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MR. YUNG LEE (Orcid ID : 0000-0002-6257-4400)

MR. JAMES YU (Orcid ID : 0000-0002-6482-8152)

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Title: The Impact of Bariatric Surgery on Urinary Incontinence: A Systematic Review and Meta-Analysis

Authors:

Yung Lee BHSc[1,2,3], James Yu BHSc[2,3], Kari A.O. Tikkinen MD PhD[4], Michał Pędziwiatr MD PhD[5,6], Piotr Major MD PhD[5,6], Ishan Aditya BHSc[7], Yonah Krakowsky MD[8], Aristithes G. Doumouras MD MPH[2,3], Scott Gmora MD[2,3], Mehran Anvari MBBS PhD[2,3], Dennis Hong MD MSc[2,3*]

Author affiliations:

[1]Michael G. DeGroote School of Medicine, McMaster University, Hamilton, Ontario, Canada.

[2]Division of General Surgery, Department of Surgery, McMaster University, Hamilton, Ontario, Canada.

[3]Centre for Minimal Access Surgery (CMAS), St. Joseph's Healthcare, McMaster University, Hamilton, Ontario, Canada.

[4]Departments of Urology and Public Health, University of Helsinki and Helsinki University Hospital, Helsinki, Finland.

[5]2nd Department of General Surgery, Jagiellonian University, Krakow, Poland.

[6]Centre for Research, Training and Innovation in Surgery (CERTAIN Surgery), Krakow, Poland.

[7]Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada.

[8]Division of Urology, Department of Surgery, University of Toronto, Women's College Hospital and Sinai Health System, Toronto, ON, Canada.

Address all correspondence to (*):

Dennis Hong, MD, MSc, FRCSC, FACS

Division of General Surgery

Department of Surgery, McMaster University

St. Joseph's Healthcare

50 Charlton Avenue East

Hamilton, Ontario, L8N 4A6, Canada.

Email: dennishong70@gmail.com

Phone: (905) 522-1155 Ext. 32938

Fax: (905) 521-6123

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Yung Lee, James Yu, Kari A.O. Tikkinen, Michał Pędziwiatr, Piotr Major, Ishan Aditya, Yonah Krakowsky, Aristithes G. Doumouras, Scott Gmora, Mehran Anvari, and Dennis Hong have no conflict of interest to declare.

Abstract:

Objectives: To systematically review and meta-analyze the impact of bariatric surgery on obese patients with urinary incontinence (UI).

Methods: A search of Medline, EMBASE, CENTRAL, and PubMed to June 2018 was performed using methods pre-published on PROSPERO. Reporting followed the Preferred Reporting Items for Systematic Review and Meta-analysis guidelines. Studies comparing UI status in obese patients before and after bariatric surgery were included. Primary outcomes were the improvement or complete resolution of any UI, stress urinary incontinence (SUI), and urgency urinary incontinence (UUI). Secondary outcomes were validated UI questionnaire scores. The GRADE approach assessed overall quality of evidence.

Results: 33 cohort studies (2,910 patients) were included (median follow-up 12 months). Bariatric surgery resulted in improvement or resolution of any UI in 56% (95% confidence interval [CI] 48–63%), SUI in 47% (95% CI 34–60%), and UUI in 53% (95% CI 32–73%) of patients. Moreover, bariatric surgery significantly decreased (P<0.001) questionnaire scores such as Urogenital Distress Inventory (UDI) by 13.4 points (95% CI 7.2–19.6), International Consultation on Incontinence Questionnaire (ICIQ) by 4.0 points (95% CI 2.3–5.7), and Incontinence Impact Questionnaire (IIQ) by 5.3 points (95% CI 3.9-6.6). However, worsening or new onset of UI was present in 3% of patients. Quality of evidence was very low for all outcomes.

Conclusion: Half of obese patients report improvement or resolution of UI after bariatric surgery, but overall quality of evidence is very low. Comparative studies examining the benefits of bariatric surgery in obese patients with UI are warranted.

Keywords: Bariatric surgery, Obesity, Urinary incontinence, Stress urinary incontinence, Urge urinary incontinence

Introduction

Urinary incontinence (UI) decreases quality of life, creates emotional distress, and imposes economic burden for hundreds of million people worldwide (1). The International Continence Society and International Urogynecological Association defines UI as the involuntary loss of urine, stress urinary incontinence (SUI) as the involuntary loss of urine on effort or physical exertion, or on sneezing or coughing, and urgency urinary incontinence (UUI) as the involuntary loss of urine associated with a sudden and compelling desire to pass urine (2). From an individual perspective, UUI is the most bothersome symptom in both genders, and from societal perspective, SUI is the most burdensome of all urinary symptoms in women (3).

Obesity is a major risk factor for UI. Obesity affects more than one third of adults in the United States and is predicted to affect 51.1% by 2030 based on current trends (4). Every 5-point increase in body mass index (BMI) has been associated with a 30 to 60% increased odds of UI over 5 to 10 years (5). Mechanistically, central adiposity in patients with obesity may increase intra-abdominal pressure, intravesical pressure, and urethral mobility, causing UI (6). All patients with UI may benefit from pelvic floor muscle training, bladder training, and weight loss, but traditionally, SUI is treated surgically while UUI can be treated with pharmacotherapy including antimuscarinics (7,8). The European Association of Urology gives a strong recommendation for obese adults with UI to lose weight and maintain it, however, long-term weight loss of at least 10% is only maintained in an estimated 20 to 30% of people who undertake lifestyle interventions (9).

Bariatric surgery is the most effective form of sustained weight loss in patients with obesity (10). Earlier studies have also reported a decreased prevalence of UI in obese patients, even years after bariatric surgery (11–16). Despite the increasing evidence investigating the effect of bariatric surgery on UI, no quantitative synthesis exists.

Unfortunately, studies commonly use a wide range of questionnaires and outcome measures to evaluate UI, making comparisons difficult, and complicating the assessment of bariatric surgery on specific types of UI (12–19).

UI is not currently a prerequisite for bariatric surgery in patients with clinically severe obesity according to the National Institutes of Health consensus statement (20). As UI is common among bariatric surgery patients, and as the improvement of obesity-related comorbidities is often the motivating factor encouraging patients to pursue bariatric surgery, it would be crucial the know its impact on UI (21). We therefore performed a systematic review and meta-analysis to establish the effects of bariatric surgery on UI.

Methods

Search strategy

We comprehensively searched the following databases from database inception through June 9th, 2018: Medline, EMBASE, Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL), and PubMed. The search was designed and conducted by a medical research librarian with input from study investigators (complete search strategy available in Supplementary Table 1). We searched abstracts published from annual meetings of International Urogynecological Association (1999-2014) and International Incontinence Society (1999-2014). We did not discriminate full texts by language. This systematic review and meta-analysis is conducted and reported in accordance with the Meta-analyses Of Observational Studies in Epidemiology (MOOSE) (22). The protocol of this study was registered before commencement in the Prospective Register of Systematic Reviews (PROSPERO CRD42018106900).

