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REVIEW ARTICLE

The impact of bariatric surgery on urinary incontinence: a systematic review and meta-analysis

Bhawana Purwar [1] · Rufus Cartwright [2] · Geraldo Cavalcanti [3] · Giuseppe Alessandro Digesu [4] · Ruwan Fernando [4] · Vik Khullar [4]

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Abstract

Introduction and hypothesis Obesity and overweight are strongly associated with stress and urgency urinary incontinence, and weight loss has been associated with improvement in urinary incontinence. We aimed to measure pooled effect sizes for different weight loss procedures on incontinence-specific quality of life and incontinence cure rate in a systematic review and meta-analysis.

Methods MEDLINE, Embase and the Cochrane library were searched using a pre-defined strategy for relevant cohort studies. Random effects meta-analyses were conducted for the weighted mean difference for urinary quality of life scores and weighted overall pooled estimates for proportions of women cured. We explored heterogeneity using meta-regression, testing the type of bariatric surgery and change in BMI as predictors of effect size. The studies were categorised as either low or high risk of bias using a novel instrument specifically designed for longitudinal symptom research studies.

Results Twenty-three studies ($n = 3{,}225$) were included. Incontinence-specific quality of life scores were improved by 14% (weighted mean difference = −14.79; CI = −18.47 to −11.11; $I^2 = 87.1\%$); the proportion of women cured of any urinary incontinence was 59% (95% CI = 51 to 66%) and the proportion of women cured of stress urinary incontinence was 55% (95% CI = 40 to 70%).

Conclusions Bariatric surgery results in clinically meaningful improvements in incontinence-specific quality of life. Current data are limited by both short-term follow-up and unexplained heterogeneity among studies.

Keywords Bariatric surgery · Urinary incontinence · Obesity · Surgically induced weight loss

Introduction

Obesity is a growing pandemic with a huge burden of associated harmful effects on both physical and mental health. The role of bariatric surgery is well established in reducing morbidity from obesity. Bariatric surgery results in greater weight loss and greater improvement in weight-associated comorbidities compared with non-surgical interventions, regardless of the type of procedures used [1].

Overweight and obese women are at risk of urinary storage symptoms and lower urinary tract symptoms including almost double the risk of stress urinary incontinence (SUI) and a three times increased risk of urge urinary incontinence [2, 3]. Previous systematic reviews have addressed different aspects of the relationship between obesity and treatments for obesity and incontinence [4]. Non-surgical weight loss interventions are known to be associated with an improvement in urinary incontinence (UI) in overweight and obese women [2, 5]. Current incontinence guidance from bodies including The National Institute for Health and Care Excellence (NICE) [6] and the European Association of Urology (EAU) [7] recommends weight loss for obese women, as non-surgical weight loss through a variety of lifestyle and dietary interventions has

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✉ Bhawana Purwar
drbhawanapurwar@yahoo.com

1 Department of Urogynaecology, Singleton Hospital, Sketty Lane, Swansea, Wales SA2 8QA, UK

2 Department of Urogynaecology, John Radcliffe Hospital, Oxford, UK

3 Federal University of Pernambuco (UFPE), Recife, Brazil and University of Pernambuco (UPE), campus Recife, Recife, Brazil

4 Department of Urogynaecology, St Mary's Hospital, London, UK

been consistently associated with benefits for UI [3, 8, 9] even for women with moderately increased BMI.

Multiple cohort studies have tested the effects on UI of surgical weight loss for the morbidly obese. One earlier systematic review reported pooled benefits for specific incontinence scales, but was able to include only a minority of available studies, and could not differentiate between subtypes of UI [10].

Our aim was to systematically assess all available studies reporting the effect of bariatric surgery on changes in BMI in women with urinary incontinence. We planned to quantify the pooled effect sizes on quality of life (QoL) and cure, and test for associations between effects on weight loss and effect on UI across different procedures.

Materials and methods

We followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidance [11]. No ethical approval was required.

Eligibility criteria

Studies were eligible if they were randomised controlled trials, case–control and cohort studies (either retrospective or prospective); if they included obese and overweight individuals who have undergone bariatric surgery; if they had used validated urinary or pelvic floor questionnaires; and if they had a follow-up of at least 6 months.

Search strategies

We identified relevant studies using the keywords “urinary incontinence,” “bariatric surgery,” “surgically induced weight loss,” and obesity. We searched MEDLINE, Embase and the Cochrane library up to September 2016. The references of all eligible studies were also hand-searched. We also searched abstracts published at the annual meetings of the American Urological Association (AUA), European Association of Urology (EAU), International Continence Society (ICS) and International Urogynecological Association (IUGA) up to September 2016. Our search was restricted to humans and the English language.

Two independent reviewers (BP, GC) independently screened titles and abstracts first, and subsequently full texts, with duplicate data extraction. Disagreements were resolved by consensus.

Data collection and risk of bias assessment

No randomised controlled trials were identified. All identified studies were cohort studies. Two independent reviewers categorised studies as being either at a low or at a high risk of bias using a novel instrument developed by CLARITY group specifically designed for longitudinal symptom research studies aimed at the general population (Tables 1, 2), evaluating the representativeness of the source populations, the accuracy of the outcome assessment and the proportion of missing data [31].

Data synthesis and statistical analysis

We categorised the method of diagnosis of urinary incontinence: self-report, structured clinical interview, objective testing (cough test/pad test), or patient completed questionnaires; and the criterion for diagnosis, i.e. the number of episodes weekly/monthly. Included studies used different validated questionnaires with some studies using more than two validated questionnaires. Where a single study provided multiple estimates of cure or improvement, we selected the most widely employed or validated measure for pooling. Symptom and QoL scores were standardised on a scale of 0–100, whereas measures of incontinence cure were converted to proportions to enable pooling.

