

1 **Title:** Bariatric Surgery versus Lifestyle Interventions for Severe Obesity: 5-Year
2 Changes in Body Weight, Risk Factors and Comorbidities.

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18

19 **Running head:** Conservative and surgical treatment of obesity

20

21 **Keywords:** weight loss; weight loss maintenance; obesity; bariatric surgery;
22 conservative treatment.

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26 **What is already known about this subject:**

27

28 - Lifestyle interventions can result in significant weight loss in the short-term,
29 even in patients with severe obesity.

30 - Bariatric surgery is currently considered the best treatment option for
31 severe obesity.

32 - Not all severely obese patients are eligible for or want bariatric surgery.

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34 **What this study adds:**

35 - Lifestyle interventions can result in significant weight loss in patients with
36 severe obesity, in the long-term (5-year follow-up).

37 - Lifestyle interventions can result in clinical relevant weight loss (>10% from
38 baseline weight) in the long-term (5 years) in approximately 25% of patients
39 with severe obesity.

40 - Roux-en-Y gastric bypass results in a larger weight loss and larger
41 improvement in risk factors and hypertension resolution in the long-term,
42 compared with structured lifestyle interventions, in patients with severe
43 obesity.

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52 **Abstract**

53 *Objective:* To compare changes in body weight, risk factors and comorbidities 5
54 years after Roux-en-Y gastric bypass (RYGB) or different lifestyle interventions.

55 *Methods:* 209 (75% women) severe obese adults were non-randomly allocated
56 to: A) RYGB (n=58), B) weight loss camp (n=30), C), residential intermittent
57 program (n=64), or D) hospital outpatient program (n=57). Body weight, risk
58 factors and comorbidities were assessed at baseline, 1 and 5 years.

59 *Results:* 89% and 54% completed the 1- and 5-year follow-up. The RYGB group
60 experienced more weight loss at 5 years (-23.9%, 95% CI [-27.7, -20.0])
61 compared with lifestyle groups: B (-9.2%, 95% CI [-16.9, -1.5]), C (-4.1%, 95% CI
62 [-8.0, -0.1]) and D (-4.1 kg, 95% CI [-10.0, 1.8]) (all $p < 0.001$). No differences were
63 observed between lifestyle groups, although groups B and C had significant
64 weight loss after 5 years (all $p < 0.05$). Plasma glucose and high-density
65 lipoprotein cholesterol were improved in the RYGB group at 5 years compared
66 with lifestyle groups (all $p < 0.05$). More patients in the RYGB group experienced
67 remission of hypertension ($p < 0.05$).

68 *Conclusion:* RYGB was associated with a lower body weight, improved blood
69 parameters and hypertension remission compared with lifestyle interventions at
70 5 years. However, significant weight loss was also achieved with lifestyle
71 interventions.

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76 **Introduction**

77 Bariatric surgery is currently considered the best treatment option for severe
78 obesity, with Roux-en-Y gastric bypass (RYGB) being one of the most common
79 procedure [1, 2]. Despite significant and improved health outcomes following
80 RYGB, not all severely obese patients are eligible for, or want bariatric surgery.
81 Thus, this patient group is in demand of effective lifestyle interventions. Several
82 studies have reported that lifestyle interventions may also result in significant
83 weight loss (WL) in severely obese patients in the short-term [3-5]. However,
84 results are usually not maintained in the long-term [6, 7].

85 Although RYGB results in significantly larger WL and higher remission rates of
86 diabetes mellitus type 2 (DM2) [8], lifestyle interventions can also induce
87 significant improvements in weight and risk factors [3, 4, 9]. Moreover, it is well
88 known that even a small WL, achieved with lifestyle interventions, can lead to
89 significant improvements in risk factors and comorbidities in the severely obese,
90 as previously reported by us [3] and others [4]. Additional long-term studies
91 comparing RYGB with structured lifestyle interventions are, however, needed.
92 The aim of this study was, therefore, to compare RYGB with three lifestyle
93 interventions in terms of changes in body weight (BW), risk factors and
94 comorbidities, in severely obese patients at 5 years follow-up.

95 **Subjects and Methods**

96 **Participants**

97 For this study, 221 caucasian participants (56 men) were recruited. Inclusion
98 criteria were an age between 18-65 years and a body mass index (BMI) ≥ 40
99 kg/m^2 or BMI $\geq 35 \text{ kg/m}^2$ with comorbidity. Non-eligibility criteria included

100 pregnancy, previous bariatric surgery, drug or alcohol abuse, severe psychiatric
101 disorders and/or physical impairment that could interfere with the treatment. This
102 study was conducted according to the guidelines laid down in the Declaration of
103 Helsinki. All participants gave written consent before enrolling in the study and
104 approval was obtained from the Regional Ethics Committee (Central Norway,
105 Trondheim, Norway).

