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ORIGINAL CONTRIBUTIONS

Psychosocial Outcomes Following Adolescent Metabolic and Bariatric Surgery: a Systematic Review and Meta-Analysis

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Abstract

Background Metabolic and bariatric surgery is an effective strategy to curb the natural history of obesity progression and improve psychosocial status in the short term for adolescents with severe obesity. The medium- and long-term psychosocial impact of bariatric surgery in this population is not established.

Methods We searched MEDLINE (Ovid), EMBASE, Web of Science, PsycInfo, and the Cochrane Libraries through October 2017 for reports of weight loss surgery (roux-en-Y gastric bypass, sleeve gastrectomy, and adjustable gastric banding) on adolescents with severe obesity (age ≤ 21 years) having ≥ 6 months of follow-up. The primary outcome for inclusion in systematic review was use of a validated quality of life (QoL) or other psychosocial instrument at baseline and postoperatively. We used standardized mean difference (SMD) and random-effects modeling to provide summary estimates across different instruments.

Results We reviewed 5155 studies, of which 20 studies met inclusion criteria for qualitative synthesis. There were 14 studies and 9 unique cohorts encompassing 573 patients which were eligible for meta-analysis regarding postoperative change in QoL. Across surgical procedures, there was significant improvement in QoL of 1.40 SMD (95% confidence interval 0.95 to 1.86; $I^2 = 89\%$; $p < 0.001$) at last follow-up (range 9–94 months). Trends in QoL improvement demonstrated the greatest improvement at 12 months; however, significant improvement was sustained at longest follow-up of 60+ months.

Conclusions Weight loss surgery is associated with sustained improvement in QoL for adolescents with severe obesity across surgical procedures. Long-term data for psychosocial outcomes reflecting other mental health domains is lacking.

Keywords Adolescent · Bariatric surgery · Psychosocial outcomes · Quality-of-life

Introduction

Obesity is an evolving epidemic in industrialized nations with increasing impact on a younger population [1]. Today, about one in five children and adolescents aged 12–19 years are obese, and nearly one in ten are severely obese (BMI > 120% of the 95th percentile) [2]. There is a concordant trend toward earlier onset of comorbidities including cardiovascular disease, type 2 diabetes, obstructive sleep apnea, and psychosocial disease [3, 4]. Earlier onset and increasing severity of obesity in adolescents come at a great expense to society, with total healthcare costs attributable to obesity in the USA estimated to reach nearly $1 trillion by 2030 [5]. Adolescent obesity is also disproportionately affecting lower socioeconomic strata in the developed world, becoming a driver for worsening socioeconomic inequality [6]. While the need for effective

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obesity treatments is clear, no ideal approach has materialized. Pharmacologic options are limited, and lifestyle modification and behavioral strategies have demonstrated little sustainable success, particularly in the adolescent population [7–9].

First described in the 1970s, adolescent bariatric surgery gained interest in the mid-2000s given the potential for significant BMI reduction and comorbidity resolution [10, 11]. Multiple efforts to study the biochemical and physiologic effect of this intervention are ongoing worldwide [12, 13]. At the same time, increasing attention has been given to the complex relationship between obesity and psychiatric disease found in an adolescent population [14, 15]. Prior systematic reviews have evaluated adolescent bariatric surgery and reported favorable impacts on BMI reduction and comorbidity resolution as well as improvement in quality of life (QoL) and reduction in anxiety and depression [10, 16–19]. Duration of follow up for studies included in these reviews, however, was generally limited to 2 years or less. This is problematic given that one study found the most improvement in QoL occurred in the first year following surgery, followed by regression in the second year [19]. More recently, a systematic review of adolescent bariatric patients with a minimum of 3 years of follow-up was performed, but psychosocial outcomes were not evaluated [20].

This study aims to update current understanding of psychosocial outcomes for severely obese adolescents undergoing bariatric surgery. We evaluate short-, medium-, and long-term psychosocial outcomes to determine how this important facet of adolescent obesity and well-being is impacted over time by metabolic and bariatric surgery.

Methods

Review Protocol

After preliminary review of the existing literature, we devised and registered a systematic review research protocol with PROSPERO (CRD42018089023) [21]. We developed our methodology consistent with the Cochrane Handbook and PRISMA Statement guidelines [22, 23].

Study Eligibility Criteria

The following eligibility criteria were applied for our systematic review:

1. Study design: randomized controlled trials (RCTs), non-randomized controlled trials, quasi-experimental studies, and observational series with prospective data collection
2. Intervention: adjustable gastric banding (AGB), roux-en-Y gastric bypass (RYGB), and sleeve gastrectomy (SG)
3. Population: obese adolescents ≤ 21 years old meeting local criteria for bariatric surgery
4. Outcome: collection of psychosocial outcomes at baseline and a minimum of 6 months after surgery using a validated instrument

Outcome Measures

The primary outcome of interest was change in psychosocial outcomes for adolescents undergoing bariatric surgery. The most common domain in which validated psychosocial measures are assessed relate to QoL, which includes health-related or weight-related measures. We also abstracted any inventories of anxiety, depression, body image, or other psychosocial domains. The Mental Component Score of the 36-Item Short Form Health Survey was treated as a global measure of mental health [24]. Secondary outcomes were changes in BMI, resolution in comorbidities (type 2 diabetes, dyslipidemia, hypertension, metabolic syndrome, elevated liver enzymes, non-alcoholic steatohepatitis, obstructive sleep apnea, and anemia), changes in nutrition (iron, vitamin D, vitamin B12 and vitamin A), and complications (readmissions, reoperations and mortality).