Data were analysed using metan in Stata 14, using the metafunnel, metabias and metareg packages. The Metaprop [32] command was used to pool cure rates, as standard weighting methods produce inaccurate 95% confidence intervals with binomial data, where rates approach 0% or 100%. The lower and upper confidence intervals were computed using the “exact” or Clopper–Pearson method. Changes in symptom scores and QoL were pooled with inverse-variance weights obtained from a random-effects model. We calculated heterogeneity between studies with Higgins’ I^2. We explored heterogeneity using meta-regression, testing the type of bariatric surgery and change in BMI as predictors of effect size.

Results

Literature search and study characteristics

Thirty full-text articles were screened after reviewing abstracts and titles, and 23 full-text articles were included in the meta-analysis (Fig. 1).

From a total of 23 studies ($n = 3,225$), 17 studies ($n = 1,069$) provided data for the change in the urinary scores [13–17, 19–26, 28–30, 33] and 17 studies ($n = 1506$) studies provided data for the proportion of women cured of any UI [12–21, 24–28, 30, 34] and 8 studies ($n = 377$) provided data for the proportion of women cured of SUI [12, 13, 21, 24, 30, 33–35]. We could not collate data for UUI because of inconsistencies in data reporting.

Twenty studies specified the type of bariatric procedure, whereas three studies did not give information. Gastric bypass was performed exclusively in 6 studies,

Table 1 General characteristics of studies included in the systematic review

References	Country	Mean age all (years)	Surgery type	Preoperative BMI (kg/m^2)	Postoperative BMI (kg/m^2)	Change in BMI/ weight (p value)	Follow-up (months)
Bump et al. [12]	USA	41 ± 11.9	Gastric bypass	49.4 ± 7.9	33.1 ± 6.7	NG/NS	14.5
Burgio et al. [13]	USA	40.2 ± 8.9	Laparoscopic Roux-en-Y gastric bypass	48.9 ± 7.2	30.2 ± 5.7	18.8 ± 4.5/ $p = 0.01$	12
Castro et al. [14]	Brazil	38.83 ± 7.86	NG	46.96 ± 5.77	29.97 ± 3.48	70.77 ± 13.26% weight loss	12
Cuicchi et al. [15]	Italy	42	Roux-en-Y gastric bypass	43.8 ± 8.5	34 ± 6.7	9.7 ± 5.0	12
Daucher et al. [16]	USA	47 ± 9	Laparoscopic Roux-en-Y gastric bypass surgery	46 ± 6	33 ± 6	154 ± 99 kg weight loss	6
Deitel et al.[34]	Canada	34.8 ± 8.7	Horizontal and vertical gastroplasty, jejunoileal bypass	123.8 ± 23.4	79.1 ± 12.8	50% weight loss	24–60
Frigg et al. [35]	Switzerland	41 (18–67)	Laparoscopic adjustable silicone gastric banding, biliopancreatic diversion with duodenal switch	45 (31–75)	34 (23–46)	54% weight loss	44 (0–70)
Kuruba et al. [17]	USA	49 ± 11	Roux-en-Y gastric bypass (93%), laparoscopic gastric banding surgery (7%)	48 ± 7	NG	64% weight loss	12
Knoepp et al. [18]	USA	44.5 ± 0.16	NG	NG	NG	NG	36
Laungani et al. [19]	USA	46 ± 10	Laparoscopic gastric bypass surgery	48 ± 7	32 ± 4;	17 ± 4/ $p = 0.08$	12
McDermott et al. [20]	USA	47.5 ± 10.9	Laparoscopic gastric bypass (58) or laparoscopic sleeve gastrectomy (6)	43.7 ± 6	29 ± 5.1	NG/$p < 0.001$	12
O'Boyle et al. [21]	Ireland	49 ± 9.7	Laparoscopic gastric bypass (57), laparoscopic sleeve gastrectomy (24), laparoscopic gastric banding (1)	50	34	16/$p = 0.1$	15
Olivera et al. [22]	USA	41.3 ± 12.3	Roux-en-Y gastric bypass, laparoscopic adjustable gastric band, or laparoscopic sleeve gastrectomy	45.8 ± 6.5	31.55 ± 7.31	14.21/$p < 0.0001$	37
Palleschi et al. [23]	Italy	64.4 ± 7.77	Laparoscopic sleeve gastrectomy	40.1 ± 3.7	32 ± 1.8	NG/$p < 0.001$	6
Ranasinghe et al. [24]	Australia	47.8	Laparoscopic gastric banding surgery	43.5 ± 6.6	35.5 ± 6.8	8.28/$p < 0.0001$	31.81 ± 24.42
Roberson et al. [39]	USA		Roux-en-Y gastric bypass and gastric banding	50.2 ± 7.7	32.9 ± 7.5	19.1 (bypass); 8.5 (banding)/$p =$ 0.0004	26 ± 16
Romero-Talamas et al. [33]	USA	48.8 ± 10.5	Roux-en-Y gastric bypass (90.2%), laparoscopic gastric banding surgery (2.7%) and laparoscopic sleeve gastrectomy (6.9%)	47.5 ± 9.4	32.7 ± 8.1	NG/$p < 0.001$	12
Scozzari et al. [25]	Italy		Laparoscopic Roux-en-Y gastric bypass, laparoscopic vertical banded gastroplasty, laparoscopic gastric banding and laparoscopic sleeve gastrectomy.	46.3 ± 6.3	31.3	71.8% ($p < 0.001$)	6
Shimonov et al. [26]	Israel	45.6 ± 10.9	Laparoscopic sleeve gastrectomy	42 ± 4.7	33 ± 4.7	NG/$p < 0.001$	6
Subak et al. [27]	USA (multicentric)	47 (18–78)	Roux-en-Y gastric bypass, laparoscopic adjustable gastric band, sleeve gastrectomy, biliopancreatic diversion with duodenal switch and banded gastric bypass	46 median (34–94)		28.5% weight loss	36
Vella et al. [28]	USA	45.4 ± 10.49	NG	47.5 ± 8.12	31.0 ± 6.47	49.2 kg weight loss/$p < 0.0001$	20
Wasserberg et al. [29]	USA	45 (20–67)	Roux-en-Y gastric bypass (21), duodenal switch (22), sleeve gastrectomy (3)	45 (35–75)	28 (22–44)	>50% weight loss/NG	12
Whitcomb et al. [30]	USA	43.3 ± 11.8	Laparoscopic gastric banding (96) and laparoscopic sleeve gastrectomy (3)	39.7 ± 6.2	34.0 ± 5.6	5.7 ± 0.6 (14%)	12

