Schardt C., Adams M. B., Owens T., Keitz S. & Fontelo P. (2007) Utilization of the PICO framework to improve searching PubMed for clinical questions. *BMC Medical Informatics and Decision Making* **7:** 16. DOI: 10.1186/1472-6947-7-16.

Schimpf M. O. & Miller J. M. (2014) Effect of irritant beverage intake on overactive bladder symptoms: a randomised controlled trial. [Abstract.] *International Urogynecology Journal* **25** (Suppl. 1), S64–S65.

Segal S., Saks E. K. & Arya L. A. (2011) Self-assessment of fluid intake behavior in women with urinary incontinence. *Journal of Women's Health* **20** (12), 1917–1921.

Shaw C., Matthews R. J., Perry S. I., *et al.* (2002) Validity and reliability of an interviewer-administered questionnaire to measure the severity of lower urinary tract symptoms of storage abnormality: the Leicester Urinary Symptom Questionnaire. *BJU International* **90** (3), 205–215.

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Shim J.-S., Oh K. & Kim H. C. (2014) Dietary assessment methods in epidemiologic studies. *Epidemiology and Health* **36:** e2014009. DOI: 10.4178/epih/e2014009.

Smith N. (2019) *Is Drinking Soda Better Than Drinking Alcohol?* [WWW document.] URL https://www.livestrong.com/article/549652-is-drinking-soda-better-than-alcohol/

Starkman J. S. & Dmochowski R. R. (2008) Urgency assessment in the evaluation of overactive bladder (OAB). *Neurourology and Urodynamics* **27** (1), 13–21.

Stewart W., Van Rooyen J., Cundiff G., *et al.* (2003) Prevalence and burden of overactive bladder in the United States. *World Journal of Urology* **20** (6), 327–336.

Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Group (2007) *STROBE Statement – Checklist of Items That Should Be Included in Reports of Cross-sectional Studies*. [WWW document.] URL https://www.strobe-statement.org/fileadmin/Strobe/uploads/checklists/STROBE_checklist_v4_cross-sectional.pdf

Swithinbank L., Hashim H. & Abrams P. (2005) The effect of fluid intake on urinary symptoms in women. *The Journal of Urology* **174** (1), 187–189.

Tollosa D. N., Van Camp J., Huybrechts I., *et al.* (2017) Validity and reproducibility of a food frequency questionnaire for dietary factors related to colorectal cancer. *Nutrients* **9** (11): 1257. DOI: 10.3390/nu9111257.

Vandenbroucke J. P., von Elm E., Altman D. G., *et al.* (2007) Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. *PLoS medicin*e **4** (10): e297. DOI: 10.1371/journal.pmed.0040297.

Wells M. J., Jamieson K., Markham T. C. W., Green S. M. & Fader M. J. (2014) The effect of caffeinated versus decaffeinated drinks on overactive bladder: a double-blind, randomized, crossover study. *Journal of Wound, Ostomy and Continence Nursing* **41** (4), 371–378.

Whelan C. (2017) *How to Create a Diet for Your Overactive Bladder.* [WWW document.] URL https://www.healthline.com/health/overactive-bladder/overactive-bladder-diet

Yeniel A., Mete Ergenoglu A., Meseri R., *et al.* (2012) The prevalence of probable overactive bladder, associated risk factors and its effect on quality of life among Turkish midwifery students. *European Journal of Obstetrics & Gynecology and Reproductive Biology* **164** (1), 105–109.

Judi Battle has been a band 7 physiotherapist at the Lewisham and Greenwich NHS Trust for over 10 years, and developed her interest in women's health physiotherapy during this time. She became a specialist women's health physiotherapist 5 years ago. This literature review was undertaken as part of the Theory of Women's Health Physiotherapy MSc module at the University of Bradford.

Catherine Carus has been a physiotherapy lecturer at the University of Bradford for over 18 years. She is currently the postgraduate programme lead, and leads the Physiotherapy in Women's Health and Continence for Physiotherapists specialist postgraduate certificates.

Appendix 1

The full-text studies that were excluded from the present literature review following the assessment for eligibility, and the reasons for doing so, are listed in Table 3.

Table 3. Full-text studies excluded from the critical review following assessment for eligibility, and the reasons for doing so

Study	Reason
Bradley *et al.* (2005)	Carbonated drink intake not investigated
Korytkowski (2013)	Multimodal lifestyle intervention; therefore, unable to draw conclusions about the specific effects of eliminating carbonated drinks
Mendive *et al.* (2012)	No validated outcome measures of bladder symptoms used
Miller *et al.* (2016)	Subjects eliminated all potentially irritating beverages; therefore, unable to draw conclusions about the specific effects of eliminating carbonated drinks
Schimpf & Miller (2014)	Subjects eliminated all potentially irritating beverages; therefore, unable to draw conclusions about the specific effects of eliminating carbonated drinks
Segal *et al.* (2011)	No data reported on the impact of carbonated drink intake on bladder symptoms because of the low rate of carbonated drink intake in the study sample

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