Search Methods

We searched MEDLINE (Ovid), EMBASE, Web of Science, PsycInfo, and the Cochrane Libraries from January 1992 through October 2017. We used exploded MeSH terms and keywords to generate sets for the following themes combined with Boolean term "OR": bariatric surgery, adolescent, and obesity. We then used the Boolean term "AND" to find their intersection (Supplementary Appendix A). We did not include any limits on our search strategy. We reviewed references for all included studies and searched the trial registry ClinicalTrials.gov.

Study Selection

Execution of our search strategy resulted in a total of 7640 published entries; after removal of duplicates, this yielded 5155 unique articles. In an unblinded fashion, five authors screened articles for inclusion based on title and abstract review using Rayyan software [25]. This left 346 potentially eligible studies which were subjected to full-text review by three authors in a duplicative and blinded fashion. Any discrepancies were resolved through group consensus.

Data Collection and Assessment of Methodological Quality

We developed a standardized data collection form and abstraction was performed in a duplicative, blinded fashion by two authors. Completed data flowsheets were consolidated, and all

discrepancies were resolved based on group consensus. In the event of missing data on the primary outcome for a series published in the last 5 years, efforts were made to contact the primary author. Due to a reliance on data from observational series, we adapted the ECRI Before-After Study Quality scale to assess methodological quality of eligible studies [26]. Specifically, we rated included studies as having low, high, or unclear risk of bias with respect to 10 domains: (1) description of previous treatments attempted, (2) use of prospective data collection methods, (3) enrollment of all/consecutive patients, (4) identification of clinical exclusion/inclusion criteria, (5) uniform treatment of study subjects, (6) use of objective and/or validated outcome measures, (7) attrition < 15%, (8) comparison of attrition group characteristics, (9) financial conflict of interest, and (10) conclusions which fit the reported results.

Analysis

Data Synthesis

We performed meta-analyses using RevMan 5.3 [27]. To facilitate comparison across different psychosocial instruments, we calculated summary estimates using standardized mean difference (SMD), which normalizes the mean difference between baseline and follow-up scores by the standard deviation within a given study. Random-effects modeling was used given the variation attributable to different surgical centers, patient populations, and psychosocial instruments. We performed tests of heterogeneity using traditional cutoff values for low heterogeneity of $p < 0.10$ and $I^2 < 50\%$. For the primary outcome of change in QoL, we performed subgroup analysis by surgical procedure. We then performed pooled analyses across surgical procedures to produce summary estimates for studies using only the PedsQL instrument as well as those using any instrument measuring depression, physical self-assessment, and overall mental health. When multiple studies reported on the same cohort of patients, we performed analysis on the study with the longest duration of follow up.

Dealing with Missing Data

We attempted to contact the primary author for all manuscripts for which data was lacking to complete meta-analysis. Four studies did not provide information about the number of patients completing the psychosocial instrument at last follow-up [28–31]. To include as many unique series as possible in meta-analysis, we assumed 25% attrition in these studies—a conservative assumption based on an average attrition rate of 18% in the remaining studies included in qualitative synthesis. In addition, for studies reporting variance in psychosocial outcomes using confidence intervals, we statistically converted these to standard deviations for use in meta-analysis [13, 32, 33].

Sensitivity Analyses and Publication Bias Assessment

We conducted various sensitivity analyses for the primary outcome of change in QoL. First, based on our methodological assessment of study quality, we excluded studies that were felt to have a high risk of attrition bias or unclear bias from conflicts of interest. We also performed sensitivity analysis by calculating a summary estimate using mean difference (MD) for only the PedsQL instrument, removing heterogeneity inherent to meta-analysis across different instruments. Finally, to assess for publication bias, we constructed a funnel plot of treatment effect size versus study precision for studies included in the primary outcome meta-analysis (Supplementary Appendix B).

Results

Description of Studies

Results of Search

We reviewed 5155 studies by title and abstract and 346 articles by full text. After this search, 27 studies met final eligibility criteria; 7 of these were publications from identical patient cohorts that did not provide any additional information and were excluded. The remaining 20 reports comprised 14 unique patient cohorts and 771 adolescent patients who underwent bariatric surgery and were included in qualitative synthesis. Three studies did not have sufficient data for meta-analysis [34–36]. This left 17 reports from 11 patient cohorts eligible for meta-analysis of psychosocial outcomes. Of these, 9 cohorts (573 patients) examined QoL and 6 cohorts (210 patients) specifically used the PedsQL instrument—Fig. 1.