Outcomes assessed

Primary outcomes included complete resolution or improvement of any UI, SUI, and UUI after bariatric surgery. While the exact definition of complete resolution or improvement varied between studies, most studies evaluated it using questions from validated questionnaires. Secondary outcomes were: (1) Other measures of UI (voids per day, episodes of nocturia per week, UI episodes per day, and pad use per day) (2) worsening of UI after bariatric surgery (3) adverse events after bariatric surgery. Major complications were classified as Clavien-Dindo complication classification grade III or above (conditions requiring surgical, radiological, and endoscopic intervention, organ dysfunction, or death) (23).

Study Selection and Data extraction

Articles were included if they examined the effect of bariatric surgery on any UI, including SUI and UUI in patients with class 2 obesity or higher (BMI > 35 kg/m^2). Due to the heterogeneity present in the definition of UI, we accepted the definition of UI in each study as long as it captured the patient's own perception of incontinence (24). Studies were eligible for inclusion if they were cohort studies (prospective or retrospective) and randomized controlled trials. Letters, editorials, case-reports, case-series, and review papers were excluded. We included both single-arm studies (effect of bariatric surgery on UI before and after surgery without a comparator) or double-arm studies (bariatric surgery versus medical therapy or no surgery). We excluded studies with fewer than 10 eligible patients.

Two reviewers independently evaluated the systematically searched titles and abstract using a standardized, pilot-tested form. Discrepancies that occurred at the title and abstract screening stages were resolved by automatic inclusion to ensure relevant papers were not missed. Discrepancies at the full-text stage were resolved by consensus between two

reviewers and if disagreement persisted, a third reviewer was consulted. Two reviewers independently conducted data abstraction onto a data collection manual designed *a priori*. Abstracted data included study characteristics (eg. author, year of publication, study design, funding source) patient demographics (eg. age, % female, preoperative and postoperative BMI, % diabetes, type of bariatric surgery), UI assessment description (eg. validated UI questionnaire used, type of survey, type of UI assessed), and outcomes. For studies reporting multiple follow-up time points, we analyzed the time point closest to one year. This was because previous studies of UI, including the largest observational cohort to date by Subak et al., have found that weight loss and the improvement and resolution of UI peak one year after bariatric surgery, and decline afterwards (11). In the case of Subak et al., the one year prevalence of UI was 18.3% in women and 9.8% in men, while the three year prevalence increased to 24.8% in women and 12.2% in men, with the increase attributed to the lack of continued follow-up (11).

Risk of Bias Assessment and Certainty of Evidence

A post-hoc decision was made to use a UI-specific risk of bias tool for non-randomized studies that was previously reported in the literature (24). Risk of bias for each study was assessed using six criteria, modified from a novel risk of bias tool for UI: sampling and representativeness of population, assessment of exposure, assessment of outcome, presence of UI at the start of the study, adjustment for confounding, and missing data (Supplementary Table 2) (24). Each criterion was rated low or high risk of bias and studies with at least two "high risk of bias" criteria were classified as high risk of bias overall. Quality of evidence for estimates derived from meta-analyses were assessed by GRADE (Grading of Recommendations, Assessment, Development and Evaluation) (25).

Data Synthesis and Analysis

All statistical analysis and meta-analysis were performed on STATA, version 14 (StataCorp, College, TX) and Cochrane Review Manager 5.3 (London, United Kingdom). Scores for Urogenital Distress Inventory (UDI) and Incontinence Impact Questionnaire (IIQ) questionnaires were converted using previously determined formulas to UDI-7 and IIQ-7 respectively (26). The threshold for statistical significance was set *a priori* at alpha = 0.05. The pooled proportion of patients with improvement or complete resolution of UI after bariatric surgery was calculated using the Freeman-Tukey double arcsine transformation of proportions. DerSimonian and Laird random effects meta-analysis of proportions was used to generate the overall effect size of each outcome. The same method was applied for worsening of UI after bariatric surgery. We performed pairwise meta-analyses using a DerSimonian and Laird random effects model for continuous variables before and after bariatric surgery. Pooled effect estimates were obtained by calculating the mean difference (MD) in outcomes along with their respective 95% confidence intervals (CI) to confirm the effect size estimation. Assessment of heterogeneity was completed using the inconsistency (I^2) statistic. We considered I^2 higher than 50% to represent considerable heterogeneity (27). For significant outcomes, a leave-one-out sensitivity analysis was performed by removing one study at a time to confirm that our findings were not driven by any single study. Publication bias was assessed using a funnel plot. In addition, we performed subgroup analyses based on different types of UI.

Results

Study Characteristics

From 817 potentially relevant reports, 35 studies (all observational; no randomized trials) were eligible (12,13,29–38,14,39–48,15,49–52,16–19,21,28). Of these 35, we excluded two studies in this systematic review: Shimonov et al. and Leshem et al. (40,48). These

studies were excluded because their study cohort were nearly identical, and we suspected they included members of the same cohort and decided to avoid double counting of patients. Figure 1 represents a detailed PRISMA flow diagram of study selection process. Included studies were conducted between 1988 and 2018, with median follow-up of 12 months (range 6 to 60 months) after bariatric surgery. The weighted mean BMI before surgery was 46.0 ± 2.8 kg/m^2 and 32.2 ± 2.4 kg/m^2 at follow-up, with absolute percent reduction of 30%.

Table 1 presents descriptions of the 33 included studies. Table 2 provides each authors' definition of SUI and UUI, and descriptions of validated questionnaires used to assess UI. A wide range of 14 different UI questionnaires were used across included studies (complete list of UI questionnaires is available in Supplementary Table 3). Some studies did not clarify the method used to assess UI, but still reported UI status before and after surgery based on interviewing patients (19,29,33,35,45,52). Bariatric surgeries conducted in the included studies were Roux-en-Y gastric bypass (RYGB, 20 studies), Sleeve Gastrectomy (SG, 16 studies), Laparoscopic Adjustable Gastric Bypass (LAGB, 11 studies), One Anastomosis Gastric Bypass (OAGB, 1 study), Banded Gastric Bypass (BGB, 1 study), Vertical Banded Gastroplasty (VBG. 1 study), Biliopancreatic Diversion with Duodenal Switch (BPD-DS, 2 study), Horizontal Gastroplasty (1 study), and Jejunoileal Bypass (JIB, 1 study).

Effect of bariatric surgery on improvement of UI

From the 33 studies included, 30 studies reported any UI (n=2,772), 13 reported SUI (n=1,186), and 8 reported UUI (n=720) before and after bariatric surgery. Meta-analysis of proportions demonstrated a resolution or improvement of any UI in 56% (95% CI 48–63%) of patients, SUI in 47% (95% CI 34–60%), and UUI in 53% (32–73%) of patients after bariatric surgery (Figure 2A–C). Complete resolution of any UI was seen in 48% (39–57%),

SUI in 39% (24–55%), and UUI in 55% (29–80%) (Supplementary Figure 1A–C). A list of outcomes for UI reported in individual studies can be found in Supplementary Table 4A–C. Heterogeneity was high across all outcomes ranging from I^2 of 87.6 to 96.3%. Subgroup analyses based on type of bariatric surgery were not possible because in most studies more than one type of bariatric surgeries was conducted but results were not reported separately.