106

107 **Methods**

108 This was an observational study with four cohorts conducted between 2005-
109 2013. Patients with severe obesity on the waiting list for bariatric surgery, at the
110 Centre for Obesity at St. Olavs Hospital in Trondheim, Norway, were offered the
111 options of either (A) remaining on the waiting list for and undergoing RYGB, or
112 enrolling in a lifestyle treatment. The lifestyle treatments available were (B) a
113 commercial weight loss camp, (C) a residential intermittent program and (D) a
114 hospital outpatient program. Participants could choose any of the conservative
115 treatments depending on preference and availability.

116

117 Group A had laparoscopic Roux-en-Y gastric bypass (RYGB) performed at St.
118 Olavs Hospital (Trondheim).

119

120 Group B underwent a 16 week stay at a private health resort (Ebeltoft Kurcenter,
121 Denmark). A multidisciplinary team organized an intensive intervention program
122 involving a low-calorie diet, two daily sessions of structured physical activity, and
123 weekly cognitive therapy. Following the stay in Denmark, patients were offered
124 optional monthly consultations by telephone or in person with a psychiatric nurse

125 at the Obesity Center at St. Olavs Hospital (Trondheim, Norway). For details see
126 Christiansen et al. (2007) [10].

127

128 Group C received a residential intermittent program at Røros Rehabilitating
129 (Røros, Norway). The intervention was arranged as three stays the first year (first
130 stay at Røros for 8-10 weeks, 8 weeks at home, second stay at Røros for 4
131 weeks, 4-5 months at home and then a third stay of 2 weeks at Røros). After the
132 1st year, patients were invited to return to Røros for 2 weeks every 6th months up
133 to 5 years. At Røros they consulted with a nutritionist, a physical therapist, a
134 psychologist, a nurse, a medical doctor and a social worker. The patients
135 attended monitored and structured physical activity with a physical therapist, both
136 individually (one session/day) and in groups (two sessions/day). They were
137 lectured on healthy eating, received nutritional education (principles of energy
138 balance, nutritious food, healthy cooking, etc.) and ate six meals a day (four main
139 meals and two snacks). Also part of the treatment was group-based
140 psychotherapy, focusing on how to use what they had learned when they got
141 home and how to change their lifestyle. For more details see Martins et al. (2011)
142 [3].

143

144 Group D had a six-month outpatient multidisciplinary weight loss program at St.
145 Olavs Hospital, followed by a six-month maintenance phase. The intervention
146 was organized by a physical therapist, an occupational therapist, a clinical
147 nutritionist and a social worker. The main goal of the intervention was to introduce
148 healthier behavior by the means of diet and exercise. This also involved a second
149 phase focusing on WL maintenance. This involved physical exercise in groups

150 once a week in the local community and a motivation meeting with the
151 multidisciplinary team every other month. The project was evaluated after 12
152 months, and the subjects were more or less 'left on their own', but summoned for
153 measurements every year. Further details about the intervention can be found in
154 Nossum et al. (2009) [11].

155

156 Body weight, risk factors (fasting plasma levels of glucose, total cholesterol, low
157 and high density lipoproteins (LDL and HDL), triglycerides (TG)) and
158 presence/absence of comorbidities (asthma, arthritis, DM2, coronary disease,
159 hypertension, sleep apnea, cholelithiasis, eating disorder and mental disorder)
160 were obtained at baseline, year 1 and 5. Baseline BW was measured at the clinic,
161 while later data was self-reported, measured at the clinic, or found in hospital
162 journals. The risk factors were assessed through fasting blood samples.
163 Comorbidities were self-reported.