Included Studies

The characteristics of all 20 studies included in qualitative synthesis are provided in Table 1. Studies originated from eight different countries. Most studies were observational series, with the exception of one randomized controlled trial [32], one non-randomized controlled study [12], and one prospective cohort study [37]. Females comprised the majority of patients (range 49–100%), and mean baseline age was between 15.2 and 18.6 years. Mean follow-up ranged from 9 to 94 months. Among the 17 studies eligible for meta-analysis, we analyzed 9 unique cohorts reporting QoL outcomes [13, 28–30, 37–41], 3 reporting on depression [29, 33, 42], 3 on physical self-assessment [31, 33, 37], and 4 reports on changes to overall mental health [12, 32, 42, 43].

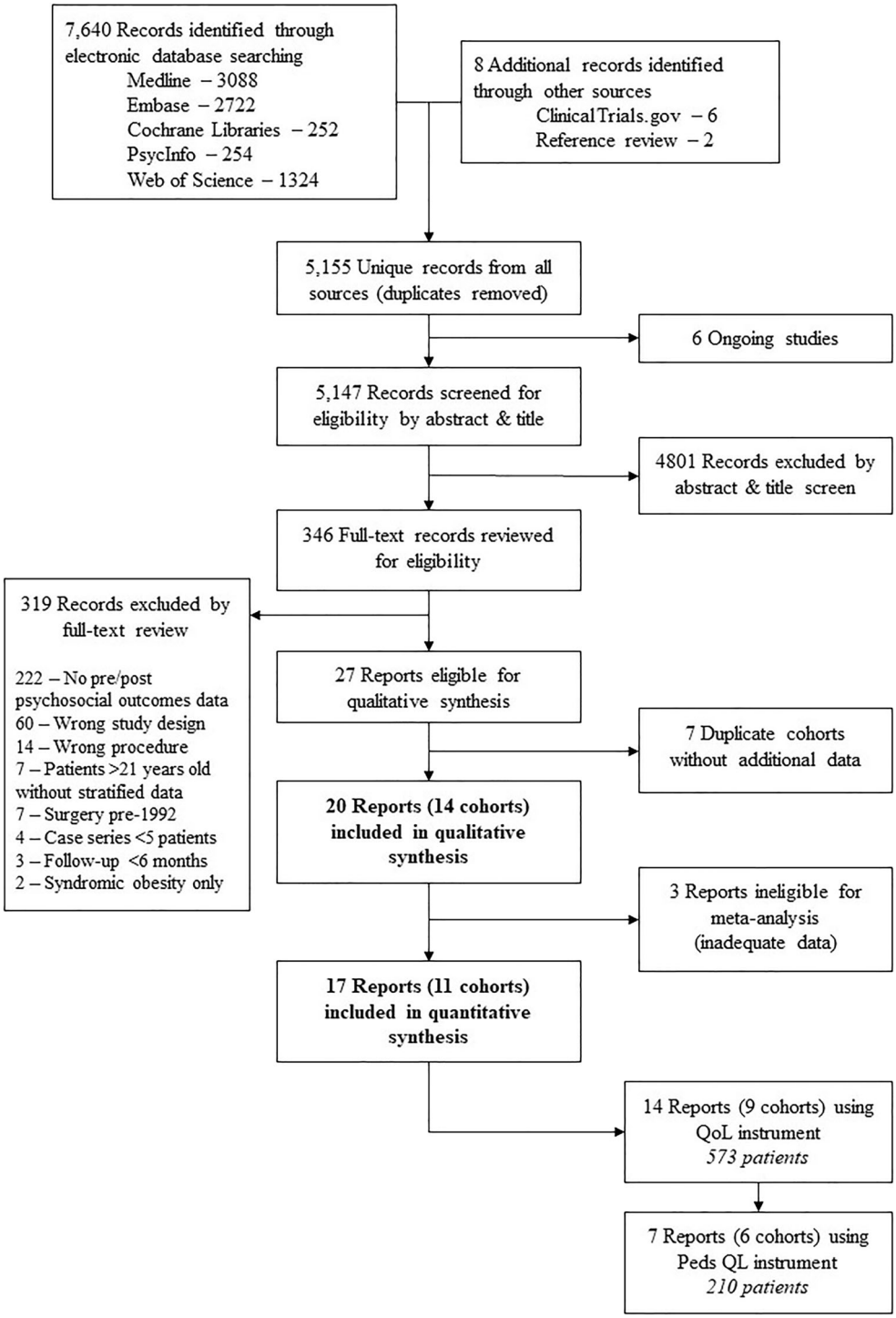

Fig. 1 PRISMA study selection flow diagram

Excluded Studies

Most studies excluded during full-text review did not report on psychosocial outcomes (Fig. 1). Of the studies included in qualitative synthesis, three were excluded from meta-analysis for lack of adequate information on variance related to the psychosocial instrument used. El-Matbouly used the Body Image Questionnaire for 91 patients undergoing sleeve gastrectomy and reported significant improvement at 5 years of follow-up, although attrition was over 50% in this series [34]. The other two studies used the PedsQL questionnaire on smaller cohorts of gastric banding patients to 48 months of follow-up, and also reported improvement in QoL [35, 36].

