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Original citation:
By-Band-Sleeve Collaborative Group, 2023, 'Roux-en-Y gastric bypass, gastric banding, or sleeve gastrectomy for severe obesity: Baseline data from the By-Band-Sleeve randomized controlled trial', Obesity, vol. 31, no. 5, pp. 1290-1299. https://dx.doi.org/10.1002/oby.23746

DOI 10.1002/oby.23746
ISSN 1930-7381
ESSN 1930-739X

Publisher: Wiley

Received: 25 November 2022 | Revised: 1 January 2023 | Accepted: 22 January 2023

DOI: 10.1002/oby.23746

ORIGINAL ARTICLE

Clinical Trials and Investigations

Obesity A Research Journal | THE OBESITY SOCIETY | WILEY

Roux-en-Y gastric bypass, gastric banding, or sleeve gastrectomy for severe obesity: Baseline data from the By-Band-Sleeve randomized controlled trial

By-Band-Sleeve Collaborative Group*

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Funding information
Health Technology Assessment Programme, Grant/Award Number: HTA 09/127/53

Abstract

Objective: This paper reports the study design, participant characteristics, and recruitment results of By-Band-Sleeve, which investigated the clinical and cost-effectiveness of gastric bypass, gastric banding, and sleeve gastrectomy in adults with severe obesity in the UK.

Methods: A pragmatic open adaptive noninferiority trial with 3-year follow-up was conducted. Participants were randomly assigned to bypass or band initially and to sleeve after the adaptation. Co-primary end points are weight loss and health-related quality of life assessed using the EQ-5D utility index.

Results: Between December 2012 and August 2015, the study recruited into two groups and, after the adaptation, into three groups until September 2019. The study screened 6960 patients; 4732 (68%) were eligible and 1351 (29%) were randomized; 5 subsequently withdrew consent to use data, leaving 462, 464, and 420 assigned to bypass, band, and sleeve, respectively. Baseline data showed high levels of obesity (mean BMI = 46.4 kg/m^2; SD: 6.9) and comorbidities (e.g., 31% diabetes), low scores for health-related quality of life, and high levels of anxiety and depression (e.g., 25% abnormal scores). Nutritional parameters were poor, and the average equivalized household income was low (£16,667).

Conclusions: By-Band-Sleeve fully recruited. Participant characteristics are consistent with contemporary patients having bariatric surgery, and therefore the results will be generalizable.

INTRODUCTION

Obesity is increasing worldwide. It is a major risk factor for type 2 diabetes mellitus, cardiovascular disease, cancer, poor health-related quality of life (HRQoL), and mortality. Bariatric surgery can provide sustained weight loss and improvement in obesity-related disease, and guidelines recommend it should be offered to selected patients [1]. Several types of bariatric surgery exist, including Roux-en-Y gastric bypass (bypass), adjustable gastric banding (band), and sleeve gastrectomy (sleeve). More recently, other techniques have emerged (e.g., one anastomosis gastric bypass). As with many surgical procedures, the literature supporting the effectiveness of surgical interventions is limited. Comparative studies are often not randomized and randomized controlled trial (RCT) studies are often single center, are at risk of bias, and have limited follow-up. These issues were

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highlighted in 2009, when two systematic reviews highlighted the need for better quality bariatric surgical trials with long-term follow-up and assessment of HRQoL [2,3]. The paucity of evidence led to a call for research comparing the different procedures, which led to the design of the By-Band trial. Initially it intended to compare bypass and band (the two surgical procedures that predominated at that time). However, because of the increasing popularity of sleeve in the years that followed, it became relevant to adapt the study to include this type of surgery [4]. In 2015, By-Band became By-Band-Sleeve, and the sample size was increased to provide adequate power for the 3 two-way comparisons [5]. Here, we summarize demographics, disease prevalence, baseline HRQoL scores, dietary and binge eating characteristics, and income and benefits of the randomized participants in By-Band-Sleeve.

Study Importance

What is already known?

- The UK By-Band-Sleeve randomized controlled trial is a pragmatic open adaptive noninferiority trial, with dual primary end points of weight loss and quality of life, with 3-year follow-up, to investigate the clinical and cost-effectiveness of gastric bypass, gastric banding, and sleeve gastrectomy in participants with severe obesity in the UK.
- Between December 2012 and August 2015, we recruited into two groups and, after the adaptation to add sleeve gastrectomy, into three groups.

What does this study add?

- By-Band-Sleeve fully recruited in December 2019, randomly assigning 1351 participants between the operations in 12 hospitals in the UK.
- We describe participant baseline characteristics that showed high levels of obesity (mean BMI = 46.4 kg/m^2) and comorbidity, high levels of anxiety and depression, poor physical and mental health, poor quality of life, and poor average equivalized household income, similar to those undergoing routine care in the UK.

How might these results change the direction of research or the focus of clinical practice?