Scores of validated questionnaires after bariatric surgery

Similar to the overall improvement and resolution of UI, bariatric surgery resulted in a significant decrease in several UI questionnaire scores. The most commonly reported questionnaires were UDI, International Consultation on Incontinence Questionnaire (ICIQ), IIQ, and Pelvic Organ Prolapse/UI Sexual Questionnaire (PISQ) (Supplementary Table 3). Bariatric surgery resulted in a significant decrease in UDI scores by 13.4 points (95% CI 7.2 to 19.6, $P = <.001$), ICIQ by 4.0 points (2.3 to 5.7, $P = <.001$), and IIQ by 5.3 points (3.9 to 6.6, $P = <.001$). In contrast, there was no significant difference in PISQ scores (MD -0.3, -2.4 to 1.8, $P = 0.78$) (Figure 3A-D). Other UI questionnaires and their scores were sparsely reported, or raw scores were not reported and therefore were not meta-analyzed. Sensitivity analyses across all outcomes did not affect the pooled estimates or significance of the results.

Narrative summary of other UI outcomes

Although four measures of UI (voids per day, episodes of nocturia per week, UI episodes per day, and pad use per day) were not meta-analyzed due to being reported in a small number of studies or due to incomplete data, there appeared to be improvements in all four measures. All three studies reporting the number of voids per day before and after

bariatric surgery found improvements, with Palleschi et al. reporting that in 120 patients, voids decreased from a mean of 9.6 per day before surgery to 6.6 per day following surgery (36,44,52). Two studies reporting episodes of nocturia per week both found improvements, with Palleschi et al. reporting that episodes of nocturia decreased from 16.1 per week to 7.7 per week after bariatric surgery (44,52). Both studies reporting pad use per day also found improvements with Daucher et al. reporting that pad use decreased from 3.5 per day to 1.75 per day after bariatric surgery (36,52). All three studies examining incontinence episodes per day found improvements with Bump et al. reporting that episodes decreased from 1.91 per day to 0.13 per day after bariatric surgery (36,44,52).

Adverse events

Worsening or new onset of UI was reported in only 8 (24%) out of 33 studies (n=1,302). In total, 2 patients reported worsening of UUI (17), 2 patients reported worsening SUI (45), and 54 patients reported worsening or new onset of any UI. Meta-analysis of proportions demonstrated that worsening or new onset of UI occurs in 3% (95% 0–14%) (Figure 2D). Adverse events related to bariatric surgeries were only reported in 5 (15%) studies. In these studies, among 1,007 patients, there were 33 (3%) major complications related to bariatric surgery including 3 (0.3%) deaths, 7 (0.7%) band slippages or erosions, 12 (1%) bowel obstructions, 9 (0.9%) hernias, 3 (0.3%) strictures, and 1 (0.1%) staple line leak (Supplementary Table 5).

Risk of Bias Assessment and Quality of Evidence

All studies included in this review drew patients from their chosen database over the same time frame, and we judged there to be low risk of bias for sampling and representativeness of the population. In 11 studies (31%), it was uncertain how much BMI changed after surgery or BMI was not assessed in person. 18 studies (51%) either did not report how many patients had UI at the beginning and end of the study or did not explicitly exclude confounders. 21 studies (60%) had little missing data with high proportions of patients reporting data at baseline and follow-up. 8 studies (23%) adjusted or matched for all important confounders including BMI, age, and parity. 22 studies (63%) used self-reported validated questionnaires or another method with demonstrated validity (Supplementary Table 6). The GRADE quality of evidence profile is summarized on Table 3. Because of the high loss to follow up and the presence of confounders, the evidence was rated down for serious risk of bias for all outcomes. The evidence was rated down for inconsistency in all outcomes except IIQ due to high heterogeneity. Due to the low number of participants with outcomes reported for PISQ, the evidence was rated down for imprecision. While there was a large magnitude of effect for the improvement or complete resolution of any UI, SUI, and UUI, the certainty was not upgraded because of major concerns with risk of bias and inconsistency (53). Overall, there was a very low certainty of evidence suggesting the effect of estimate is uncertain. Symmetry shown in our funnel plot suggests that there is a low possibility of publication bias, meaning that there may be a low number of unpublished negative studies (Supplementary Figure 2).

Discussion

This is the most comprehensive systematic review and meta-analysis investigating the effect of bariatric surgery on UI to date. The current evidence suggests that bariatric surgery results in the improvement or resolution of any UI in 56% (95% CI 48–63%), SUI in 47% (95% CI 34–60%), and UUI in 53% (95% CI 32–73%) of patients. Complementing the objective improvements in UI, this review also demonstrated improvements in quality of life and patient-perceived symptoms of UI. Bariatric surgery significantly (*P*=<.001) decreased UDI scores by 13.41 points (95% CI 7.2–19.6), ICIQ score by 4.00 points (95% CI 2.3–5.7), and IIQ scores by 5.28 points (95% CI 3.9–6.6) after surgery (very low-quality evidence). Conversely, 3% (95% CI 0–14%) of patients experienced worsening or new onset of UI after surgery. These data suggest that patients undergoing bariatric surgery may experience substantial improvements in UI.

Previous meta-analyses have been conducted exploring the impact of bariatric surgery on UI. Reviews by Lian et al. and Zhang et al. included 11 and 10 cohort studies respectively compared to the 33 cohort studies in the present study (54,55). Furthermore, their reviews did not separately analyze SUI and UUI, making it uncertain what group of patients with UI would benefit from bariatric surgery as the causes of SUI and UUI differ. The present review also differs from previous reviews in its rigorous assessment of included studies. While the protocol specified that the methodological index for non-randomized studies (MINORS) instrument would be used to evaluate of risk of bias on the individual study level, a post-hoc decision was made to instead use a modified tool specifically designed for UI that was previously reported in the literature.(24) Risk of bias on the body of evidence level was also evaluated using GRADE (54,55). The findings of the present review also agree with well-performed previous studies exploring the effect of both weight loss and bariatric surgery on

UI. In a recent large prospective cohort study of bariatric surgery patients with follow-up of 1 year after surgery, the prevalence of UI decreased from 49 to 18% in women and from 21 to 10% in men (11).

The results of this review are encouraging as UI is present in 60 to 70% of obese women with a BMI above 40 kg/m^2 who are considering bariatric surgery (28,35,56). The minimal important differences (MID) for ICIQ-UI is previously reported to be a decrease of 5 points at 12 months (57). While the MID for UDI-6 and IIQ-7 are not available, the MID for their parent questionnaires range from -22.4 to -6.4 points for UDI and -16.5 to -4.6 points for UIQ (58). Therefore, the improvements in the ICIQ-UI, UDI-6, and IIQ-7 scores in the present review appear to be within the range of error for the MID and may result in important improvements in UI for patients. Considering the present review suggests that bariatric surgery may improve UI in a significant proportion of obese patients with associated improvements in quality of life, morbidly obese patients seeking treatment for UI may benefit from discussing possible surgical and non-surgical interventions with both their urologist and a bariatric surgeon. While common surgical, pharmacological and behavioral treatments for UI target incontinence alone, bariatric surgery has been demonstrated to improve or resolve a variety of comorbidities including diabetes, which increases urination, and contributes to the development of UI (59). Given the wide range of benefits associated with bariatric surgery, it may warrant consideration to treat obese patients with UI and open to bariatric surgery, with bariatric surgery first, before determining whether further treatments such as midurethral slings for UI are required. Although the overall certainty of evidence is very low for all outcomes, obese patients with UI can still reasonably be counseled on the potential benefits of weight loss from bariatric surgery.