Two large, recent studies with long-term follow up of young bariatric patients were excluded from qualitative synthesis as only postoperative QoL data was collected. Jong

Table 1 Characteristics of studies included in qualitative synthesis

Study Design	Year, Primary Author	Cohort	Location	Surgical Procedures (n)	% Female	Baseline Age, Mean ± SD (years)	Baseline BMI, mean ± SD (kg/m^2)
Randomized controlled trial	2010, O'Brien	1	Australia	AGB (25)	64	16.5 ± 1.4	42.3 ± 6.1
Non-randomized controlled study	2017, Olbers	2	Sweden	RYGB (81)	65	16.5 ± 1.2	45.5
	2016, Jarvholm	2	Sweden	RYGB (82)	67	NR	NR
	2015, Jarvholm	2	Sweden	RYGB (88)	65	16.8 ± 1.2	45.4 (44.4–46.8)
Cohort study	2013, Aldaqal	3	Egypt	SG (32)	69	15.19 ± 1.2	49.6 ± 4.9
Observational series	2017, El-Matbouly	4	United Arab Emirates	SG (91)	49	17 ± 1.5	48 ± 7.5
	2017, Manco	5	Italy	SG (20)	65	16.7 ± 1.4	48.6 ± 4.2
	2017, Pena	6	Australia	AGB (21)	57	17.3	Median 47.1
	2017, Zeller	7	USA	RYGB (14)	64	16 ± 1.3	59.2 ± 8.9
	2016, Hervieux	8	France	AGB (36)	NS	16.7 ± 1.3	43.6 ± 5.5
	2016, Inge	9	USA	RYGB (161) SG (67) AGB (14)	75	17 ± 1.6	53 (51–54)
	2016, Schmitt	10	France	AGB (16)	75	17.4	43.0 (36.8–48.5)
	2012, Ratcliff	7	USA	RYGB (16)	69	16.3 ± 1.2	66.2 ± 12.0
	2012, Sysko	11	USA	AGB (101)	72	15.8 ± 1.1	47.2 ± 0.9
	2011, Silberhumer	12	Austria	AGB (50)	NS	17.1 ± 2.2	45.2 ± 7.6
	2011, Zeller	7	USA	RYGB (16)	63	16.2 ± 1.4	59.9 ± 8.7
	2010, Holterman	13	USA	AGB (20)	75	16 ± 1	50 ± 10
	2007, Holterman	13	USA	AGB (10)	100	16 ± 0.1	50 ± 13
	2006, Silberhumer	12	Austria	AGB (50)	62	17.1 ± 2.2	45.2 ± 7.6
Not reported	2008, Loux	14	USA	RYGB (13)	69	18.6 ± 1.7	54.1 ± 7.6

Study Design	Follow-up, Mean ± SD (months)	Number with baseline data (Primary Outcome)	Attrition Rate (%)	Quality-of-life instrument	Other psychosocial instrument	Eligible for meta-analysis
Randomized controlled trial	24	25	4	–	CHQ CF-50	Y
Non-randomized controlled study	60	81	0	OP-14	SF-36 MCS	Y
	60	82	9	OP-14	–	Y
	24	86	13	OP-14	BYI, RSE, MACL	Y
Cohort study	12	32	0	PedsQL	RSE	Y
Observational series	46 ± 9	91	52	–	BIQ	N
	12	20	0	PedsQl		Y
	46	21	57	PedsQL		Y
	94 ± 12	14	14	IWQoL-Kids, IWQoL Lite	YSR/ASR	Y
	24	36	NR	PedsQL	–	N
	36	RYGB - 161 SG - 67 AGB - 14	RYGB – 13 SG - 19 AGB - 14	IWQoL-Kids	–	Y
	Median 26	16	25	PedsQL, Fatigue PedsQL	–	N

Table 1 (continued)

Study Design	Follow-up, Mean ± SD (months)	Number with baseline data (Primary Outcome)	Attrition Rate (%)	Quality-of-life instrument	Other psychosocial instrument	Eligible for meta-analysis
	12	16	NR	IWQoL	SFRS, SPPA	Y
	NR	NR	NR	PedsQL	BDI	Y
	86 ± 18	50	10	Moorehead-Ardelt	–	Y
	24	16	13	IWQoL-Kids, PedsQL	BDI	Y
	29 ± 9	20	40	PedsQL	–	Y
	9	10	0	PedsQL	BDI	Y
	35 ± 18	50	10	Moorehead-Ardelt	–	Y
Not reported	17 ± 12	13	31	–	SF-36 MCS	Y