NS not significant, *NG* not given

Table 2 More general characteristics of studies included in the systematic review

References	Design	Sample size of the whole study	Sample size of cases (if applicable)	Sample size of controls (if applicable)	Prevalence of UI	Criteria	*p* value for UI symptoms
Bump et al. [12]	Longitudinal (prospective)	18	12		Any UI 12; SUI 10; UUI 9	UDS	NS
Burgio et al. [13]	Longitudinal (prospective)	101	92		92: any UI (66.7%); SUI (59.8%); UUI (35.9%); MUI (31.6%)	MESA stress/urge score, UDI, III	<0.001
Castro et al. [14]	Longitudinal (prospective)	24	17		17: any UI (70.8%)	KHQ	< 0.001
Cuicchi et al. [15]	Longitudinal (prospective)	100	87		51: any UI (58.6%)	ICIQ-SF, PFDI-20, PFIQ-7, POPDI-6	< 0.0001
Daucher et al. [16]	Longitudinal (prospective)	54	34		12: any UI (35%)	PFDI, PISQ-12 POPIQ, CRAIQ	0.05
Deitel et al. [34	Longitudinal (retrospective)	138			85: SUI (61.2%)	A self-administered questionnaire based on validated tools	< 0.001
Frigg et al. [35]	Observational	295	243 (1 year), 200 (2 years), 155 (3 years), 98 (4 years), women 79%		76 (26%)	A self-administered questionnaire based on validated tools	NG
Kuruba et al. [17]	Longitudinal (prospective)	45	38		Any UI (32%); MUI (60%); SUI (35%); UUI (5%)	Sandvik's incontinence severity index	< 0.001
Knoepp et al. [18]	Observational	3,898	204 (5.23%)	287 (7.36%)	Any UI (5.23%)	ICD-9 for UI	< 0.001
Laungani et al. [19]	Longitudinal (prospective)	309	58		Any UI (66%)	ICIQ-SF	< 0.001
McDermott et al. [20]	Longitudinal (prospective)	64	63		Any UI (86%)	PFDI-20, PFIQ-7	0.2
O'Boyle et al. [21]	Longitudinal (prospective)	104	82		Any UI (45%); SUI 13 (16%); MUI 38 (46%); OAB 13 (16%)	ICIQ-UI SF	NS
Olivera et al. [22]	Longitudinal (prospective)	44	36		NG	PFIQ, PISQ-12, FSFI	NA
Palleschi et al. [23]	Longitudinal (prospective) and case–control	120 (male and female)	60	60	OAB: grade A 21 (35%); grade B 17 (28%)	OABq SF	< 0.001
Ranasinghe et al. [24]	Observational (retrospective)	176 (male and female)	142		SUI 11/38 (29%)	ICIQ-SF	0.0164
Roberson et al. [39]	Observational, cross-sectional survey	193 (male and female)	161		NG	Sandvik's incontinence severity index	NS
Romero-Talamas et al. [33]	Longitudinal (prospective)	72			SUI 60 (83.3%); UUI 54 (75%)	PFDI-20, PISQ-12, PFIQ-7	< 0.001
Scozzari et al. [25]		103	32	71	32	PFDI-20, PFIQ-7	NS

Table 2 (continued)

References	Design	Sample size of the whole study	Sample size of cases (if applicable)	Sample size of controls (if applicable)	Prevalence of UI	Criteria	*p* value for UI symptoms
	Longitudinal (prospective) and case–control						
Shimonov et al. [26]	Longitudinal (prospective)	77	29	48	UI 29; SUI 17 (59%); UUI 2 (7%); MUI 10 (34%)	ICIQ-UI, BFLUTS-SF, PFDI-20, PISQ-12	< 0.001
Subak et al. [27]	Longitudinal (prospective)	1,987 (male and female)	1,565		Any UI 772; SUI 646; UUI 505	UIQ	< 0.001
Vella et al. [28]	Longitudinal (retrospective)	126			Any UI (45%)	UDI-6, IIQ-7	< 0.001
Wasserberg et al. [29]	Longitudinal (prospective)	178	46		NG	PFDI-20, PFIQ-7	< 0.0002
Whitcomb et al. [30]	Longitudinal (prospective)	98	69		SUI (32%)	EPIQ	0.05

UI urinary incontinence, *SUI* stress urinary incontinence, *UUI* urge urinary incontinence, *MUI* mixed urinary incontinence, *OAB* overactive bladder, *UDS* urodynamics studies, *MESA* Medical, Epidemiologic and Social Aspects of Aging, *KHQ* King's Health Questionnaire, *ICIQ-SF* International Consultation on Incontinence Questionnaire Short Form, *PFDI-20* Pelvic Floor Distress Inventory, *PFIQ-7* Pelvic Floor Impact Questionnaire, *POPDI-6* Pelvic Floor Distress Inventory and Pelvic Floor Impact, *PISQ-12* Pelvic Organ Prolapse/Urinary Incontinence Sexual Questionnaire, *POPIQ-7* Pelvic Organ Prolapse Impact Questionnaire, *CRAIQ* Colorectal–Anal Impact Questionnaire, *ICD-9* International Classification of Diseases, *FSFI* Female Sexual Function Index, *OABq SF* Overactive Bladder Questionnaire Short Form, *BFLUTS-SF* Bristol Female Lower Urinary Tract Symptoms Scored Form, *UIQ* Urinary Incontinence Questionnaire, *IIQ-7* Incontinence Impact Questionnaire, *EPIQ* Epidemiology of Prolapse and Incontinence Questionnaire whereas gastric banding was carried out in 2 studies, and 12 studies included women with different types of bariatric surgery, including sleeve gastrectomy, and diversion surgery. Four studies had follow-up data of 6 months, nine studies had a follow-up of 12 months and 10 studies had a follow-up of more than 1 year (maximum of up to 44 months).