The findings in our study should be interpreted in light of the following limitations. First, all studies were observational with no comparators, leading to a very low certainty of evidence in all outcomes. No RCTs examining the effect of bariatric surgery on UI were found in the literature. Heterogeneity between included studies was high for many outcomes including UDI and ICIQ. Although we conducted sensitivity analyses to address this heterogeneity, our results failed to explain why heterogeneity was present across pooled effect estimates. Moreover, if there were enough studies exclusively reporting one type of bariatric surgery and its impact on UI, a subgroup analysis would have been possible to reveal the difference in UI outcomes between surgeries (e.g. LSG versus RYGB). Potential causes could include the wide range of follow-up time points across included studies, the variety of surgeries used, or other comorbidities at an individual patient level. Unfortunately, there is no definitive quantitative tool to measure UI, and studies reported a wide range of questionnaires, including the Sandvik severity score and Bristol Female Lower Urinary Tract Symptoms (BFLUTS) questionnaires which were not reported in enough studies to warrant meta-analysis (16,17,60). In many studies, data on the improvement and resolution of UI was drawn from validated questionnaires rather than urodynamic assessments. While self-reported questionnaire data may be influenced by recall bias, we consider the self-reporting of UI the most patient-important outcome. The definition of UI and specific questions asked to participants also slightly varied amongst studies, potentially explaining some of the heterogeneity in the improvement and resolution of UI, SUI, and UUI. Worsening or new onset of UI was also only reported by 8 out of 33 studies, creating the possibility that any harms of bariatric surgery on UI were not unreported or even underestimated.

In conclusion, a very low certainty of evidence exists that bariatric surgery leads to improvement or resolution of UI in half of patients, making it a potentially useful strategy for management of UI in obese patients. Further large-scale studies with a standardized method

of reporting UI outcomes are warranted to confirm the therapeutic benefits of bariatric surgery on UI.

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Figure Legends:

Figure 1. PRISMA Diagram **–** transparent reporting of systematic reviews and meta-analysis flow diagram outlining the search strategy results from initial search to included studies

Figure 2. Proportion random-effects meta-analysis forest plot of **A**, improvement or complete resolution of any urinary incontinence (UI). **B**, improvement or complete resolution of stress UI. **C**, improvement or complete resolution of urgency UI. **D**, worsening or new onset of any UI.

Figure 3. Random effects meta-analysis forest plot of **A,** Urogenital Distress Inventory (UDI) scores. **B,** International Consultation on Incontinence Questionnaire (ICIQ). **C,** Incontinence Impact Questionnaire (IIQ). **D,** Pelvic Organ Prolapse/UI Sexual Questionnaire (PISQ).

Supplementary Figure 1. Proportion random-effects meta-analysis forest plot of **A**, resolution of any urinary incontinence (UI). **B**, resolution of stress UI. **C**, resolution of urgency UI.

Supplementary Figure 2. Funnel plot testing the presence of publication bias in studies addressing the improvement or resolution of urinary incontinence after bariatric surgery.

Study	N analyzed	Surgery	Age	% Female	Pre-op BMI	Post-op BMI	% Diabetes	Specific inclusion criteria
Ahroni, 2005	193	LAGB	43.8 ± 10.1	82.8	45.8 ± 7.7	32.3 ± 7	15.4	NIH criteria or patients with significant medical co-morbidities that can be improved by weight loss.
Bulbuller, 2017	120	LSG	39.19 ± 9.94	100	46.17 ± 5.35	31.6 ± 4.4	30	Women who met NIH criteria.
Bump, 1992	13	RYGB	41 ± 11.9	100	49.4 ± 7.9	33.1 ± 6.7	-	Women at least 45 kg above their ideal body weight as estimated by 1983 Metropolitan Life Insurance tables for medium frame.
Burgio, 2007	92	LRYGB	40.2 (20-55)	100	48.9 ± 7.2	30.2 ± 5.7	15.8	Women with BMI of 40 kg/m^2 or more who underwent bariatric surgery between October 2003 and February 2005.
Castro, 2012	24	Not specified	38.83 ± 7.86	100	46.96 ± 5.77	29.97 ± 3.48	-	Women with BMI ≥ 40 kg/m^2, and older than 18 years old.
Choi, 2010	66	LAGB	40.7 ± 11	89.4	36.1 ± 2.6	-	6.5	18 to 65 years old, BMI of 30–40 kg/m^2, reported history of 3 years of obesity (BMI > 30 kg/m^2) with failed conservative weight reduction efforts.
Cuicchi, 2013	87	RYGB	42 (median) (20-66)	100	43.8 ± 8.5	30 ± 5.9	12	Female patients with BMI of > 30 kg/m^2 from March 2007 to May 2010.
Daucher, 2010	34	LRYGB	47 ± 9	100	46 ± 6	33 ± 6	-	Women 18 years or older scheduled to undergo weight reductive surgery.
Deitel, 1988	138	JIB, HG, VBG	34.8 ± 8.7	100	-	-	-	Women who were morbidly obese and lost more than 50% of their excess weight following bariatric surgery.
Gabriel, 2018	447	LAGB, RYGB, SG	52.5 ± 8	100	-	-	-	Women who were morbidly obese (BMI, > 40 kg/m^2), over the age of 35 years and underwent LAGB, RYGB, or SG.
Kim, 2017	57	LRYGB	38.5 ± 9.5	100	37.5 ± 5.9	28 ± 4.9	-	Women from August to December 2012.
Knepfler, 2016	70	LRYGB, SG, GR	41.4 ± 11.4	100	44.50 ± 6.31	31.83 ± 5.83	18.57	Obese patients between December 2012 and January 2014 with BMI > 40kg/m^2 or a BMI > 35kg/m^2 with comorbidities.
Knoepp, 2013	3898	Any bariatric surgery	44.5 ± 0.16	100	-	-	-	Female patient undergoing bariatric surgery within the 5-year study period with postoperative follow-up period of at least 3 years.
Kuruba, 2007	45	LRYGB, LAGB	49 ± 11	97.78	48 ± 7	-	40	Patients who underwent bariatric surgery from April 2004 to June 2006 and reported UI.
Laungani, 2009	58	LRYGB	46 ± 10	100	48 ± 7	-	-	Morbidly obese females seeking bariatric