164

165 **Statistical analysis**

166 Statistical analysis was performed with SPSS version 21.0 (SPSS IBM, New
167 York, U.S.A.). Statistical significance was set at $p < 0.05$ unless otherwise stated.
168 Since several patients were lost to follow-up or excluded at the 5-year follow-up,
169 analysis was also performed by merging all lifestyle groups into one combined
170 lifestyle group. The primary analysis focused on subjects who completed the
171 intervention and from whom 5-year data was available. Moreover, an intention-
172 to-treat analysis, using last observation carried forward (LOCF) and baseline
173 carried forward (BCF) to replace missing values was also performed. Continuous
174 variables were analyzed with Linear Mixed Model (LMM). All variables were

175 analyzed within and between groups, and Bonferroni post hoc test was used
176 when needed. Given that glucose plasma levels were found to be non-normally
177 distributed, the Kruskal-Wallis (four groups) or Mann-Whitney (two groups) tests
178 were used to compare the groups at the different time-points, and Friedman's
179 ANOVA was used to analyze changes over time within each treatment group.
180 Categorical variables were assessed with Chi-square test when assumptions
181 were met, otherwise Fisher's Exact test.

182

183 **Results**

184 A flow diagram of the study can be seen in Figure 1.

185 Of the 209 patients who started the study, 186 (89.0%) and 113 (54.1%)
186 completed the 1 and 5-year follow-up, respectively. Self-reported BW was used
187 in 16 (14.2%) of the 5-year completers.

188 The baseline characteristics of study participants can be viewed in Table 1.

189 Significant differences in BW ($p < 0.001$), BMI ($p < 0.01$) and gender distribution
190 ($p < 0.001$) were found between groups at baseline. There was a significantly
191 larger percentage of women in the RYGB and outpatient groups, compared with
192 the residential group. BW was significantly lower in the RYGB and the outpatient
193 groups compared with the weight loss camp group; additionally the outpatient
194 group had a significantly lower BW compared with the residential group.
195 However, BMI was only significantly lower in the outpatient group compared to
196 the WL camp group.

197 **Analysis of completers**

198 Changes in BW over 5 years in each treatment group are displayed in Figure 2.

199 Both at year 1 and 5, RYGB was associated with a significantly lower BW
200 compared to all the lifestyle groups: WL camp ($p<0.05$), residential and outpatient
201 group ($p<0.001$). There were no significant differences in BW at year 1 or 5
202 among the lifestyle groups.

203 All groups had significant WL the first year of treatment. RYGB g, WL camp and
204 residential program were associated with significant weight regain from year 1 to
205 5, but still these groups were associated with a significantly lower weight at the
206 5-year follow-up, compared to baseline. The outpatient program was not
207 associated with a significantly different BW at the 5-year follow-up compared to
208 baseline or the 1-year follow-up.

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210 **Percentage of WL**

211 WL in percent, at different time points, in each group is displayed in Table 2.

212 The percentage of patients within each group experiencing weight gain or at least
213 a 5, 10, 15, or 20% WL at 5 years can be seen in Table 3.

214 The RYGB group had a higher proportion of patients who lost weight in all WL
215 categories and a lower proportion of patients who gained weight, compared with
216 both the residential group and the outpatient group (all $p<0.001$). This was also
217 found when comparing RYGB with the combined lifestyle group (all $p<0.001$),
218 even though 1 in 4 patients in the combined lifestyle group was able to achieve
219 at least a 10% WL at 5 years.

220

221 **Changes in risk factors**

222 Changes in risk factors over time are shown in Table 4.

223 RYGB was associated with significantly lower glucose level at the 5-year follow-
224 up compared to all other lifestyle groups: WL camp and residential group
225 ($p<0.05$), outpatient group ($p<0.001$). Significant glucose changes over time
226 within groups were only found in the residential group ($p<0.01$), with a significant
227 increase from year 1 to year 5 ($p<0.01$).

228 The WL camp group was associated with significantly higher HDL than the
229 residential group ($p<0.01$) and outpatient group ($p<0.01$) at the 1-year follow-up.
230 At the 5-year follow-up, RYGB was associated with a significantly higher HDL than
231 the other lifestyle groups: WL camp, residential and outpatient group ($p<0.05$,
232 $p<0.001$, $p<0.001$, respectively). There were no significant changes in HDL over
233 time in either the residential or the outpatient group. The WL camp group was
234 associated with a significant increase in HDL from baseline to year 1 ($p<0.05$),
235 and a reduction from year 1 to year 5 ($p<0.01$). RYGB was also associated with
236 a significant increase in HDL from both baseline to year 1 ($p<0.001$), and from
237 year 1 to year 5 ($p<0.001$). Hence, the HDL level was significantly greater at the
238 5-year follow-up in this group ($p<0.001$).