Data regarding BMI was available for 21 studies. Pre-operative and post-operative BMI data were available to assess the change in BMI in 15 studies. The general characteristics of individual studies are presented in Tables 1 and 2 and urinary scores data are shown in Table 3.

Risk of bias

Of the 23 studies included, 17 studies (74%) had a high risk of bias and 6 (26%) had a low risk of bias (Table 4). Of these 23 studies, 17 (74%) had data both at baseline and at follow-up; 10 (43%) had few missing data in the follow-up, and 6 (17%) used representative source populations.

Changes in BMI

Changes in BMI were pooled for 15 studies. Bariatric surgery was associated with a significant reduction in BMI (13%, 95%

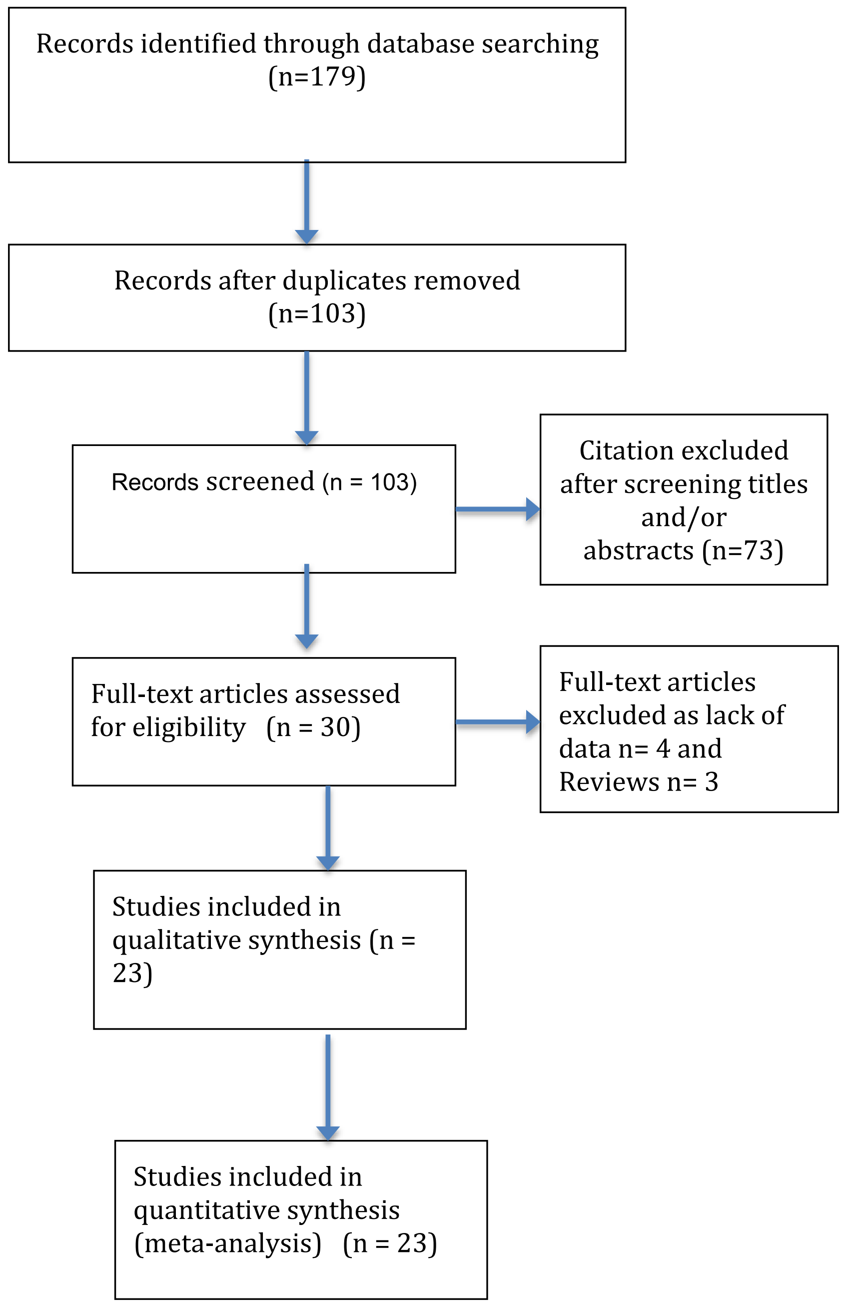

Fig. 1 Four-phase flow diagram of the systematic reviewing process

Table 3 Outcomes (urinary scores) of the studies

References	Change in total UI	Change in quality of life	Difference in mean score after rescale (0–100)
Bump et al. [12]	Number of incontinence episodes per week 13.4 ± 2.9 vs 0.9 ± 0.5, $p = 0.001$ Number of incontinence pads per day 2.0 ± 0.3 vs 0.08 ± 0.08, $p = 0.00008$		
Burgio et al. [13]	66.7% vs 37% ($p < 0.001$)	UDI-6 21.6 ± 21.1 vs 9.3 ± 11.9 ($p < 0.001$; CI =8.31–16.21) IIQ-7 15.8 ± 24.5 vs 6.1 ± 18.0 ($p < 0.001$; CI 4.71–14.60)	UDI-6 (0–100) = 12.3 IIQ-7 (0–100) = 9.7
Castro et al. [14]	70.8% vs 20.8% ($p < 0.001$)	KHQ 316.74 ± 28.10 vs 37.44 ± 6.57 ($p = 0.001$)	KHQ (0–100) = 31.03
Cuicchi et al. [15]	58.6% vs 9.2% ($p < 0.001$)	ICIQ-SF 7.7 ± 4.5 vs 2.6 ± 5.3 ($p = 0.0001$) UDI-6 18.8 ± 20.1 vs 5.4 ± 14.7 ($p < 0.0001$) UIQ-7 5.5 ± 14.2 vs 0.0 ± 0.5 ($p < 0.0001$)	ICIQ-SF (0–21) = 25.5 UDI-6 (0–100) = 13.4 UIQ-7 (0–100) = 5.5
Daucher et al. [16]	35% vs 17.659 ($p < 0.05$)	UDI 41 ± 32 vs 15 ± 10 ($p = 0.05$) UIQ 44 ± 60 vs 27 ± 40 ($p = 0.05$)	UDI (0–300) = 8.6 UIQ (0–400) = 4.25
Deitel et al. [34	SUI before = 85/138 (61.2%) SUI after = 16/138 (11.6%); $p < 0.001$		
Frigg et al. [35]	26% vs 14.9%		
Kuruba et al. [17]		Sandvik severity index score 5.4 ± 2.3 vs 2.3 ± 2.8 ($p < 0.001$) (14)	Sandvik (1–8) = 43.4
Knoepp et al. [18]	62.4% with ICD−9 coding diagnosed with UI no longer had a diagnosis of UI post-operatively. UI proportion cured = 62.4%, no change = 37.6%		
Laungani et al. [19]		ICIQ-SF total symptom score 7.6 ± 4 vs 1.8 ± 4 ($p < 0.001$) (5) QoL score 3.2 ± 3 vs 0.4 ± 2 ($p < 0.001$)	ICIQ (0–21) = 29