- We have shown that it is possible to recruit into a very large pragmatic randomized controlled trial with comprehensive collection of participant characteristics, including employment, income, benefits, dietary macro- and micronutrient intake and measurement, and binge eating.
- Future bariatric surgery randomized controlled trials should consider collection of these additional characteristics in the evaluation of different procedures.
- The trial results will be generalizable to all those having surgery for severe obesity in the UK.

METHODS

Trial design and participants

Full details of the design have been published previously [5, 6]. Briefly, the RCT design is pragmatic, with eligibility based on national guidance (Supporting Information Table S1). By-Band began with an internal pilot phase in December 2012 in two centers to establish the feasibility of recruitment, supported by a Quintet Recruitment Intervention (QRI) [7]. By-Band expanded into four more centers (phase two), and then twelve centers involving more than 40 surgeons (phase three), when it became By-Band-Sleeve after the adaptation to include sleeve (August 2015). The sample size was increased from 724 to 1341.

Surgical interventions and quality assurance

Centers were required to commit at least two surgeons to participate, to undertake a minimum of 50 bariatric operations per year, and to have prior experience of 200 gastric banding, 250 gastric bypass, and 200 sleeve gastrectomy procedures. Mandatory and prohibited components of the operations were identified and monitored on the Case Report Forms. When prohibited components were undertaken, or mandated components omitted, the Chief Investigator (CI) discussed instances with the relevant centers.

Recruitment

The recruitment processes established by the QRI working closely with the CI, Trials Center, and clinical teams from phases one and two were continued into phase three [8]. Recruitment issues were understood using interviews with nurses and dietitians, audio recordings of recruitment discussions, and scrutiny of recruitment logs. Activities to optimize presentation of study information and recruitment included training sessions and individual feedback to recruiters, to avoid the development of treatment preferences, and site visits.

Randomization and masking

In By-Band, participants were randomized in a 1:1 ratio. After adapting the trial to include sleeve, the allocation ratio was 1:1:1 for new

centers. For existing centers, center-specific allocation ratios were set (with lower probabilities of bypass and banding and a higher probability of sleeve), aiming to maintain allocation concealment and achieve a 1:1:1 final ratio. Randomization was performed in each center using a secure, internet-based system (Sealed Envelope Ltd.). Allocations were computer-generated using cohort minimization, incorporating diabetes (yes/no) and body mass index (BMI) more than 50 kg/m^2 (yes/no), and stratification by center.

Outcomes and data storage

The co-primary end point of weight loss and HRQoL at 3 years after randomization [5,6] was chosen to ensure that the three procedures were compared fairly, because of different weight-loss trajectories over time. The weight-loss metric is percentage excess BMI lost. The HRQoL metric is the EQ-5D-5L health state (utility) score [9,10]. Secondary outcomes include generic and disease-specific aspects of HRQoL (Supporting Information Table S2), obesity-related diseases, dietary outcomes, adverse events, and resource use. Baseline data were collected during prerandomization clinics, recorded on Case Report Forms, and stored in the study database (custom-designed, built, and maintained by the Bristol Trials Centre).

Statistical analysis

Sample size calculations are described in the protocol [5, 6]. Means and standard deviations (SD) were calculated for symmetrically distributed measures and medians and interquartile ranges (IQR) for asymmetric distributions. Categorical and ordinal measures are expressed as frequencies and percentages. Participants are grouped by their randomized allocation. Summary statistics were generated using SAS software version 9.4 (SAS Institute Inc.). EQ-5D-5L scores were calculated by mapping onto the EQ-5D-3L value set [9]. SF-12 version 2 scores were calculated using the OPTUM PRO CoRE software. Dietary recalls were analyzed with the nutrient analysis program Dietplan7 (Forestfield Software Limited, version 7.00.47) [11]. Benefits being received were categorized into three groups that were considered potentially modifiable by bariatric surgery: any, disability-related, and child-related benefits. Baseline gross household income and total benefits received were combined to obtain the gross household income including benefits before and after adjusting (equivalizing) for the number of adults and children in the household.

Study management and leadership

By-Band-Sleeve is led by the CI (JMB) supported by a multidisciplinary trial management group including methodologists, statisticians, qualitative and quantitative researchers, patient and public members, trial managers, and clinicians (dietitians, surgeons and endocrinologists). Each participating site has a principal investigator (bariatric surgeon/physician) and dedicated research nurses/dietitians. The study is overseen by a Steering Committee and Data Monitoring and Safety Committee (online Supporting Information). CAR and EG had full access to all the baseline data and,