AGB adjustable gastric banding, *ASR* Adult Self-Report, *BDI* Beck Depression Inventory, *BIQ* Body Image Questionnaire, *BYI* Beck Youth Inventory, *CHQ CF-50* Child Health Questionnaire-Child Form, *IWQoL* Impact of Weight on Quality of Life, *MACL* Mood Adjective Check List, *NR* Not Reported, *OP-14* Obesity-related Problem questionnaire, *PedsQL* Pediatric Quality of Life inventory, *RSE* Rosenburg Self-Esteem questionnaire, *RYGB* roux-en-Y gastric bypass, *SF-36 MCS* 36-Item Short Form Health Survey Mental Component Score, *SFRS* Stunkard Figure Rating Scale, *SG* sleeve gastrectomy, *SPPA* Self Perception Profile for Adolescents, *YSR* Youth Self-Report

et al. reported on 96 young adults aged 18 to 24 who underwent banding, bypass, or sleeve gastrectomy and completed postoperative QoL questionnaires at 6 to 72 months of follow up. Mean postoperative QoL was below national norms, with clusters of well-adjusted and poorly adjusted patients. There was no difference in outcomes by surgery type and little relation to degree of weight loss [44]. Ryder and colleagues published QoL data from the Follow-up of Adolescent Bariatric Surgery at 5 Plus years (FABS-5+) cohort, which collected psychosocial data at 1 year and between 5 and 12 years after surgery for 50 adolescents undergoing RYGB [45]. Improved QoL was one of the only identifiable factors associated with long-term weight loss maintenance versus weight regain in this study.

Methodological Quality of Included Studies

An adapted version of the ECRI Before-After Study Quality scale revealed that attrition bias (> 15% attrition in 5/20 studies; not reported in 3/20 studies), failure to examine characteristics of patients lost to follow-up (15/20 studies), and unclear impact from disclosed conflicts of interest (14/20 studies) were the leading potential sources of methodological bias (Fig. 2).

Publication Bias

We constructed a funnel plot of treatment effect size versus study precision for the nine studies included in meta-analysis of improvement in QoL at last follow-up (Supplementary Appendix B). One small study was a significant positive outlier [37], but there was no overt asymmetry to suggest publication bias.

Meta-Analyses

Change in Quality of Life

Meta-analysis of change in QoL at last follow-up grouped by surgical procedure is shown in Fig. 3. Data was available for 573 adolescent bariatric patients at baseline and, after imputation for incomplete follow-up data, 465 patients at last follow-up (83.8% follow-up for 401 patients in studies with complete data, 81.2% follow-up for all 573 patients after imputation). Across the different surgical weight loss procedures, there was significant improvement in quality of life of 1.40 SMD (95% confidence interval (CI) 0.95 to 1.86; $p < 0.0001$) at last follow-up. There was no significant difference ($p = 0.16$) between sleeve gastrectomy (+ 1.75 SMD; CI 0.49 to 3.00; $p < 0.0001$), adjustable gastric banding (+ 1.66 SD; CI 0.89 to 2.44; $p < 0.0001$), and roux-en-Y gastric bypass (+ 0.92 SMD; CI 0.48 to 1.36; $p < 0.0001$). Heterogeneity was significant within ($I^2 = 75–92\%$) as well as between ($I^2 = 89\%$) the

Fig. 2 Methodological risk of bias assessment for included studies using adapted version of ECRI Before-After Study Quality scale

procedures. These findings were stable to sensitivity analyses that excluded studies at high risk of attrition bias or with potential conflict of interest.

An additional analysis of mean difference was performed limited to six studies using the PedsQL instrument, encompassing 210 patients (Fig. 4). This demonstrated a mean improvement of 14.1 points (CI 10.3 to 18.0), although heterogeneity remained high ($I^2 = 81\%$). The biggest sources of heterogeneity in this analysis were the series from Sysko and Aldaqal; when these were removed, the mean improvement was 19.7 points ($p = 0.04$) with more moderate heterogeneity ($I^2 = 64\%$).

Because these analyses used data from different time points of last follow-up, and to evaluate any trajectory in QoL change over time, we performed summary estimates of change in QoL at 6, 12, 18, 24, 36, and 60+ months (Fig. 5). We found the greatest improvement at 12 months (+ 1.69 SMD; CI 0.99 to 2.40) followed by gradual decline in effect size. However, QoL improvement was sustained at 60+ months (+ 0.76 SMD; CI 0.10 to 1.43) in the two studies providing this long-term data.