								surgery.
Leshem, 2018	43	LSG, OAGB	41.6 ± 11.8	100	41.6 ± 4.6	27.5 ± 4.4	17	Female patients (age ≥18 years) with BMI between 35-39.9 kg/m^2 associated with comorbidities, BMI >40 kg/m^2, or BMI of 30-35 kg/m^2 who previously failed bariatric surgery, and able to read Hebrew.
Maher, 2008	324	LRYGB	42.4 ± 11.0	80.5	49.5 ± 9.0	-	29.9	All patients undergoing L-GBP were within the guidelines of the 1991 National Institutes of Health Con-sensus Conference
McDermott, 2012	64	LSG, LRYGB	47.5 ± 10.9	100	43.7 ± 6.0	29.0 ± 5.1	30	Female, >18 years of age, fulfill the NIH criteria for bariatric surgery (BMI≥ 40 kg/m^2 or BMI ≥ 35 kg/m^2 with at least two comorbidities and attempted to lose weight in the past)
O'Boyle, 2015	82	LRYGB, LSG, LAGB	49 ± 9.7	100	50 ± 6.3	34 ± 6.8	-	Bariatric surgery was performed in all cases in accordance with international guidelines (NICE, NIH, IFSO
Olivera, 2012	36	RYGB, LAGB, LSG	31.28 ± 12.28	100	45.76 ± 6.48	31.55	-	Females scheduled to undergo bariatric surgery for weight loss who were at least 45 kg above ideal body weight (using Metropolitan Life—Insurance Tables), and/or body mass index (BMI) > 35kg/m^{2}with comorbidities, or BMI > 40kg/m^2 without co- morbidities.
Palleschi, 2015	120	LSG	Female: 64.4 ± 7.77; Male: 42.4 ± 8.24	50	Female: 41.2 ± 2.8; Male: 40.7 ± 4.9	Female: 32 ± 1.8; Male: 31 ± 0.9	70	Inclusion criteria were morbid obesity (BMI >40 kg/m^2), age 18 and 60 y, and eligibility for laparoscopic surgery.
	120	Control group	Female: 63.6 ± 3.3; Male: 44 ± 6.34	50	Female: 40 ± 2.7; Male: 41 ± 5.5	Female: 40.2 ± 3.6; Male: 41.7 ± 4.5	71	Class 2 obesity (BMI 35–39.9 kg/m^2) associated with comorbidities, class 3 obesity (BMI >40 kg/m^2) and obese women with BMI 30–35 kg/m^2 who had previously failed bariatric surgery. Other criteria for inclusion were age over 18 years
Ranasinghe, 2010	196	LAGB	Male: 52.8; Female: 47.8	81.63	Male: 47.3 ± 12.67; Female: 43.5 ± 6.65	Male: 38.4 ± 6.18; Female: 35.5 ±6.80	-	Males and females who had underwent LGB over a period of 10 years
Roberson, 2010	193	LAGB, RYGB	-	83	50.2 ± 7.7	32.9 ± 7.5	15	Adults who underwent bariatric surgery at University of Wisconsin Hospital and Clinics, Madison, Wisconsin from July 2002 to May 2006
Romero-Talamas,	72	LSG, SG, LAGB	48.8 ± 10.5	100	47.5 ± 9.4	32.7 ± 8.1	-	Severely obese women (BMI > 35kg/m^2) over

2015								age 17 affected by at least 1 type of PFD as identified by a positive Pelvic Floor Disorder Screening Questionnaire
Said, 2016	116	LSG, LRYGB	47.6 ± 11.9	72	43.6 ± 6.9	31.6 ± 5.2	31.9	Each patient was discussed during a multidisciplinary meeting to choose the technique best adapted (LSG or bypass) to the patient's characteristics
	40	Control group	-	-	43.6 ± 5.9	-	-	40 obese patients followed in the nutrition department with no surgery scheduled
Schouten, 2013	60	LRGYB	43; range: 21-65	100	43.5; range: 33.8-60.9	-	17	Morbidly obese female patients with obesity-related comorbidities; RGYB patients included in the study with no further inclusion or exclusion criteria according to the purpose of the study
Scozzari, 2013	32	LRYGB, AGB, LSG	39.4 ± 9.5	100	46.3 ± 6.3	31.3	15.6	Inclusion criteria were female gender, standard criteria for bariatric surgery, absence of previous surgical, obstetrical, or traumatic anal sphincterial injuries, absence of previous anorectal surgery, absence of chronic diarrhea, inflammatory bowel diseases, and neurological diseases involving pelvic innervation, and informed consent to the study protocol.
	71	Control group	41.3 ± 14	100	21 ± 2.3		0	As control group, 71 age-matched healthy volunteer non-obese women selected with the same inclusion criteria, except for obesity
Srinivasa, 2010	171	LSG	44 ± 9	73	50 ± 7	25 ± 7	47.3	Patients greater than 18 years of age were selected as per European consensus guidelines on surgery for severe obesity (BMI >40kg/m^2 or >35 kg/m^2 with comorbidities).
Subak, 2015	1987	RYGB, LAGB; SG, BPD-DS, BGB	47; range: 18-78	78.8	Female: 45.5; range: 41.6-50.9; Male: 47.1; range: 42.6-52.8	-	31.5	Patients 18 years or older seeking first time bariatric surgical procedure with a participating surgeon were recruited. Participants had to complete the UIQ at baseline and 1 or more follow-up assessments within the first 3 postoperative years.
Uruc, 2016	22	LSG	34.59 ± 8.07	0	49.57 ± 6.21	38.98 ± 5.51	0	Patients who do not satisfy the exclusion criteria as stated
Vella, 2009	126	Not specified	45.4 ± 10.49	100	47.5 ± 8.12	31 ± 6.47	-	All women who underwent bariatric surgery at Temple University Hospital between January

								2004 and March 2006 were identified from the Preoperative Information Systems database.
Wasserberg, 2009	46	RYGB, DS, SG	45; range: 20-67	100	45; range: 35-75	28; range: 22-44	26	Women with BMI of >=35 kg/m^2 attending the University of Southern California Bariatric Surgery Program from December 2003 to December 2005. Patients who underwent surgery during the study period and achieved a >50% excess weight loss postoperatively
Whitcomb, 2012	69	LAGB, SG	43.3 ± 11.8	100	39.7 ± 6.2	34.4 ± 5.8	-	Women with a BMI>=30kg/m^2 meeting surgical eligibility were screened by telephone or in-person interview, with eligibility criteria including severe or morbid obesity (BMI>=40kg/m^2) or obesity (BMI>=30kg/m^2) in the presence of two US NIH-identified comorbidities

Table 1. Characteristics of eligible studies (Pre-op, preoperative; Post-op, post-operative; BMI, Body mass index; LAGB, Laparoscopic adjustable gastric binding; LSG, Laparoscopic sleeve gastrectomy; RYGB, Roux-en-y gastric bypass; LRYGB, Laparoscopic roux-en-y gastric bypass; SG, Sleeve gastrectomy; JIB, jejunoileal bypass; OAGB, one-anastomosis gastric bypass; -, Not available)