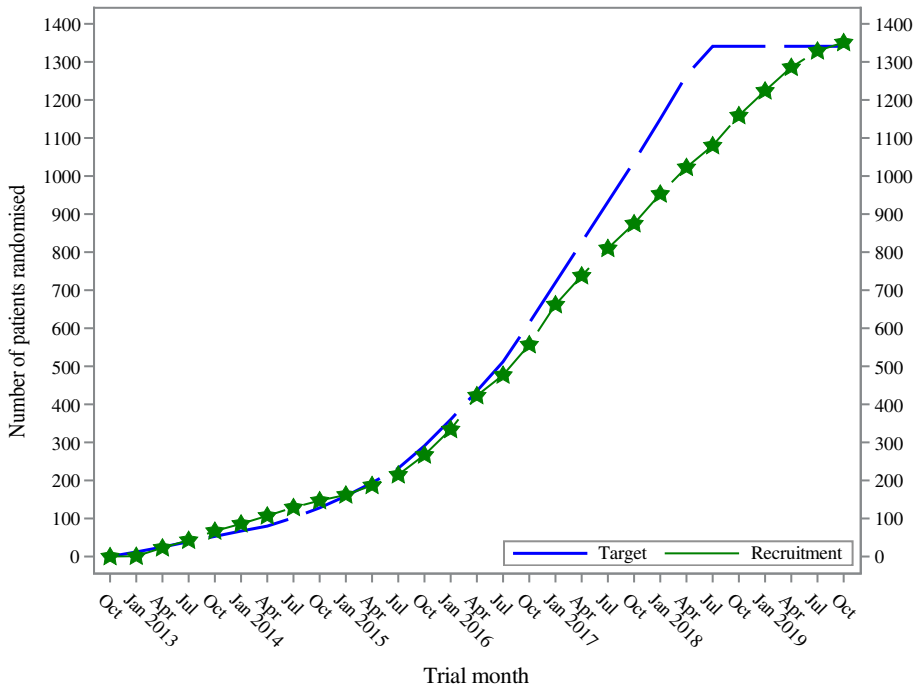
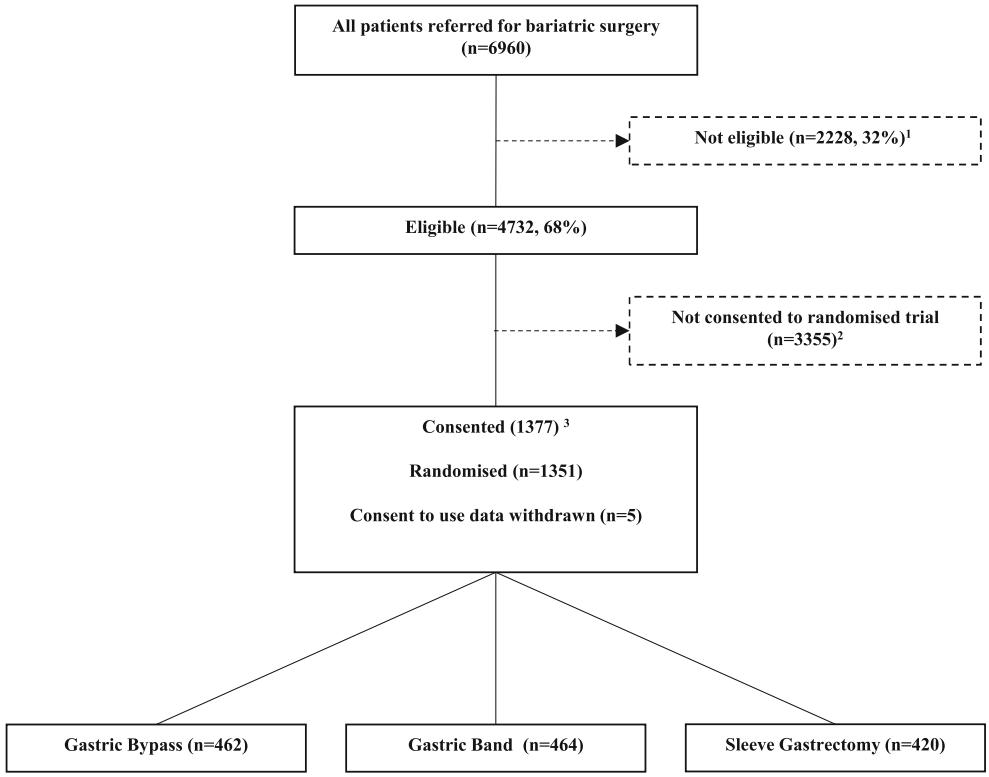


FIGURE 1 Recruitment to the randomized trial against target [Color figure can be viewed at wileyonlinelibrary.com]



[1]Includes patients with incomplete eligibility information. See Supplementary eTable S3 for more detail
[2]Includes patients with incomplete consent information. See Supplementary eTable S4 for more detail
[3]26 patients consented but not randomised

FIGURE 2 CONSORT diagram

with JMB, had final responsibility for the decision to submit for publication.

RESULTS

Recruitment

Between December 2012 and September 2019, 6960 patients were screened, of whom 4728 (68%) were confirmed eligible and approached. Of these, 1351 (28.6%) consented and were randomized. Target recruitment was achieved for the first 4 years, falling behind thereafter (Figure 1). Opportunities were taken to improve the presentation of trial information to make it clearer and balanced to patients. Training sessions for surgeons, research nurses, and dietitians were undertaken at annual investigator meetings and at regular visits to centers.