McDermott et al. [20]		UDI-6 35 (0, 79) vs 4 (0, 38) $p = 0.001$ IIQ-7 5 (0, 86) vs 0 (0, 7) $p = 0.001$ PFIQ-7 5 (0, 133) vs 0 (0, 214)	UDI-6 (0–100) = 31 IIQ-7 (0–100) = 5 PFIQ-7 (0–300) = 2
O'Boyle et al. [21]		ICIQ-SF 9.3 ± 4.4 vs 4.9 ± 5.3 ($p = 0.05$)	ICIQ-SF (0–21) = 22
Olivera et al. [22]		UIQ 143.41 ± 66.56 vs 108.49 ± 18.12 ($p = 0.0020$)	UIQ (0–400) = 8.75
Palleschi et al. [23]	UUI episodes per 24 h 1.2 (±0.7) vs 0 ($p < 0.001$) Urgency episodes per 24 h 3.5 ± 1.1 vs 0.4 (±1.9) ($p < 0.001$)	OABq score 18.69 ± 8.9 vs 12.18 ± 3.2	OAB-SF (19–114) = 6.51
Ranasinghe et al. [24]		ICIQ-SF 5.24 (5.05) vs 3.93 (4.83) ($p < 0.0008$) QoL 2.48 (1.94) vs 1.79 (1.78) ($p < 0.0001$)	ICIQ-SF (0–21) = 6.55
Roberson et al. [39]	UI improved 39%, unchanged 30%	Sandvik severity score	
Romero-Talamas et al. [33]	Prevalence of SUI improved from 83.3% to 44.4% Prevalence of UUI improved from 75% to 37.5% ($p < 0.001$)	PFDI-20 76.7 ± 47.2 vs 52.2 ± 50.9 ($p < 0.001$); PFIQ-7 30.3 ± 39. 2 vs 16.8 ± 36.9 ($p = 0.002$)	PFDI-20 (0–300) = 8.16 PFIQ-7 (0–300) = 4.5
Scozzari et al. [25]		UDI-6 14.6 vs 8.3 ($p < 0.001$) UIQ-7 2.4 vs 0 ($p = 0.033$) QoL (PFIQ) 4.8 vs 0.0 ($p = 0.044$)	UDI-6 (0–100) = 6.3 UIQ-7 (0–100) = 2.4
Shimonov et al. [26]		ICIQ-UI 9.28 ± 3.6 vs 2.9 ± 3.8 ($p < 0.001$) UDI-6 31.41 ± 7.9 vs 9.3 ± 12.3 ($p < 0.001$)	ICIQ-SF (0–21) = 31.9 UDI-6 (0–100) = 22.11
Subak et al.[a] [27]	Prevalence of any UI 49.3% to 24.4% Prevalence of SUI 4.2% to 18.8%	UIQ	

Table 3 (continued)

References	Change in total UI	Change in quality of life	Difference in mean score after rescale (0–100)
	Prevalence of UUI 33% to 17.2% Number of incontinence episodes 352 to 157		
Vella et al. [28]	Odds of urinary leakage before surgery 7.56 times the odds of leakage after surgery ($p < 00001$)	UDI-6 = 39.56–34.95 ($p = 0.001$) UIQ-7	UDI-6 (0–100) = 4.61 (OR = 0.13) UIQ-7 (0–100) = 16
Wasserberg et al. [29]	Prevalence on UDI-6 71.3% vs 39%	UDI-6 = 26.07 vs 10.77 ($p = 0.003$, 95% CI: 12–54) UIQ-7	UDI-6 (0–100) = 15.3
Whitcomb et al. [30]		PFIQ 26.8 ± 25.2 vs 9.3 ± 10.6 ($p < 0.001$) PFDI 42.1 ± 21.3 vs same at 12 months VAS SUI 63.1 ± 11.4 vs 41.6 ± 26.0 ($p < 0.001$) VAS OAB 75.1 ± 10.4 vs 42.9 ± 24.6	PFIQ-7 (0–300) = 5.83 PFDI-20 (0–300) = 6.93 VAS SUI (0–100) = 21.5 VAS OAB (0–100) = 32.2