Study	Validated questionnaire used	Type of survey	Type of UI assessed	Specific SUI question used	Specific UUI question used	Response options/ Definition of normal-abnormal[a]
Ahroni, 2005	Not validated, author-created	In person	Stress	-	-	Much better/Somewhat better/No change**/Somewhat worse/Much worse/Don't know**
Bulbuller, 2017	ICIQ-UI-SF, IIQ-7	Given questionnaire	Stress and urgency	When does urine leak?	When does urine leak?	Never**/Leaks before you can get to the toilet (UUI)/Leaks when you cough or sneeze (SUI)/Leaks when you are active or exercising (SUI)/All the above (MUI)**
Bump, 1992	Not validated, author-created	In person	Stress and urgency	-	-	No complaints**/Complaints of SUI (SUI)/Complaints of UUI (UUI)/ Complaints of both SUI and UUI (MUI)**
Burgio, 2007	UDI-6-SF, IIQ-7, MESA	Given questionnaire	Stress and urgency	Does coughing gently or hard, sneezing, lifting things, bending over, vomiting, straining to do something, laughing, sexual activity, walking briskly, or jogging ever cause you to lose urine?	Does finding the toilet is occupied or being delayed in getting to use it, having the feeling that your bladder is very full, or having an urge to urinate ever cause the loss of urine beyond your control?	Never/Rarely/**Sometimes/Often**
Castro, 2012	King's Health Questionnaire-Portuguese	In person, given questionnaire	Any urinary incontinence	-	-	No/**Yes**
Choi, 2010	Not validated, author-created	In person, given questionnaire	Stress	-	-	-
Cuicchi, 2013	PFDI-20, UDI-6-SF, PFIQ-7, IIQ-7	Given Questionnaire	Stress and urgency	Do you experience, and if so, how much are you bothered by leakage related to physical activity, coughing, or sneezing?	Do you experience, and if so, how much are you bothered by leakage related to feeling of urgency?	Not at all/**A little bit/Moderately/Greatly**
Daucher, 2010	PFDI, UDI, PFIQ, UIQ, PISQ-12	Given Questionnaire, 3-day voiding diaries	Stress and urgency	Do you experience, and if so, how much are you bothered by leakage related to physical activity, coughing, or sneezing?	Do you experience, and if so, how much are you bothered by leakage related to feeling of urgency?	Not at all/**A little bit/Moderately/Greatly**
Deitel, 1988	Not validated, author-created	In person	Stress	-	-	-

Gabriel, 2018	PFDI-20, UDI-6-SF	Mail or online questionnaire	Stress and urgency	Do you usually experience urine leakage related to coughing, sneezing, or laughing?	Do you usually experience urine leakage associated with a feeling of urgency, that is, a strong sensation of needing to go to the bathroom?	Not at all/**A little bit/Moderately/Greatly**
Kim, 2017	OABSS, PPBC, Sandvik	Given	Any urinary	Do you leak when coughing,	Is leakage accompanied	Not at all/**Slight/Moderate/Severe**
Knepfler, 2016	PFDI-20, UDI-6	Given questionnaire	Any urinary incontinence	Do you experience, and if so, how much are you bothered by leakage related to physical activity, coughing, or sneezing?	Do you experience, and if so, how much are you bothered by leakage related to feeling of urgency?	Not at all/**A little bit/Moderately/Greatly**
Knoepp, 2013	-	Insurance database	Any urinary incontinence	-	-	None/**CPT code for previous UI procedures/ICD-9 code for UI/Prescription of UI medication.**
Kuruba, 2007	MESA, Sandvik questionnaire	Telephone interview, given questionnaire	Stress and urgency	Does coughing gently or hard, sneezing, lifting things, bending over, vomiting, straining to do something, laughing, sexual activity, walking briskly, or jogging ever cause you to lose urine?	Does finding the toilet is occupied or being delayed in getting to use it, having the feeling that your bladder is very full, or having an urge to urinate ever cause the loss of urine beyond your control?	Never/Rarely/**Sometimes/Often**
Laungani, 2009	ICIQ-UI-SF	Given questionnaire	Stress and urgency	When does urine leak?	When does urine leak?	Never/**Leaks before you can get to the toilet (UUI)/Leaks when you cough or sneeze (SUI)/Leaks when you are active or exercising (SUI)/All the above (MUI)**
Leshem, 2018	ICIQ-UI-SF, BFLUTS-SF, PFDI-20, UDI-6, PISQ-12	Given questionnaire	Stress and urgency	When does urine leak?	When does urine leak?	Never/**Leaks before you can get to the toilet (UUI)/Leaks when you cough or sneeze (SUI)/Leaks when you are active or exercising (SUI)/All the above (MUI)**
Maher, 2008	Not validated, author-created	In person	Any urinary incontinence	-	-	-
McDermott, 2012	PFDI-20, PFIQ-7	In person, given questionnaire	Stress and urgency	Do you usually experience urine leakage related to coughing, sneezing or laughing?	Do you usually experience urine leakage associated with a feeling of urgency, that is, a strong sensation of needing to go to the bathroom?	Not present/not at all/**somewhat/moderately/quite a bit**

O'Boyle, 2015	ICIQ-UI-SF	In person, given questionnaire	Stress and urgency	When does urine leak?	When does urine leak?	Never/**Leaks before you can get to the toilet (UUI)/Leaks when you cough or sneeze (SUI)/Leaks when you are active or exercising (SUI)/All the above (MUI)**
Olivera, 2012	PFIQ/IIQ, PISQ-12	In person, mail, telephone interview	Any urinary incontinence	-	-	**Yes**/No
Palleschi, 2015	OABq-SF	In person, given questionnaire	Urgency	N/A; SUI part of exclusion criteria	During the past 4 weeks, how bothered were you by an uncomfortable urge to urinate? During the past 4 weeks, how bothered were you by a sudden urge to urinate with little or no warning?	Not at all**, a little bit, somewhat, quite a bit, a great deal, a very great deal**
Ranasinghe, 2010	ICIQ-SF	Mailed	Stress and urgency	When does urine leak?	When does urine leak?	Never/**Leaks before you can get to the toilet (UUI)/Leaks when you cough or sneeze (SUI)/Leaks when you are active or exercising (SUI)/All the above (MUI)**
Roberson, 2010	Not validated; author-created	Mailed	Stress, urgency, mixed	Do you leak urine when you perform some physical activity such as coughing, sneezing, lifting, or exercise?	Do you leak urine when you have the strong feeling that you needed to empty your bladder but cannot get to the toilet fast enough?	**Yes**/No
Romero-Talamas, 2015	PFDI-20, PFIQ-7, PISQ-12	In person, given questionnaire	Stress and urgency	Do you usually experience urine leakage related to coughing, sneezing or laughing?	Do you usually experience urine leakage associated with a feeling of urgency, that is, a strong sensation of needing to go to the bathroom?	Not present/not at all/**somewhat/moderately/quite a bit**
Said, 2016	ICIQ	In person, given questionnaire, follow up by mail	Stress and urgency	When does urine leak?	When does urine leak?	Never/**Leaks before you can get to the toilet (UUI)/Leaks when you cough or sneeze (SUI)/Leaks when you are active or exercising (SUI)/All the above (MUI)**
Schouten, 2013	Not validated; author created	In person, given questionnaire	Any urinary incontinence	-	-	Yes/No
Scozzari, 2013	PFDI-20, PFIQ-7	In person, given	Stress and urgency	Do you usually experience	Do you usually experience	Not present/**not at**