Among the 6960 patients screened for eligibility, most reasons for ineligibility related to unspecified clinical or psychological factors, a history of gastric or abdominal surgery, or concerns about commitment to long-term follow-up (Supporting Information Table S3). Among eligible patients approached to take part, the main reason recorded for nonconsent was patient preference for one or other surgical method (Supporting Information Table S4). The numbers allocated to different procedures, excluding participants who withdrew consent to use data ($n = 5$), were 462 to bypass, 464 to band, and 420 to sleeve (Figure 2). In June 2022, the median follow-up after randomization was 3 years (IQR: 2.05–3.09 years). Overall, 1153 participants reached 3 years and the co-primary outcomes of weight and EQ-5D-5L questionnaire data were complete for 993/1153 (86.1%) and 929/1153 (80.6%) participants, respectively.

Balance of baseline data between randomized groups and data completeness

Baseline data by randomized group and overall are shown in Tables 1–3 and Supporting Information Tables S5–S9. Randomization worked well: all baseline characteristics were balanced between groups. Baseline data completeness is shown in Supporting Information Tables S10–S15. Data completeness was excellent (>90%) for most clinical and sociodemographic variables. Completion rates for HRQoL questionnaires were all above 93%. The completion rate for the hospital anxiety and depression questionnaire was lower, but still above 91%. Blood measurements were complete in >91% of participants. Completion for dietary macronutrient intake details and the binge eating questionnaire was 78% and 85%, respectively.

TABLE 1 Participant sociodemographics, employment, income, and benefits by randomized group and overall

	Gastric bypass ($n = 462$)	Gastric band ($n = 464$)	Sleeve gastrectomy ($n = 420$)	Overall ($n = 1346$)
Sex, *n* (%)				
Female	345 (74.8)	354 (76.3)	321 (76.6)	1020 (75.9)
Age, mean (SD) (y)	47.4 (10.3)	46.8 (10.4)	47.8 (11.0)	47.3 (10.6)
Ethnicity, *n* (%)				
White	401 (87.0)	394 (84.9)	345 (82.3)	1140 (84.8)
Mixed/multiple ethnic groups	11 (2.4)	11 (2.4)	11 (2.6)	33 (2.5)
Asian/Asian British	10 (2.2)	21 (4.5)	15 (3.6)	46 (3.4)
Black/African/Caribbean/Black British	30 (6.5)	26 (5.6)	36 (8.6)	92 (6.8)
Other ethnic group	9 (2.0)	12 (2.6)	12 (2.9)	33 (2.5)
Employment, *n* (%)				
Full time	191 (41.5)	188 (40.5)	182 (43.4)	561 (41.8)
Part time	81 (17.6)	67 (14.4)	69 (16.5)	217 (16.2)
Self-employed	25 (5.4)	27 (5.8)	16 (3.8)	68 (5.1)
Homemaker	39 (8.5)	50 (10.8)	40 (9.5)	129 (9.6)
Student	5 (1.1)	5 (1.1)	4 (1.0)	14 (1.0)
Retired	44 (9.6)	33 (7.1)	31 (7.4)	108 (8.0)
Unable to work	43 (9.3)	62 (13.4)	50 (11.9)	155 (11.5)
Unemployed	32 (7.0)	32 (6.9)	27 (6.4)	91 (6.8)
Gross household income including benefits				
Median (IQR)	£28,000 (£19,404–£45,000)	£26,400 (£17,285–£45,000)	£26,774 (£17,847–£45,000)	£26,870 (£18,259–£45,000)
Unknown/unwilling to say, *n* (%)	93 (20.1)	101 (21.8)	78 (18.6)	272 (20.2)
Equivalized gross household income including benefits				
Median (IQR)	£16,667 (£11,387–£23,939)	£16,434 (£10,202–£23,664)	£16,093 (£11,220–£25,000)	£16,667 (£10,924–£24,430)
Unknown/unwilling to say, *n* (%)	93 (20.1)	102 (22.0)	79 (18.8)	274 (20.4)
Benefits, *n* (%)				
Any benefits	179 (38.8)	204 (44.0)	165 (39.4)	548 (40.8)
Disability benefits	106 (23.0)	123 (26.5)	97 (23.2)	326 (24.3)
Child benefits	46 (10.0)	48 (10.3)	37 (8.8)	131 (9.7)

Baseline sociodemographics and employment and income benefits

Participants were predominantly female (1020/1344, 75.9%) and of White ethnicity (1140/1344, 84.8%), with a mean age of 47.3 years (SD: 10.6; Table 1). Baseline BMI and mean body weight were 46.4 (SD: 6.9) and 129.7 kg (SD: 23.6), respectively (Table 2). The mean baseline EQ-5D-5L utility score was 0.61 (SD: 0.28). Overall, 778/1343 (57.8%) of participants were in full- or part-time employment, 91/1343 (6.8%) were unemployed, 155/1343 (11.5%) were unable to work, and a further 129/1343(9.6%) were homemakers (Table 1). The median gross household income was £26,870, which reduced to £16,667 after adjusting for household composition. In total, 326/1344 (24.3%) of the recruited population received disability-related benefits, including statutory sick pay (Table 1).