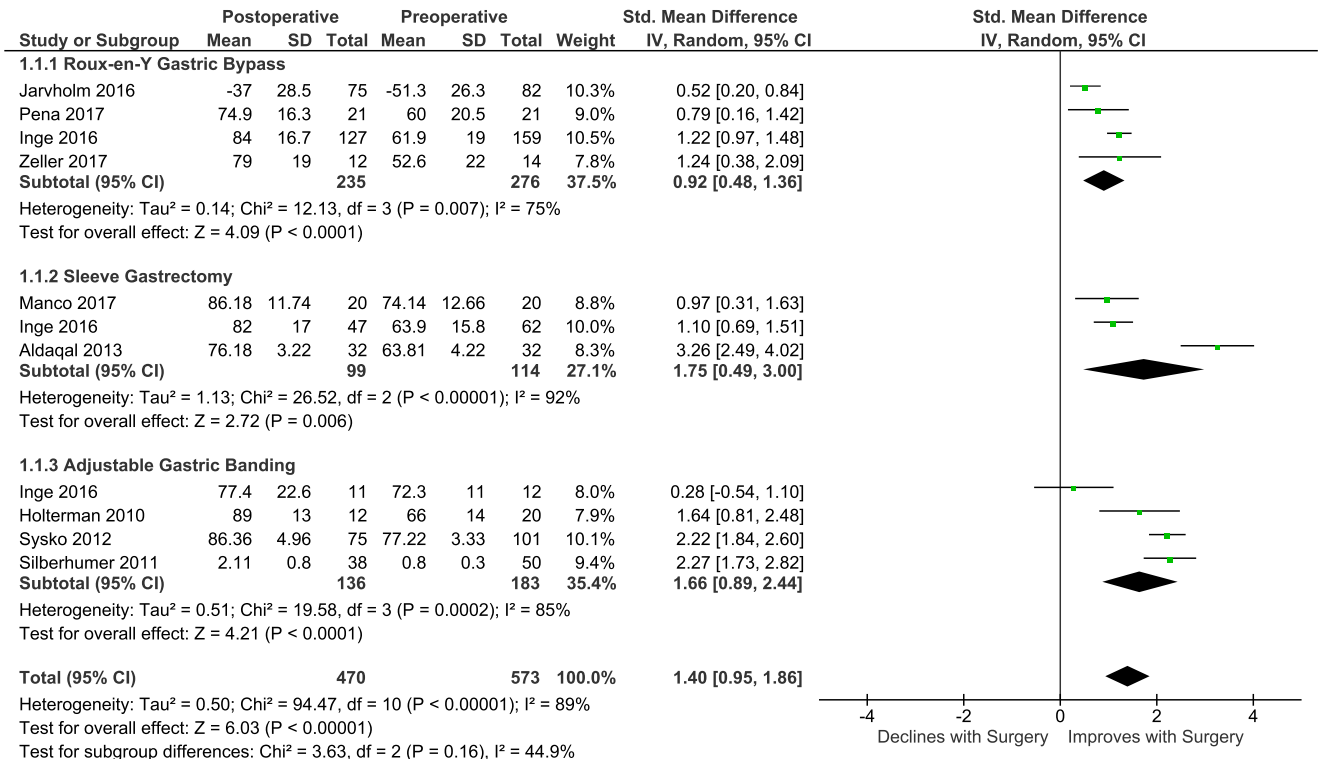

Fig. 3 Subgroup analysis of standardized change in quality of life at last follow-up demonstrates significant improvement across surgical procedures

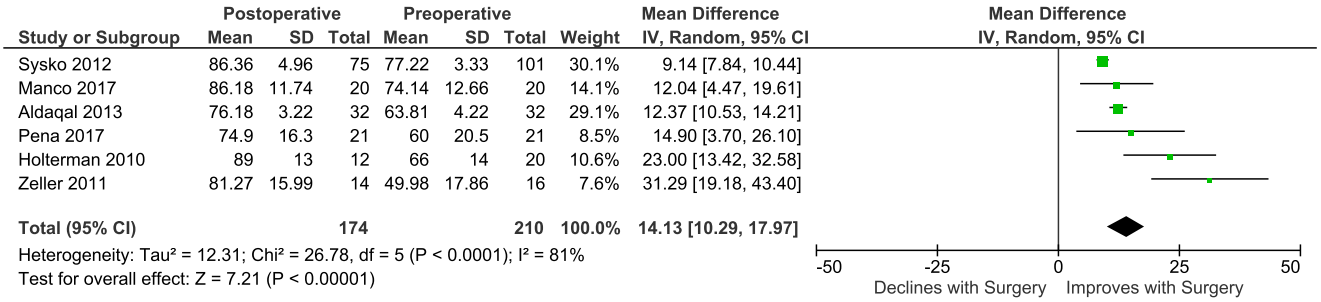

Fig. 4 Mean improvement in quality of life for studies using the Peds QoL instrument exceeds the minimal clinically important difference

Change in Other Psychosocial Outcomes

Data on other psychosocial outcomes was limited. For domains evaluated by at least three reports, we did perform meta-analyses. Three studies reported on depression at 9–24 months of follow-up using the Beck Depression Inventory [29, 31] or Beck Youth Inventory—Depression, [33] each noting significant improvement. The CI for a positive SMD of 1.37 did cross the null hypothesis ($p = 0.07$). Similarly, three studies reported improvement in physical self-assessment at 12–24 months using the Rosenburg Self-Esteem tool [33, 37] or the Stunkard Figure Rating Scale [31]. Again, the CI for a positive SMD of 1.61 did narrowly cross the null ($p = 0.06$). Finally, four studies reported on overall mental health. Two studies provided the Mental Component Score from the Short-Form 36 questionnaire at a mean of 12 months [43] and 60 months [12] of follow-up: one study used the Child Health Questionnaire Child Format out to 24 months, [32] and another used the Youth & Adult Self Report at up to 72+ months [39] of follow-up. Only one study found significant improvement in mental health, and there was no significant effect when combining the studies (+ 0.31 SMD, $p = 0.35$).