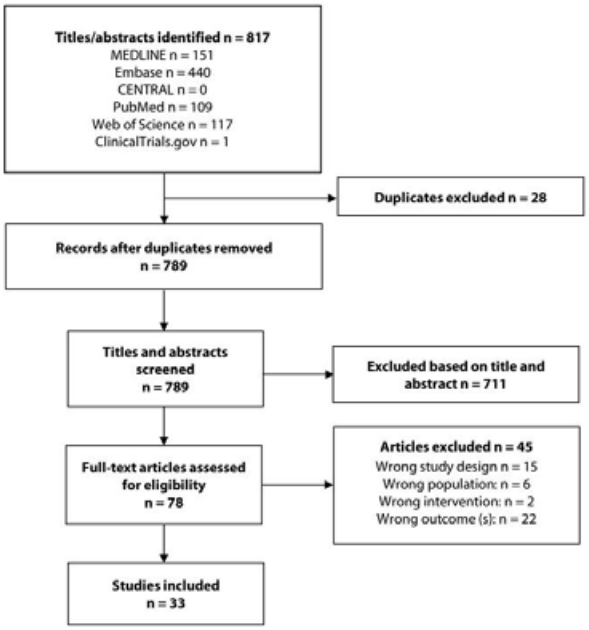
		questionnaire		urine leakage related to coughing, sneezing or laughing?	urine leakage associated with a feeling of urgency, that is, a strong sensation of needing to go to the bathroom?	**all/somewhat/moderately/quite a bit**
Srinivasa, 2010	Not validated; author created	Retrospective	Stress	-	-	-
Subak, 2015	UIQ	In person, given questionnaire	Stress	In the past 3 months, how often have you typically leaked urine, even a small amount with a physical activity like coughing, sneezing, lifting, or exercise?	In the past 3 months, how often have you typically felt an urge or the feeling that you needed to empty your bladder, but you could not get to the toilet fast enough?	Never/ **less than once per month, monthly (once or more each month), weekly (once or more each week), or daily (once or more each day).**
Uruc, 2016	ICIQ-SF	Given questionnaire	Stress and urgency	When does urine leak?	When does urine leak?	Never/**Leaks before you can get to the toilet (UUI)/Leaks when you cough or sneeze (SUI)/Leaks when you are active or exercising (SUI)/All the above (MUI)**
Vella, 2009	UDI-6, IIQ-7	Mailed	Stress and urgency	Urine leakage related to physical activity, coughing, or sneezing?	Urine leakage related to physical activity, coughing or sneezing?	Not at all/**A little bit/Moderately/Greatly**
Wasserberg, 2009	PFIQ, PFDI	Given, in person	Stress and urgency	Do you usually experience urine leakage related to coughing, sneezing or laughing?	Do you usually experience urine leakage associated with a feeling of urgency, that is, a strong sensation of needing to go to the bathroom?	Not present/not at all/**somewhat/moderately/quite a bit**
Whitcomb, 2012	PFIQ, PFDI, PISQ	Given	Stress and urgency	Do you usually experience urine leakage related to coughing, sneezing or laughing?	Do you usually experience urine leakage associated with a feeling of urgency, that is, a strong sensation of needing to go to the bathroom?	Not present/not at all/**somewhat/moderately/quite a bit**

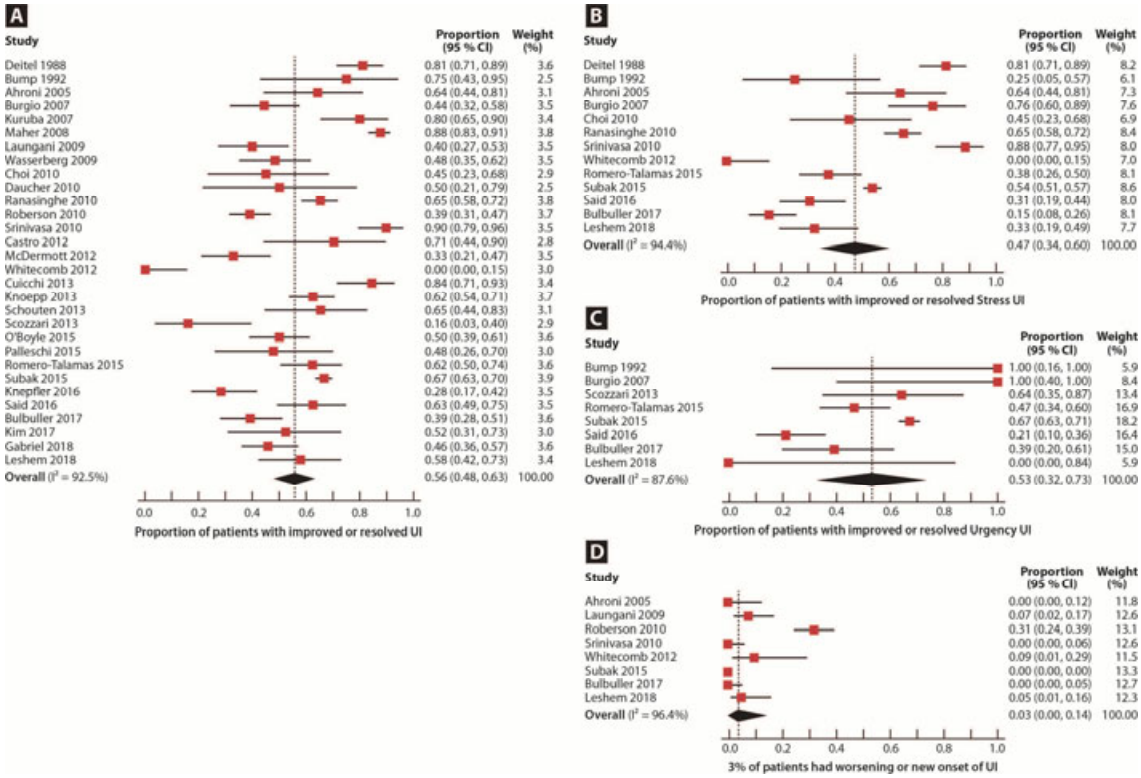
Table 2. Urinary incontinence assessment in eligible studies (UI, urinary incontinence; ICIQ-UI-SF, International consultation on incontinence questionnaire – urinary incontinence - short form; IIQ, Incontinence impact questionnaire; UDI-6-SF, Urogenital distress inventory-6-short form; MESA, Medical, Epidemiologic and Social Aspects of Aging Questionnaire; PFDI-20, Pelvic Floor Disability Index-20; PFIQ-7, Pelvic floor impact questionnaire 7; PISQ-12, Pelvic organic prolapse/urinary incontinence sexual questionnaire 12; OABSS, Overactive bladder symptom score; PPBC, Patient perception of bladder condition; BFLUTS, Bristol Female Lower Urinary Tract Symptoms; UIQ, Urinary Impact Questionnaire; OAB-q, Overactive Bladder Questionnaire; -, not reported)

[a]Cut-off point (threshold) used for normal versus abnormal symptom occurrence. Response options classified as abnormal are shown in boldface type. All studies used the same response options for both SUI and UUI.