Baseline clinical characteristics

The numbers of participants with comorbidities were high; 407/1344 (30.2%) had type 2 diabetes mellitus with a median

TABLE 2 Baseline co-primary outcomes, participant characteristics, and obesity-related disease by randomized group and overall

	Gastric bypass ($n = 462$)	Gastric band ($n = 464$)	Sleeve gastrectomy ($n = 420$)	Overall ($n = 1346$)
BMI, mean (SD) (kg/m^2)	46.9 (7.1)	46.2 (6.6)	46.1 (6.9)	46.4 (6.9)
Weight, mean (SD) (kg)	131.4 (23.8)	129.0 (23.1)	128.8 (23.8)	129.7 (23.6)
EuroQol-5D-5L utility score, mean (SD)	0.61 (0.29)	0.60 (0.28)	0.61 (0.28)	0.61 (0.28)
EuroQol-5D-5L VAS score, mean (SD)	61.5 (21.2)	61.4 (20.1)	61.2 (21.9)	61.4 (21.0)
ASA class, *n* (%)				
I: Healthy, no medical problems	93 (20.3)	93 (20.1)	91 (21.8)	277 (20.7)
II: Mild systemic disease	229 (50.0)	222 (47.9)	211 (50.5)	662 (49.4)
III: Severe systemic disease, but not incapacitating	128 (27.9)	140 (30.2)	113 (27.0)	381 (28.5)
IV: Severe systemic disease that is a constant threat to life	8 (1.7)	8 (1.7)	3 (0.7)	19 (1.4)
Diabetes status, *n* (%)				
Type 1	1 (0.2)	3 (0.6)	2 (0.5)	6 (0.4)
Type 2 – Prediabetes	8 (1.7)	5 (1.1)	1 (0.2)	14 (1.0)
Type 2 - Diet controlled	9 (1.9)	14 (3.0)	15 (3.6)	38 (2.8)
Type 2 - Oral hypoglycemics	103 (22.3)	90 (19.4)	72 (17.1)	265 (19.7)
Type 2 - GLP-1 agonist	11 (2.4)	10 (2.2)	6 (1.4)	27 (2.0)
Type 2 - Insulin	20 (4.3)	22 (4.7)	21 (5.0)	63 (4.7)
Diabetes on medication, *n* (%)				
Yes	137 (90.1)	125 (86.8)	103 (88.0)	365 (88.4)
Duration of diabetes				
Median (IQR) (y)	3.6 (1.8–9.0)	5.0 (2.4–9.8)	4.8 (2.2–10.5)	4.7 (2.1–9.8)
Number of antidiabetes medications taken				
Median (IQR)	1.0 (1.0–2.0)	2.0 (1.0–2.5)	1.0 (1.0–2.0)	1.0 (1.0–2.0)
Hypertension on medication, *n* (%)				
Yes	210 (45.5)	178 (38.4)	176 (41.9)	564 (41.9)
Depression on medication, *n* (%)				
Yes	165 (35.7)	190 (40.9)	153 (36.4)	508 (37.7)
Obstructive sleep apnea, *n* (%)				
Yes	127 (27.6)	135 (29.1)	94 (22.5)	356 (26.5)
Asthma, *n* (%)				
Yes	127 (27.6)	150 (32.3)	137 (32.7)	414 (30.8)
GORD/hiatus hernia, *n* (%)				
Yes	209 (45.4)	229 (49.4)	212 (50.6)	650 (48.4)
Back or leg pain from arthritis, *n* (%)				
Yes	251 (54.6)	247 (53.2)	226 (53.9)	724 (53.9)
Functional status, *n* (%)				
Can climb 3 flights of stairs without resting	194 (42.4)	197 (42.5)	177 (42.2)	568 (42.4)
Can climb 1 flight of stairs without resting	187 (40.8)	179 (38.7)	156 (37.2)	522 (39.0)
Can climb half a flight of stairs without resting	61 (13.3)	74 (16.0)	71 (16.9)	206 (15.4)
Requires wheelchair or housebound	16 (3.5)	13 (2.8)	15 (3.6)	44 (3.3)

Abbreviations: ASA, American Society of Anesthesiologists; GLP-1, glucagon-like peptide-1; GORD, gastroesophageal reflux disease; VAS, visual analogue scale.

duration of 4.7 years (IQR: 2.1–9.8; Table 2), and a further 6 participants had type 1 diabetes. Participants with diabetes were, on average, 5 years older than those without diabetes, although they had a similar BMI (Supporting Information Table S9). Rates of other obesity-related diseases show the illness severity of participants, with 1062/1339 (79.3%) classified as American Society of Anesthesiologists grade II or higher, and 772/1340 (57.6%) having impaired functional status. Additional