Secondary Outcomes Following Adolescent Bariatric Surgery

Postoperative outcomes following surgery for included studies are presented in Table 2. The range of absolute and percent BMI loss was 3.8–25.7 kg/m^2 and 8–41%, respectively. Substantial resolution of type 2 diabetes (50–100%), hypertension (33–100%), dyslipidemia (32–100%), metabolic syndrome (38–100%), NASH and/or transaminitis (92–100%), and obstructive sleep apnea (35–100%) was reported. Overall reoperation rates were 10% for SG, 14–25% for RYGB, and 2–43% for AGB. There was one reported death

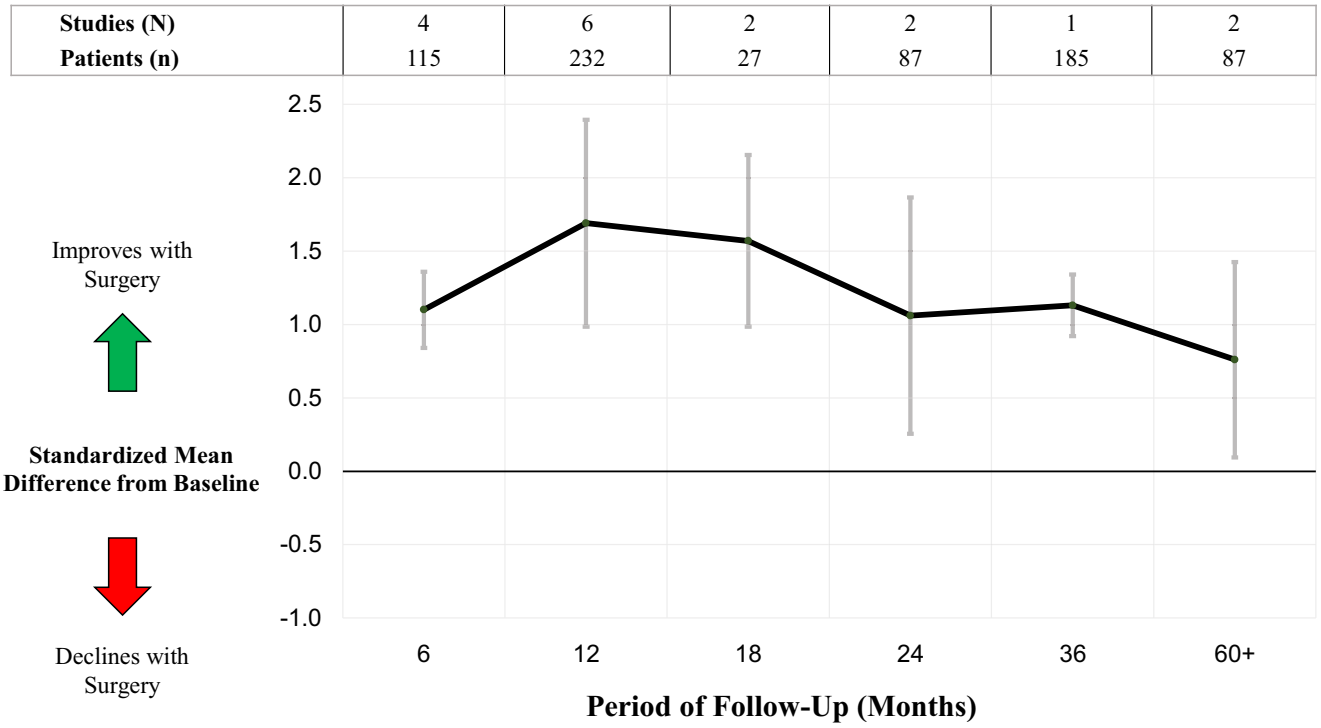

Fig. 5 Trajectory of standardized mean change in quality of life over duration of follow up with sustained improvement at 60+ months

Table 2 Outcomes of adolescent bariatric surgery for studies included in qualitative synthesis

Procedure	*N* studies (unique cohorts)	Patients at last follow-up[a]	BMI loss (kg/m^2)		Percent resolution of baseline comorbidities						Complications	
			Absolute	*Percent*	Type 2 diabetes	Hypertension	Dyslipidemia	Metabolic syndrome	NASH or transaminitis	Obstructive sleep apnea	Overall reoperation, %	Deaths (n)
Roux-en-Y	8 (4)	242	13.1–25.7	28–38.5	95–100	74–100	66–83	NR	92 (Transaminitis)	NR	14–25	1
Sleeve gastrectomy	4 (4)	150	10–20.3	20.6–41	50–94	75–100	69–92	NR	100 (NASH)	63–100	10	0
Adjustable gastric banding	10 (8)	178	3.8–17.9	8.1–39.6	50–100	33–100	32–100	38–100	100 (NASH)	35–100	2–43	0
Total/range	20 (14)	570	3.8–25.7	8.1–41	50–100	33–100	32–100	38–100	100 (NASH) 92 (Transaminitis)	35–100	2–43	0.4

[a] Unique patients from series with longest follow-up

3.3 years following RYGB in a known type I diabetic patient following a hypoglycemic episode. Our study was not designed to compare the different surgical procedures with respect to these secondary outcomes.

Discussion

This is the largest review of psychosocial outcomes following bariatric surgery for adolescents with severe obesity. It is also the first to compare QoL outcomes between surgical procedures or investigate changes in QoL over duration of follow-up beyond 2 years. Each of the three procedures we studied led to significant QoL improvement, with no significant difference between procedures. The greatest improvement in QoL was 12 months following surgery; however, significant improvement was sustained for 60+ months. Assessment of other psychosocial outcomes following adolescent bariatric surgery was limited but demonstrated a trend toward improvement in depression and physical self-assessment out to 24 months, but not in overall mental health.