Certainty Assessment										Summary of findings	
№ of participants (studies)	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication bias**	**Large magnitude of effect**	**Dose-response gradient**	**Plausible confounders or biases**	**Overall certainty of evidence**	**Effect estimate (95% CI)**	**Anticipated effects after surgery**
Any UI improvement or resolution											
2,772 (30 studies)	serious[1]	serious[2]	not serious[3]	not serious[4]	none[5]	yes[6]	N/A	no[6]	⊕◯◯◯ VERY LOW	56% (48-63%)	Any UI was improved or resolved in 56% patients
Stress UI improvement or resolution											
1,186 (13 studies)	serious[1]	serious[2]	not serious[3]	not serious[4]	none[5]	yes[6]	N/A	no[6]	⊕◯◯◯ VERY LOW	51% (40-63%)	Stress UI was improved or resolved in 51% patients
Urge UI improvement or resolution											
720 (8 studies)	serious[1]	serious[2]	not serious[3]	not serious[4]	none[5]	yes[6]	N/A	no[6]	⊕◯◯◯ VERY LOW	53% (32-73%)	Urge UI was improved or resolved in 53% patients
Worsening or new onset of UI											
1,302 (8 studies)	serious[1]	serious[2]	not serious[3]	not serious[4]	none[5]	yes[6]	N/A	no[6]	⊕◯◯◯ VERY LOW	3% (0-13%)	There was new onset or worsening of UI in 3% patients
Urogenital Distress Inventory (UDI)											
473 (6 studies)	serious[1]	serious[2]	not serious[3]	not serious[4]	none[5]	no[6]	N/A	no[6]	⊕◯◯◯ VERY LOW	MD 13.41 (7.23-19.59)	Improvement of UDI was 13.41
International Consultation on Incontinence Questionnaire (ICIQ)											
568 (7 studies)	serious[1]	serious[2]	not serious[3]	not serious[4]	none[5]	no[6]	N/A	no[6]	⊕◯◯◯ VERY LOW	MD 4 (2.32-5.69)	Improvement of ICIQ was 4.00
Incontinence Impact Questionnaire (IIQ)											
513 (7 studies)	serious[1]	not serious[2]	not serious[3]	not serious[4]	none[5]	no[6]	N/A	no[6]	⊕◯◯◯ VERY LOW	MD 5.28 (3.92-6.64)	Improvement of IIQ was 5.28
Pelvic Organ Prolapse/Urinary Incontinence Sexual Questionnaire (PISQ)											
283 (5 studies)	serious[1]	serious[2]	not serious[3]	serious[4]	none[5]	no[6]	N/A	no[6]	⊕◯◯◯ VERY LOW	MD -0.29 (-2.39-1.80)	There was no significant difference in PISQ scores

Table 3. Grading of Recommendations, Assessment, Development and Evaluation (GRADE) certainty of evidence summary table for meta-analyzed outcomes (MD, mean difference, CI, confidence interval, UI, urinary incontinence)

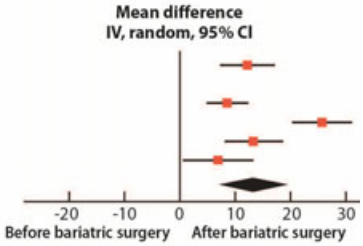




A

Studies	Before bariatric surgery Mean	SD	Total	After bariatric surgery Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Burgio 2007	21.60	21.10	92	9.30	11.90	92	20.2	12.30 (7.35, 17.25)
Vella 2009	39.50	0	126	35.00	0	126		Not estimate
Daucher 2010	13.67	10.67	34	5.00	3.33	34	21.4	8.67 (4.91, 12.43)
McDermott 2012	37.25	19.75	64	11.50	9.50	63	19.8	25.75 (20.37, 31.13)
Cuicchi 2013	18.80	20.10	87	5.40	14.70	87	19.9	13.40 (8.17, 18.63)
Knepfler 2016	19.34	20.36	70	12.38	18.27	70	18.6	6.96 (0.55, 13.37)
Total (95% CI)			473			472	100	**13.41 (7.23, 19.59)**

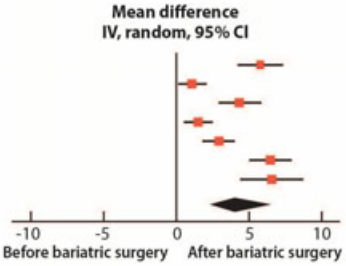
Heterogeneity: $Tau^2 = 42.69$; $Chi^2 = 30.20$, df = 4 ($P < 0.00001$); $I^2 = 87\%$
Test for overall effect: $Z = 4.25$ ($P < 0.0001$)



B

Studies	Before bariatric surgery Mean	SD	Total	After bariatric surgery Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Laungani 2009	7.60	4.00	58	1.80	3.00	25	14.0	5.80 (4.24, 7.36)
Ranasinghe 2010	4.58	4.74	176	3.49	4.59	176	15.1	1.09 (0.12, 2.06)
O'Boyle 2015	9.30	4.40	82	4.90	5.20	82	14.2	4.40 (2.93, 5.87)
Uruç 2016	1.82	2.15	22	0.32	0.95	22	15.1	1.50 (0.52, 2.48)
Said 2016	3.90	5.30	115	1.00	3.00	115	14.9	2.90 (1.79, 4.01)
Bulbuller 2017	9.55	5.52	72	3.09	2.97	72	14.2	6.46 (5.01, 7.91)
Leshem 2018	9.49	4.00	43	2.91	3.90	18	12.6	6.58 (4.42, 8.74)
Total (95% CI)			568			510	100.0	**4.00 (2.32, 6.58)**

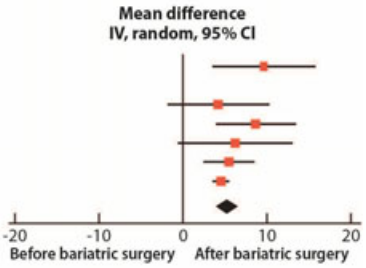
Heterogeneity: $Tau^2 = 4.66$; $Chi^2 = 71.73$, df = 6 ($P < 0.00001$); $I^2 = 92\%$
Test for overall effect: $Z = 4.65$ ($P < 0.00001$)



C

Studies	Before bariatric surgery Mean	SD	Total	After bariatric surgery Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Burgio 2007	15.80	24.50	94	6.10	18.00	94	4.7	9.70 (3.55, 15.85)
Vella 2009	52.00	0	126	35.00	0	126		Not estimable
Daucher 2010	11.00	15.00	34	6.75	10.00	34	4.8	4.25 (-1.81, 10.31)
Olivera 2012	35.85	13.89	36	27.12	4.53	36	7.5	8.73 (3.96, 13.50)
McDermott 2012	24.00	21.50	64	17.75	17.75	63	3.8	6.25 (-0.60,13.10)
Cuicchi 2013	5.50	14.20	87	0	0.50	87	17.0	5.50 (2.51, 8.49)
Bulbuller 2017	7.23	3.62	72	2.74	2.33	72	62.2	4.49 (3.50, 5.48)
Total (95% CI)			513			512	100.0	**5.28 (3.92, 6.64)**

Heterogeneity: $Tau^2 = 0.52$; $Chi^2 = 5.81$, df = 5 ($P = 0.32$); $I^2 = 14\%$
Test for overall effect: $Z = 7.59$ ($P < 0.00001$)



D

Studies	Before bariatric surgery Mean	SD	Total	After bariatric surgery Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Daucher 2010	26.00	6.00	34	25.00	5.00	34	19.2	1.00 (-1.63, 3.63)
Olivera 2012	35.78	6.06	36	38.22	6.03	36	18.5	-2.44 (-5.23, 0.35)
Whitcomb 2012	17.30	8.40	98	14.40	5.40	69	21.6	2.90 (0.80, 5.00)
Romero-Talamas 2015	34.20	5.10	72	36.00	6.00	72	22.8	-1.80 (-3.62, 0.02)
Leshem 2018	36.70	6.00	43	38.10	5.00	18	17.9	-1.40 (-4.32, 1.52)
Total (95% CI)			283			229	100.0	**-0,29 (-2.39, 1.80)**

Heterogeneity: $Tau^2 = 4.15$; $Chi^2 = 15.30$, df = 4 ($P = 0.004$); $I^2 = 74\%$
Test for overall effect: $Z = 0.28$ ($P = 0.78$)