p<0.0001

QoL quality of life, *OR* odds ratio, *VAS* visual analogue scale

[a] Data presented for women only

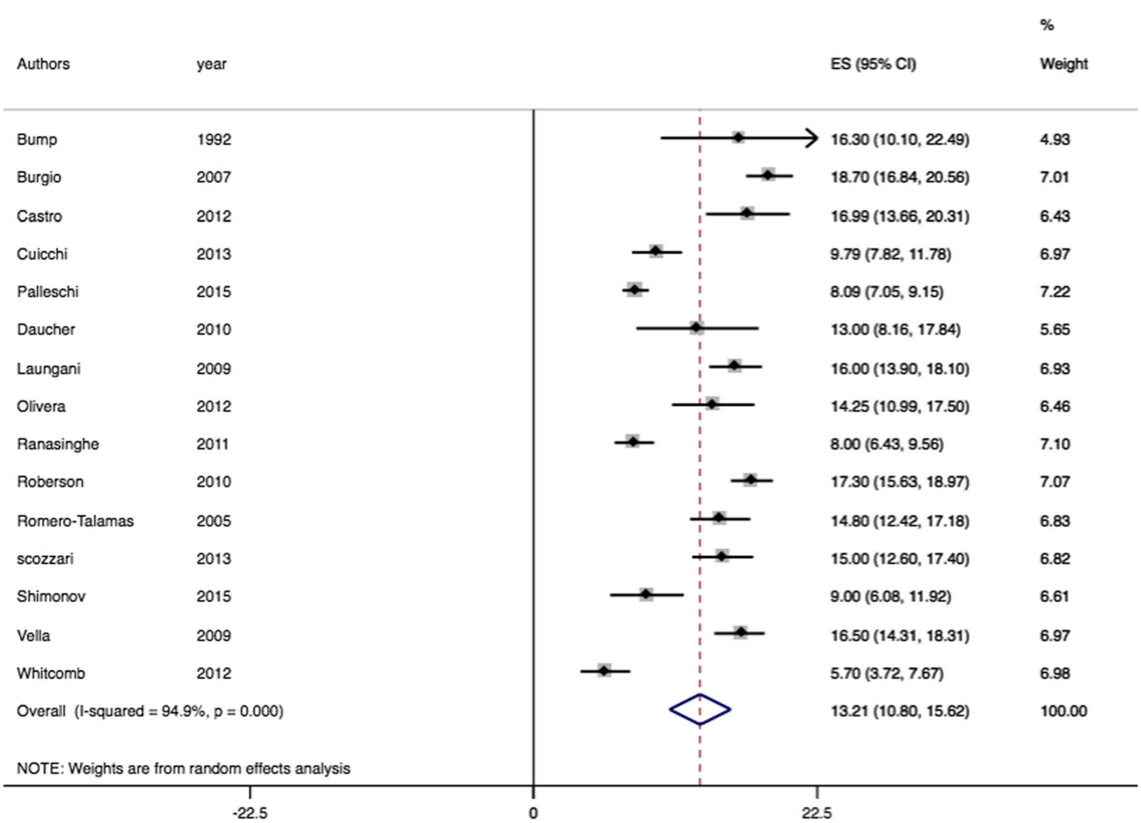

Fig. 2 Forest plot displaying the mean change in body mass index after bariatric surgery. *ES* effect size, *CI* confidence interval

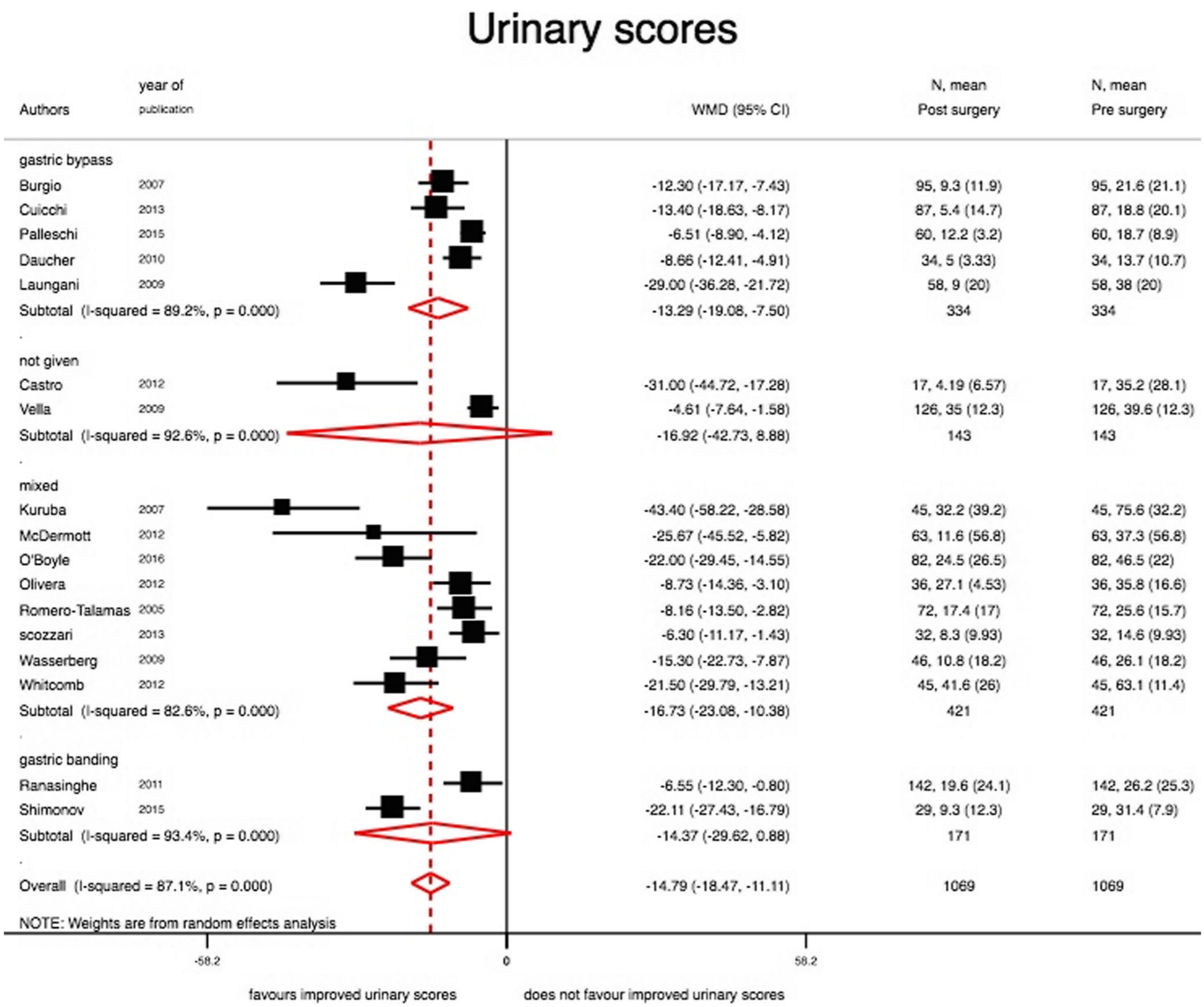

Fig. 3 Forest plot displaying the mean change in urinary scores after bariatric surgery based on the type of surgery. *WMD* weighted mean difference

confidence interval = −10.797 to -15.619, $p < 0.001$), but with high heterogeneity, $I^2 = 94.9\%$, $p = 0.0001$ (Fig. 2).