TABLE 3 Participant baseline blood measurements by randomized group and overall

	Gastric bypass ($n = 462$)	Gastric band ($n = 464$)	Sleeve gastrectomy ($n = 420$)	Overall ($n = 1346$)
Hemoglobin A_{1c}, median (IQR) (mmol/mol)				
No diabetes	37.0 (35–40)	38.0 (35–41)	38.0 (35–41)	38.0 (35–41)
Prediabetes	41.0 (39–44)	43.0 (43–45)	38.0 (38–38)	42.5 (39–45)
Diabetes	54.0 (45–64)	53.0 (45–65)	51.0 (45–63)	52.5 (45–64)
Fasting glucose, median (IQR) (mmol/L)				
No diabetes	5.0 (5–5)	5.0 (5–5)	5.0 (5–5)	5.0 (5–5)
Prediabetes	5.9 (5–6)	4.9 (4–6)	4.9 (5–5)	5.6 (5–6)
Diabetes	6.7 (6–9)	6.6 (6–9)	6.9 (5–9)	6.7 (6–9)
25-Hydroxyvitamin D				
Very low (<25 nmol/L), *n* (%)	82 (18.5)	76 (17.0)	71 (17.2)	229 (17.6)
Low (25–50 nmol/L), *n* (%)	188 (42.4)	195 (43.5)	179 (43.4)	562 (43.1)
Sufficient (>50 nmol/L), *n* (%)	173 (39.1)	177 (39.5)	162 (39.3)	512 (39.3)
All participants, median (IQR) (nmol/L)	42.6 (28.0–59.0)	44.0 (30.4–61.0)	42.8 (29.5–61.1)	43.0 (29.1–60.2)
ELF, *n* (%)				
None/mild (Ishak 0–2)	39 (14.1)	36 (12.9)	29 (12.6)	104 (13.2)
Moderate (Ishak 3–4)	215 (77.6)	210 (75.3%)	180 (78.3)	605 (77.0)
Severe/cirrhosis (Ishak 5–6)	23 (8.3)	33 (11.8%)	21 (9.1)	77 (9.8)
Total cholesterol, mean (SD) (mmol/L)	4.8 (1.2)	4.8 (1.0)	4.9 (1.0)	4.8 (1.1)
Triglycerides, median (IQR) (mmol/L)	1.4 (1.1–2.0)	1.4 (1.1–1.9)	1.4 (1.1–1.9)	1.4 (1.1–1.9)
Hemoglobin, median (IQR) (g/L)	139.0 (130.0–147.0)	139.0 (130.0–146.0)	138.0 (131.0–146.0)	139.0 (130.0–147.0)
Platelets, mean (SD) (10^9/L)	275.7 (67.5)	279.2 (72.3)	284.9 (66.0)	279.8 (68.8)
White blood cells, median (IQR) (10^9/L)	7.5 (6.2–9.1)	7.6 (6.6–9.0)	7.6 (6.3–9.0)	7.6 (6.4–9.0)

Abbreviation: ELF, enhanced liver fibrosis.

characteristics, including blood and micronutrient measurements, are shown in Tables 2 and 3 and Supporting Information Tables S5 and S6.

Baseline HRQoL profile

Scores for generic and disease-specific aspects of HRQoL were generally low, indicating poor HRQoL across all measures (Supporting Information Table S7). For example, mean physical health scores assessed in the Short Form 12 (SF12), Impact of Weight on Quality of Life-Lite, and Gastrointestinal Quality of Life Index were 38.7 (SD: 10.7), 42.8 (SD: 24.2), and 9.5 (SD: 5.6), respectively. The mean SF12 mental health overall score was 43.1 (SD: 11.1), and mean scores for self-esteem (Impact of Weight on Quality of Life-Lite) and emotional health (Gastrointestinal Quality of Life Index) were low, at 31.2 (SD: 26.4) and 8.6 (SD: 3.6), respectively (50 represents "normal" for SF12). Overall, 273/1231 participants (22.2%) reported possible anxiety, 318/1235 (25.7%) possible depression, and 313/1231 (25.4%) and 304/1235 (24.6%) reported higher scores more indicative of manifest anxiety and depression, respectively, as assessed using the hospital anxiety and depression questionnaire.

Baseline dietary and binge eating characteristics

Intake of macronutrients and binge eating scores are shown in Supporting Information Table S8. Self-reported total energy intake was low. Intakes for fat, saturated fat, and percentage of total energy from fat were average for UK recommendations, whereas intakes for energy, protein, carbohydrate, and fiber were lower than recommended. In addition, 25-hydroxyvitamin D levels were very low or low in 229/1303 (17.6%) and 562/1303 (43.1%) of participants, respectively (Table 3). The proportion of participants reporting a mild to moderate or severe binge eating disorder was 314/1145 (27.4%) and 134/1145 (11.7%), respectively (Supporting Information Table S8).

DISCUSSION

The By-Band-Sleeve trial has recruited and randomized 1351 participants with severe and complex obesity from 12 UK centers. Baseline assessments are detailed, comprehensive, and well completed. The breadth of information collected is more extensive than that collected in previous bariatric surgical studies. Baseline characteristics of

participants are similar between groups in all aspects and representative of the population of patients undergoing bariatric surgery in the UK [12,13]. There are high levels of comorbidity, poor overall mental and physical health, high levels of anxiety and depression, and high levels of unemployment. This highlights the needs of patients living with obesity who put themselves forward and who were considered suitable for bariatric surgery by NHS clinical teams. Understanding how the three surgeries impact all these outcomes is critical to health care decision-making and it will allow informed patient choice.