These findings are consistent with prior studies of psychosocial outcomes following adolescent bariatric surgery. White et al. performed a meta-analysis of four studies encompassing 110 adolescents with up to 34.7 months of follow-up and found significant improvement in QoL of + 2.8 SMD with peak improvement at 6–12 months. The same study included a meta-analysis of two reports on depression, finding significant but more modest improvement of + 0.47 SMD at 4–6 months of follow-up [19]. Zeller and colleagues, who provide the longest-term data for psychosocial outcomes for a small cohort of adolescent bariatric patients, noted improvement in weight-related QoL into adulthood, but more varied trajectories of mental health divided between those with remittance and those with persistent symptomatology [39].

The need to perform meta-analysis across instruments using standardized mean differences dilutes the ability to discern the clinical significance of these changes. A prior systematic review of studies reporting on health-related quality of life identified a threshold of discrimination of about 0.5 standard deviations, which all of our significant results exceeded [46]. Moreover, we found a 15- to 20-point improvement across studies specifically using the PedsQL instrument, for which a minimal clinically important difference of 5 points has been described [47]. To this end, the positive effect of weight loss surgery on QoL in this review reflects not only statistically significant changes, but clinically significant ones as well.

The validity of our findings regarding improvement in QoL is supported by the stability of this result despite various sensitivity analyses, in which we excluded studies at high risk of attrition bias or with potential conflict of interest. At the same time, very few studies explored the characteristics of patients lost to follow-up, which could be associated with having a

poor psychosocial outcome. We included studies with < 25 patients, and error from these smaller samples is accounted for by lesser weights in the meta-analysis. Ultimately, only one study included in meta-analysis did not report significant improvement in QoL, and this was in a subgroup of 11 adjustable gastric banding patients [13]. While the absence of negative studies in this review raises the prospect of publication bias, we did not observe overt asymmetry in a funnel plot of our primary meta-analysis.

Another important source of potential bias is heterogeneity in local criteria for adolescent bariatric surgery. One study failed to describe these criteria [43], but most reported criteria reflective of best practice guidelines at the time (i.e., age of skeletal bone maturity and BMI > 35 kg/m^2 with comorbidity or BMI > 40 kg/m^2) [12, 13, 29, 30, 33, 35, 36, 40, 41]. Current guidelines have shifted to modern definitions of severe obesity in children based on a percent above the 95th percentile of age- and sex-matched growth charts, which could impact the generalizability of our results [48].

Bariatric surgery is not, fundamentally, a procedure to address chronic mental health conditions. In a 2-year follow up of psychopathology prevalence and correlates among adolescent bariatric patients and nonsurgical controls, Hunsaker and colleagues reported half of patients with baseline disease saw symptoms improve while the other half exhibited persistent symptomatology [49]. Postoperative substance abuse, eating disorders, and suicidal ideation are established concerns among adults following bariatric surgery, but there is little understanding of how this might impact a vulnerable adolescent population [50–52]. Furthermore, adolescent surgical patients pose ethical challenges of assent and consent, how to define the best interests of this population, and the consequences of medicalizing and stigmatizing obesity at an early age [53, 54]. Providers must remain aware of these issues when consulting with prospective adolescent bariatric patients. In addition, adolescent bariatric programs have a burden of responsibility to not only evaluate psychosocial readiness for bariatric surgery, but also communicate expectations and evaluate progress relating to psychosocial outcomes.

A major limitation of the present review is the observational nature of most included studies. The failure to compare postoperative changes with adolescent controls during a volatile period of psychosocial development is a limitation of existing literature. Our study is also unable to control for confounding across adolescent bariatric centers which inevitably have non-standardized co-interventions. For example, psychologists may be more heavily involved in preoperative evaluation and postoperative follow-up at some programs. There is a randomized controlled trial (AMOS-RCT) of intensive conservative treatment versus bariatric surgery for adolescents 13–16 years old ongoing in Sweden, which will provide a higher level of evidence [55].

An additional limitation is the relatively small number of studies reporting on long-term psychosocial outcomes following adolescent bariatric surgery. There are particularly few reports of outcomes beyond 36 months; our analysis of QoL was limited to one study at 36 months and two studies at 60+ months. The QoL meta-analysis includes two of the largest cohorts to report on outcomes of adolescent bariatric surgery, AMOS, and TEEN-Labs, whose results inherently bias our findings. Inconsistent improvement in other psychosocial domains and variable trajectories of postoperative mental health in general merit further investigation.

Conclusions

Surgical weight loss interventions lead to sustained improvement in quality of life for adolescent bariatric surgery patients. Randomized controlled studies and long-term data of other psychosocial outcomes such as depression, anxiety, and overall mental health are sparse for this population. Further study is needed to understand baseline psychosocial features that may predict the response to weight loss surgery, inform patient selection, and improve postoperative psychosocial care for adolescent bariatric patients.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Statement of Human and Animal Rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent For this type of study, formal consent is not required.

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