239

240 **Changes in comorbidities**

241 Changes in comorbidities among the groups, either diagnoses or remission
242 from a condition, were only significant for hypertension. RYGB was associated
243 with a significant larger proportion of patients with reversal of hypertension at 5-
244 year follow up (78.6%) ($p<0.001$), compared with in the combined lifestyle group
245 (18.4%) (see Table 5).

246 There was also a tendency ($p=0.074$) for a larger proportion of patients in the
247 RYGB group to have remission of sleep apnea compared to the combined
248 lifestyle group (81.8% vs. 37.5%).

249

250 **Intention-to-treat**

251 Of the 163 patients included in the LOCF, mean follow-up time was 47.4 months
252 (SD = 19.5), with no significant differences between the four groups. LOCF
253 analysis of within-group weight change at the 5-year follow-up resulted in the
254 same overall results as analysis of completers. BCF analysis, with both two and
255 four groups, revealed significantly reduced BW in the RYGB and the combined
256 lifestyle group. However, when the different lifestyle groups were analyzed
257 separately, WL was no longer significant at 5-year follow (see Table 6).

258

259 **Discussion**

260 Overall, we found that RYGB was associated with better outcomes in terms of
261 WL, risk factors and hypertension remission compared with all lifestyle groups at
262 5-year follow up. However, lifestyle interventions were also associated with
263 significant WL in the long-term.

264 As expected, RYGB was associated with a larger 5-year WL (-30.9 kg, 95% CI
265 [-35.9, -25.9]) compared to the lifestyle groups. This is in accordance with
266 previous, similar studies on RYGB [12-14]. However, the WL camp and the
267 residential groups were also associated with a significant 5-year WL, opposite
268 the outpatient group. This may be due to the absence of structured follow-up
269 sessions from trained personnel after the first year in the outpatient group.

270 Structured follow-up sessions and long-term follow-up are known to be important
271 for WL maintenance [15-17]. Björvell & Rössner (1985) showed that behavioral
272 modification, exercise, nutritional advice and readmission at relapse, yielded a
273 WL of 11.7 kg after 4 years, and 10.6 kg at the 10-12 year follow-up [15, 16]. The
274 much smaller WL described in the lifestyle groups in the present study is possibly
275 explained by the absence of an intensive follow up program, with a distinct focus
276 on relapse treatment. It would be interesting to test how our inpatient intermittent
277 residential approach would perform, in terms of long-term WL maintenance, if an
278 intensive follow-up program was in place. Nevertheless, even though lifestyle
279 interventions were not associated with a large WL in the present study, they might
280 have prevented some patients from gaining additional weight, or aided in the
281 maintenance of BW [8, 18]. Also, other benefits that were not evaluated in this
282 study might have occurred, such as improvements in body composition,
283 cardiorespiratory fitness and quality of life; lower medication use; healthier food
284 intake; and increased physical activity, as reported in other studies [19-21].
285 In the present study, RYGB was associated with an overall improvement in risk
286 factors. This is in line with data from Adams et al. (2012), which reveals
287 significantly larger improvements in RYGB-patients for all risk factors (glucose,
288 total cholesterol, HDL, LDL and TG) at 6 years follow-up, compared to two control
289 groups (with little or no intervention) [8, 18]. Although no improvements in risk
290 factors were observed at the 5-year follow-up in the lifestyle intervention groups
291 in the present study, some studies in the severely obese, report improvements in
292 risk factors after lifestyle interventions, in the longer-term [19, 22]. A WL of 4.4%
293 in the combined lifestyle group in our study might explain the lack of improvement
294 in risk factors, as it has been reported that a WL of at least 9% may be needed

295 to improve several risk factors after a 10-year follow-up in severely obese
296 subjects [23].

297 The current study reports a significant larger remission of hypertension in the
298 RYGB group compared to the combined lifestyle group, as previously reported
299 [8, 18]. The remission rate in our combined lifestyle group was similar to that
300 reported in the control groups of the SOS study (with little or no intervention)
301 However Burguera and collaborators (2015) also reported no significant effect on
302 blood pressure after 2 years of an intensive lifestyle treatment [24]. There might
303 be several reasons for this, including self-reported data on comorbidities (hereby
304 hypertension). There was also a tendency for the proportion of patients with
305 remission of sleep apnea to be larger in the in the RYGB group compared with
306 the combined lifestyle group. This is in accordance with findings from Fredheim
307 and colleagues (2013), who also reported the improvements in sleep apnea to
308 be correlated with WL [25].