The trial has many strengths. Recruitment of 1351 participants to a pragmatic, well-designed and well-conducted RCT will provide data that will add to the evidence base. Recruitment was successful despite concerns at the outset that it would be prevented by strong clinician and patient preferences among members of the 12 multidisciplinary teams. The use of a QRI to optimize recruitment in collaboration with the Trials Center and clinical team has been shown to be effective in different settings, including surgery [14]. As most RCT studies in bariatric surgery have recruited fewer than 250 participants, this is a method that could be relevant in future trials in this area, especially in a trial of surgery versus best medical therapy [15]. Randomized participants are similar to patients selected to undergo bariatric surgery within the NHS, although different from patients undergoing surgery in other countries [16]. The different proportions of men and women undergoing surgery are seen worldwide and they likely reflect differences in people asking for help with their weight. Participants and patients from Sweden and the Netherlands are younger, with a lower initial mean BMI than that observed in By-Band-Sleeve [17]. This is also in keeping with registry data from the United States [18]. UK patients may have more severe disease before undergoing surgery than patients in other countries because surgery is more difficult to access in the UK than elsewhere or because patients are reluctant to ask for a surgical intervention [19]. When patients have surgery for more severe obesity it is possible that their outcomes may be less favorable than when surgery is undertaken at a lower BMI. Preplanned subgroup analyses in By-Band-Sleeve will examine this issue. The data will be generalizable, including to ethnic minority groups in the UK. The exception is that Asian representation is low (3.4% in the trial vs. 7.5% in the UK), and that Black representation is high (6.8% in the trial vs. 3.4% in the UK population).

The successful addition of sleeve after 3 years of recruitment shows how a surgical RCT can efficiently use an existing infrastructure to maintain the clinical relevance of the research question. Additionally, the By-Band-Sleeve trial chose not to drop the banding group, despite its popularity declining dramatically in the UK and worldwide after the trial opened in 2012 [16]. This decision was supported throughout by independent oversight groups. As more information becomes available about the longer-term adverse events of bariatric surgery and the risk of weight regain for all procedures, the trial will provide unbiased descriptions of living with each of the three procedures.

Uniquely among bariatric RCT studies, to our knowledge, By-Band-Sleeve was designed with a co-primary end point of weight loss and HRQoL measured 3 years after randomization. Previous RCT studies have typically been powered for a single primary outcome, usually a measure of weight loss. When By-Band-Sleeve was designed in 2011, weight loss was commonly defined by the proportion of participants achieving a weight loss greater than 50% of excess BMI. Weight-loss trials now more usually report percentage total weight loss (%TWL) [20,21], which is less influenced by baseline BMI compared with percentage excess BMI. The trial team discussed changing the primary outcome metric to %TWL; however, because of the potential that this could introduce bias because of the need to agree on a new noninferiority threshold, it was decided to retain the existing metric. By-Band-Sleeve will report %TWL data as a secondary outcome, so that the results can be used in future data syntheses and meta-analyses.

The choice of 3 years for the co-primary end point was a compromise between the desire to characterize experience after each procedure for as long as possible with the reality of finite resources and patience of participants. Weight loss for banding is slow but progressive up to 3 years, whereas the nadir of weight loss after bypass and sleeve is typically much sooner (about 12 months), with some weight regain by year 3 [22]. Although the initial early weight loss may be appealing, it is sustainability of weight loss that is linked to health benefit and improvements in HRQoL.

The By-Band-Sleeve trial aimed to include comprehensive clinical, sociodemographic, HRQoL, nutrient, and dietary intake/binge eating data. Information on income and receipt of specific benefits as well as prospective information about dietary intake, binge eating disorders, and nutritional status is not reported in other bariatric surgery RCT studies. Similar to people living with obesity in the general UK population, our trial participants tend to receive more benefits, have lower household incomes, and be more likely to live in areas with higher deprivation [23]. Our participants also have unemployment rates approximately double those observed in the general population, and many receive disability-related benefits [23, 24]. Baseline macronutrient energy intake is similar to that previously reported, although individuals with obesity are more likely to underreport total energy intake than those without [25]. To our knowledge, the trial captures more information than any other bariatric surgery RCT, and the scale of data collection compares with the breadth of information that was recorded in the Swedish Obese Subjects study in the 1980s [26]. By-Band-Sleeve should therefore provide representative, generalizable information on the impact of bariatric surgery on a comprehensive range of clinically relevant and socioeconomic variables in randomized populations.

The slightly imbalanced numbers randomized to each group (ratio bypass:band:sleeve; 0.99:1.0:0.9) arose because of fewer participants being recruited in the six centers that initially opened to "By-Band" and then continued with "By-Band-Sleeve." When the adaptation was implemented, the revised allocation ratios for these centers were set based on anticipated recruitment rates going forward. The imbalance reduces the power for comparisons involving sleeve but does not introduce bias or undermine the methodological quality of the trial (randomized allocation with concealment, creating three comparable groups of participants). By-Band-Sleeve is the largest RCT of all three procedures in the world.