Change in urinary scores

The changes in urinary scores were pooled for 17 studies. A subgroup analysis based on the type of surgery for studies showed 14% improvement in the urinary scores of patients after bariatric surgery (weighted mean difference = −14.79; CI = −18.47 to −11.11), with substantial heterogeneity ($I^2 = 87.1\%$), as shown in Fig. 3.

Results were unchanged in sensitivity analyses excluding each study once. We explored the heterogeneity using meta-regression, testing the type of bariatric surgery and change in BMI as predictors of effect size, and none of them was associated with the change in urinary scores.

Proportion of women cured

Changes in proportions of women cured of any UI were pooled for 17 studies. For overall UI, the pooled cure rate was 59% (95% CI = 51 to 66), again with high heterogeneity ($I^2 = 84.93\%$, $p < 0.0001$ (Fig. 4). Changes in proportions of women cured of SUI were pooled for 8 studies. The pooled cure rate of any SUI was 55% (95% CI = 40 to 70) with high heterogeneity ($I^2 = 89.91\%$, $p < 0.0001$; Fig. 5).

A subgroup analysis based on the type of surgery did not show any significant differences in the proportion of women cured across procedures (Fig. 4).

Table 4 Risk of bias of included studies

References	Risk of bias criteria			Overall risk of bias
	Representativity of the source population	Assessment of the outcome	Missing data	
Bump et al. [12]	–	+	–	High
Burgio et al. [13]	–	+	+	High
Castro et al. [14]	–	+	+	High
Cuicchi et al. [15]	–	+	+	High
Daucher et al. [16]	–	+	–	High
Deitel et al. [34	–	–	–	High
Frigg et al. [35]	–	–	–	High
Knoepp et al. [18]	+	–	+	High
Kuruba et al. [17]	+	+	+	Low
Laungani et al. [19]	+	+	+	Low
McDermott et al. [20]	+	+	+	Low
O'Boyle et al. [21]	–	–	–	Low
Olivera et al. [22]	–	–	+	High
Palleschi et al. [23]	+	+	+	Low
Ranasinghe et al. [24]	–	+	–	High
Roberson et al. [39]	–	–	–	High
Romero-Talamas et al. [33]	–	+	+	High
Scozzari et al. 25]	–	+	+	High
Shimonov et al. [26]	–	+	+	High
Subak et al. [27]	+	+	+	Low
Vella et al. [28]	–	+	–	High
Wasserberg et al. [29]	–	+	–	High
Whitcomb et al. [30]	–	+	–	High

Discussion

Strengths

To our knowledge, this is the first systematic review of the effect of weight loss surgery on urinary incontinence reporting cure rates. We used pre-specified criteria for the inclusion of studies, considered grey literature and carefully avoided duplicate data. We used appropriate statistical methods, and further sensitivity analysis did not change the results. Our study quantitatively summarised the available evidence for the effect of weight loss after bariatric surgery on urinary incontinence.

Limitations

There were 17 studies, which reported standardised quality of life urinary scores, but most of the studies used different quality of life scores and heterogeneity in the meta-analysis is high. Second, there were few studies with small numbers, which can skew the true effect size. The smallest included study consisted of 12 patients. Although the differences in weight loss led to the improvement in urinary scores and the proportion of women cured, on sensitivity analysis, we did not have the power to show that (using study-level statistics) the magnitude of weight loss is associated with improvement in UI. If we had individual patient data, we would have been able to explore in greater depth the change in BMI and improvement in urinary incontinence.

Another important limitation is the variable follow-up period (6–44 months), which influences the proportion cured of any UI and SUI. Also, there were insufficient data to report cure rates for UUI.

Though most studies defined their inclusion and exclusion criteria, none of the studies commented on co-interventions like conservative measures, pelvic floor exercises or medical treatment during the study period. Apart from three studies in which controls were matched, none of the other studies had a control group. This may indicate that the other treatments/factors apart from bariatric surgery may have influenced the results.

The eight studies that provided data for the cure rates of SUI had not commented on interventions such as pelvic floor exercises and this could have an impact on published data for cure rates of SUI.