309 This study has several strengths. First, the long-term follow-up and secondly,
310 very few studies have compared RYGB with three different lifestyle interventions
311 in the severely obese. Third, the study sample was from a bariatric waiting list,
312 which makes them more comparable. However, there are also limitations,
313 including lack of randomization and non-intervened control group and lost to
314 follow up, which might have introduced confounders. Moreover, comorbidities
315 were self-reported, which limits the generalizability of these results due to
316 information bias. More research is, therefore, needed in this area and a
317 randomized clinical trial comparing the long-term effects of bariatric surgery
318 versus conservative treatment should ideally be performed in order to clarify the

319 long-term effects of these interventions regarding WL and changes in risk factors
320 and comorbidities in the severely obese population.

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322 In conclusion, RYGB resulted in a larger WL and larger improvement in risk
323 factors and hypertension resolution in the long-term compared with lifestyle
324 interventions. However, lifestyle interventions were also able to produce
325 significant WL in the long-term. Future research should focus on developing
326 lifestyle interventions that can produce a larger WL in the longer term and identify
327 subgroups of severely obese patients who can benefit from them.

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331 **Author contributions:**

332 M.S. and B.K. designed the study, M.S. and C.M. carried out the study, BØ
333 analyzed the data. All authors were involved in writing the paper and had final
334 approval of the submitted and published versions.

335

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338

339 **Conflict of interest:**

340 The authors declare no conflict of interest.

341

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346 cooperation.

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349 **References**

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457 **Figure legends:**

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459 Figure 1. Flowchart with retention rates and reasons for why patients were
460 excluded. 186 available and 186 actually seen at year 1, 113 available and 97
461 actually seen at the 5-year follow-up. RYGB: Roux-en-Y gastric bypass. WL:
462 weight loss.

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464 Figure 2. Changes in body weight over time in the four intervention groups.

465 Lines are presented as means \pm SEM. The mean weight in each group is
466 presented in the table with CIs. Identical letters within columns represent
467 significant differences between groups ($p < 0.05$). Values with similar superscripts
468 across columns represent significant within-group changes ($p < 0.05$). RYGB:
469 Roux-en-Y gastric bypass. WL: Weight loss.

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482 Table 1. Baseline characteristics of starting patients (n = 209)

	RYGB (n = 58)	WL camp (n = 30)	Residential (n = 64)	Outpatient (n = 57)	Combined lifestyle (n = 151)	Total (n = 209)
Women (%)	52 (89.7%) ^{ab}	21 (70.0%)	37 (57.8%) ^{ac}	47 (82.5%) ^c	105 (69.5%) ^b	157 (75.1%)
Age (years)	40.2±8.5	38.4±10.1	42.0±9.8	41.8±9.9	41.2±9.9	40.9±9.5
BW (kg)	130.7±18.1 ^a	144.2±20.2 ^{ab}	137.1±19.8 ^c	126.2±17.2 ^{bc}	134.4±20.1	133.4±19.6
BMI (kg/m ²)	45.0±5.4	48.3±6.6 ^a	45.3±5.5	44.1±4.9 ^a	45.5±5.7	45.4±5.6

Data is shown as mean ± SD. Numbers with similar letters across columns illustrate significant differences between groups (p<0.05). BMI: Body mass index. BW: Body weight. RYGB: Roux-en-Y gastric bypass. WL: Weight loss.

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487 Table 2. Weight changes (%) in the different study groups among completers

	From BL to Y1	From Y1-Y5	From BL-Y5
RYGB	-30.4 [-34.3, -26.4] ₁₂	9.3 [3.7, 15.1] _{abc13}	-23.9 [-27.7, -20.0] _{abc23}
WL camp	-20.6 [-28.6, -13.1] ₁₂	14.6 [4.9, 24.5] _{a13}	-9.2 [-16.9, -1.5] ^{a23}
Residential	-14.4 [-18.3, -10.5] ₁₂	12.1 [7.5, 16.7] _{b13}	-4.1 [-8.0, -0.1] ^{b23}
Outpatient	-6.8 [-11.8, -1.9] ¹	3.7 [-1.7, 9.0] ^{c1}	-3.3 [-8.1, 1.5] ^c

The mean weight change in percent in each group is presented in the table with CIs. Identical letters within columns represent significant differences between groups (p<0.05). Values with similar numbers across columns represent significant within-group changes (p<0.05). 186 available and 186 actually seen at year 1, 113 available and 97 actually seen at the 5-year follow-up. BL: Baseline. RYGB: Roux-en-Y gastric bypass. WL: Weight loss. Y1: Year 1. Y5: Year 5.