BY-BAND-SLEEVE TRIAL MANAGEMENT GROUP

By-Band-Sleeve Trial Management Group was responsible for the design, gaining funding, conduct of the trial, and reviewing the final manuscript. Robert C Andrews, PhD, University of Exeter Medical School, UK; John Bessent, patient representative; Jane M. Blazeby, MD (Chief Investigator), cowrote this manuscript, Bristol Medical School: Population Health Sciences, University of Bristol, UK; James P. Byrne, MD, University Hospital Southampton NHS Foundation Trust, UK; Nicholas Carter, MSc, Portsmouth Hospitals University NHS Trust, UK; Caroline Clay (deceased), patient representative; Jenny L. Donovan, PhD, Bristol Medical School, University of Bristol, UK; Eleanor Gidman, PhD, prepared the study tables and figures, cowrote this manuscript, Bristol Trials Centre, Bristol Medical School, University of Bristol, UK; Graziella Mazza, PhD, Bristol Trials Centre, Bristol Medical School, University of Bristol, UK; Mary O'Kane, MSc, PhD, Dietetic Department, Leeds Teaching Hospitals NHS Trust, UK; Barnaby C. Reeves, PhD, Bristol Trials Centre, Bristol Medical School, University of Bristol, UK; Chris A. Rogers, PhD (lead methodologist), co-wrote this manuscript, Bristol Trials Centre, Bristol Medical School, University of Bristol, UK; Nicki Salter, DipHE, Somerset NHS Foundation Trust, UK; Janice L. Thompson, PhD, School of Sport, Exercise & Rehabilitation Sciences, University of Birmingham, UK; Richard Welbourn MD, cowrote this manuscript, Somerset NHS Foundation Trust, UK; Sarah Wordsworth, Health Economics Research Centre, Nuffield Department of Population Health, University of Oxford, UK. See full list of By-Band-Sleeve investigators in online Supporting Information.

ACKNOWLEDGMENTS

We acknowledge the support of all the By-Band-Sleeve contributors, including the investigators, research dietitians, and nurses; the independent trial steering committee; and the data monitoring and safety committee. Full details are in the online Supporting Information. We are grateful to all the patients who participated in this trial. By-Band-Sleeve is in the follow-up phase.

We acknowledge the contribution of Caroline Clay, patient representative on the Trial Management Group, who died during preparation of the manuscript.

FUNDING INFORMATION

The trial was funded by National Institute of Health and Care Research (NIHR) Health Technology Assessment Programme (HTA 09/127/53). We also acknowledge funding from the MRC ConDuCT-II Hub for Trials Methodology Research and the NIHR Biomedical Research Centre at the University of Bristol. This trial was designed and delivered in collaboration with the Bristol Trials Centre, a UK Clinical Research Collaboration registered clinical trials unit, which is in receipt of NIHR clinical trials unit support funding. Chris A. Rogers was funded by the British Heart Foundation until 2016. The funder had no role in the design or conduct of the trial; in collection, management, analysis, or interpretation of the data; or in preparation, review, or approval of the report. The views and opinions expressed therein are those of the authors and not necessarily those of the UK National Health Service, the NIHR, or the Department of Health and Social Care. Jane M. Blazeby and Jenny L. Donovan are NIHR Senior Investigators.

CONFLICT OF INTEREST STATEMENT

James Byrne is on the medical advisory board for the company Oxford Medical Products. All other authors declared no conflict of interest. The conflict of interest statement for the investigators and oversight committees is provided in online Supporting Information.

CLINICAL TRIAL REGISTRATION

ClinicalTrials.gov identifier NCT02841527.

DATA AVAILABILITY STATEMENT

Following publication of the main trial results, anonymized individual patient data will be made available upon request to the chief investigator for secondary research, conditional on assurance from the secondary researcher that the proposed use of the data is compliant with the Medical Research Council Policy on Data Sharing regarding scientific quality, ethical requirements, and value for money and is compliant with the National Institute for Health and Care Research policy on data sharing. A minimum requirement with respect to scientific quality will be a publicly available prespecified protocol describing the purpose, methods, and analysis of the secondary research (e.g., a protocol for a Cochrane systematic review), approved by a UK Research Ethics Committee or other similar, approved ethics review body. Participant identifiers will not be passed on to any third party.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article. [Correction added on 19 December 2023, after first online publication: The Supporting Information has been corrected to include four authors who made significant contribution to the research project.]

How to cite this article: By-Band-Sleeve Collaborative Group. Roux-en-Y gastric bypass, gastric banding, or sleeve gastrectomy for severe obesity: Baseline data from the By-Band-Sleeve randomized controlled trial. *Obesity (Silver Spring)*. 2023;31(5):1290-1299. doi:10.1002/oby.23746