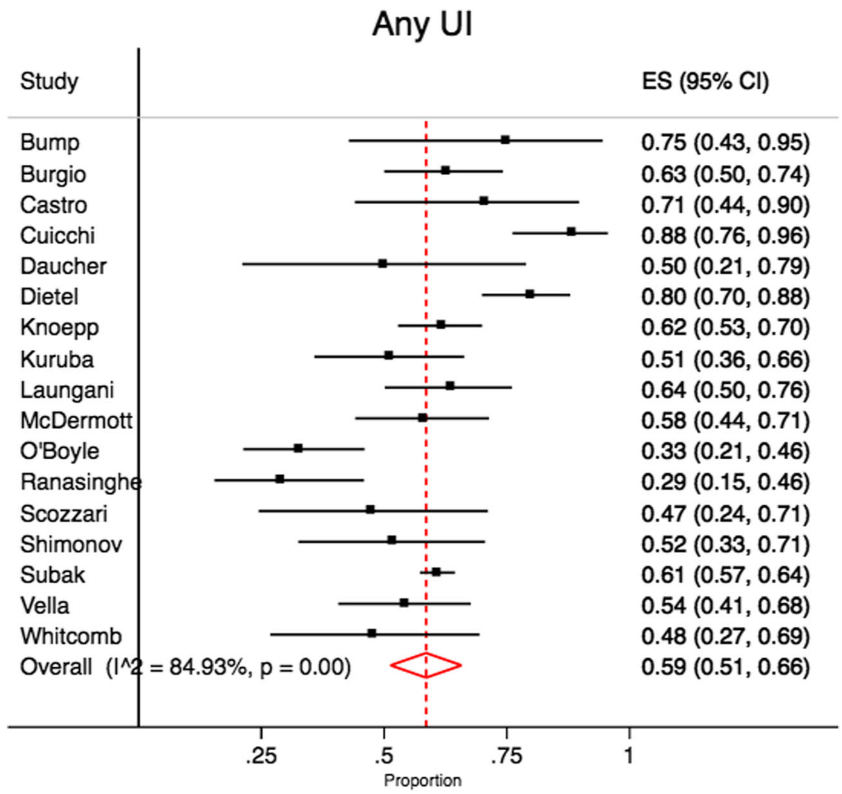

Fig. 4 Meta-analysis of proportions of women cured of any urinary incontinence (*UI*) after bariatric surgery (Metaprop)

The other limitations include response bias, as sometimes standardised questionnaires were filled out during telephone/clinic interviews where patients may have answered favourably towards what researchers want to hear, and there was lack of blinding in all the studies. The patients in these trials were recruited while women were on the waiting list for bariatric surgery and questionnaires were distributed to identify suitable women for the study. These studies relied on self-reported data, which is influenced by recall bias.

Implications for clinical practice and future research

This systematic review and meta-analysis showed improvement in the quality of life scores of women with

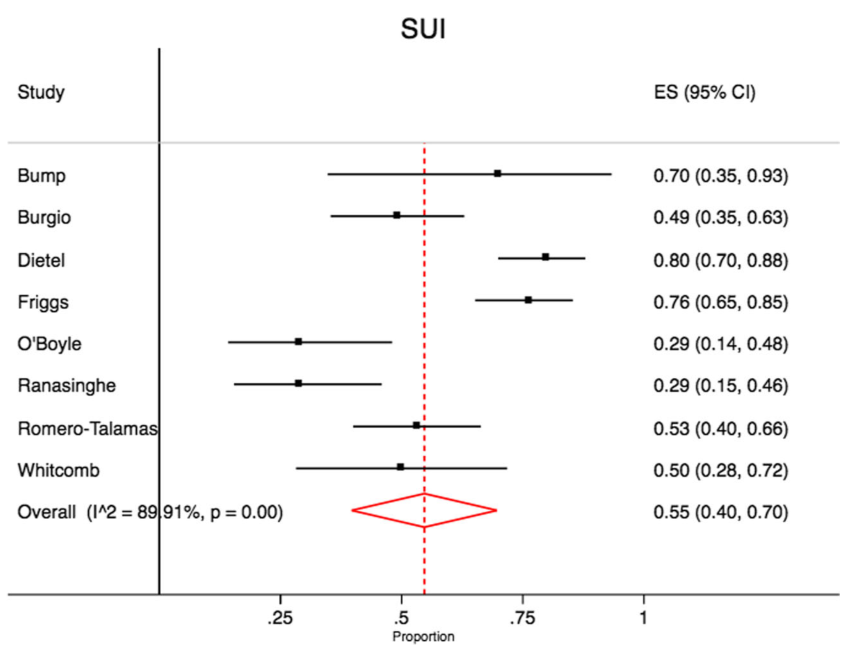

Fig. 5 Meta-analysis of proportions of women cured of stress urinary incontinence (*SUI*) after bariatric surgery (Metaprop)

urinary incontinence with a significant proportion of women achieving cure in any UI and SUI. These results make bariatric surgery a promising treatment option for obese and overweight women in whom conservative/pharmacological methods of losing weight have failed. In our SR, the degree of change in BMI was not the predictor of effect size. A subgroup analysis based on different types of surgery showed that greater weight loss (mean BMI reduction by 14%) was achieved with gastric bypass surgery compared with gastric banding (mean BMI reduction by 8%), but there was no difference in improvement in UI scores between the two subgroups. a higher degree of improvement in urinary symptom scores.

The remaining women with UI demonstrated some improvement, no change or worsening of symptoms, although they all achieved some degree of surgical weight loss. The data for these women could not be analysed because of inconsistencies in reporting in the articles. This suggests that women who achieved weight loss might have showed a trend towards improvement, although they may not have been completely cured of UI, especially UUI.

Large prospective individual studies have shown that individuals regained weight with time and associated with this is the relapse of co-morbidities [36]. Although bariatric surgery has a more sustained effect on weight loss compared with non-surgical methods of weight loss, it is associated with serious complications and a risk of death [37].

These results will help us to counsel women that weight loss surgery is beneficial in achieving improvement in urinary incontinence. We know from the EpiLUTS study that women are far more likely to report any UI, and, in particular, SUI, and SUI may be particularly sensitive to increased weight above the normal range in women [38]. When conservative measures fail to treat UI and surgical interventions are being considered, it seems appropriate to consider bariatric surgery in overweight and obese women in addition to considering specific surgery for urinary incontinence. Given serious complications associated with bariatric surgery and the lack of long-term follow up, careful consideration of other options and detailed counselling are needed before offering this surgery for the improvement of the quality of life of women with urinary incontinence.

Conclusions

Evidence from these cohort studies suggests that there might be a clinically meaningful improvement in urinary symptom scores, the proportion of women cured of SUI and any UI, and a reduction in BMI after bariatric surgery, but with substantial differences between studies.

There is a lack of data regarding improvement/cure in women with UUI, and future studies should report such data to guide our management of these women.

Current data are limited to short-term follow-up of these women, with great heterogeneity in the studies. Further studies are needed to explore the impact of bariatric surgery on individual subtypes of incontinence, and to investigate which types of surgery offer the largest benefit for LUTS.

This review will help patients and surgeons to counsel overweight and obese women for weight loss surgery as one of the treatment options for urinary incontinence.

Compliance with ethical standards

Conflicts of interest None.

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