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494 Table 3. Percentage of patients who completed the study experiencing weight
 495 gain or different amounts of weight loss after 5 years in each treatment group

Weight change (%)	RYGB	WL camp	Residential	Outpatient	p-value (4 gr)	Lifestyle combined	p-value (2 gr)
Weight gain	0.0% (0) ^{abc}	12.5% (1)	38.9% (14) ^a	37.9% (11) ^b	<0.001	35.6% (26) ^c	<0.001
≥5% WL	92.5% (37) ^{abc}	62.5% (5)	44.4% (16) ^a	37.9% (11) ^b	<0.001	43.8% (32) ^c	<0.001
≥10% WL	82.5% (33) ^{abc}	62.5% (5) ^d	16.7% (6) ^{ad}	24.1% (7) ^b	<0.001	24.7% (18) ^c	<0.001
≥15% WL	75.0% (30) ^{abc}	37.5% (3)	11.1% (4) ^a	6.9% (2) ^b	<0.001	12.3% (9) ^c	<0.001
≥20% WL	57.5% (23) ^{abc}	12.5% (1)	8.3% (3) ^a	6.9% (2) ^b	<0.001	8.2% (6) ^c	<0.001

Data is presented as percentage in each group (n). Values with identical letters across columns denote significant differences between groups (p<0.05). 113 available and 97 actually seen at the 5-year follow-up. RYGB: Roux-en-Y gastric bypass. WL: Weight loss.

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Table 4. Changes in risk factors over time in the different treatment groups who completed the study

	RYGB				WL camp				Residential				Outpatient				Lifestyle combined			
	BL	Y1	Y5	BL	Y1	Y5	BL	Y1	Y5	BL	Y1	Y5	BL	Y1	Y5	BL	Y1	Y5		
Glucose (mmol/L)	5.33 [4.66, 6.00]	5.22 ^a [4.58, 5.86]	5.07 ^{b,cd,e} [4.45, 5.68]	6.68 [5.44, 7.91]	5.23 [3.99, 6.46]	6.73 ^b [5.36, 8.10]	5.99 [5.40, 6.57]	5.25 ¹ [4.58, 5.91]	6.11 ^{c1} [5.45, 6.76]	5.52 [4.88, 6.17]	5.46 [4.48, 6.45]	6.36 ^d [5.69, 7.04]	5.88 [5.47, 6.29]	5.25 ^{a1} [4.75, 5.74]	6.36 ^d [5.69, 7.04]	5.88 [5.47, 6.29]	5.25 ^{a1} [4.75, 5.74]	6.29 ^{e1} [5.85, 6.74]		
Total cholesterol (mmol/L)	4.26 [3.95, 4.57]	4.10 [3.80, 4.40]	4.71 [4.43, 4.99]	5.13 [4.54, 5.72]	5.09 [4.50, 5.68]	5.21 [4.59, 5.82]	4.74 [4.47, 5.02]	4.65 [4.34, 4.97]	4.93 [4.64, 5.23]	5.23 [4.92, 5.54]	4.85 [4.41, 5.30]	5.26 [4.94, 5.57]	4.98 [4.78, 5.18]	4.81 [4.58, 5.04]	5.26 [4.94, 5.57]	4.98 [4.78, 5.18]	4.81 [4.58, 5.04]	5.09 [4.89, 5.30]		
HDL (mmol/L)	1.11 ¹² [1.01, 1.22]	1.41 ¹³ [1.31, 1.51]	1.64 ^{abcd23} [1.55, 1.74]	1.37 ⁴ [1.17, 1.57]	1.61 ^{ef45} [1.41, 1.81]	1.33 ^{as} [1.12, 1.54]	1.14 [1.05, 1.24]	1.24 ^e [1.13, 1.34]	1.12 ^b [1.02, 1.22]	1.28 [1.18, 1.39]	1.19 ^f [1.05, 1.34]	1.29 ^c [1.18, 1.39]	1.22 [1.15, 1.29]	1.30 [1.22, 1.38]	1.29 ^c [1.18, 1.39]	1.22 [1.15, 1.29]	1.30 [1.22, 1.38]	1.21 ^d [1.14, 1.28]		
LDL (mmol/L)	2.46 [2.18, 2.73]	2.25 [1.99, 2.52]	2.54 [2.29, 2.79]	3.15 [2.62, 3.67]	3.01 [2.49, 3.54]	3.28 [2.73, 3.82]	2.85 [2.61, 3.10]	2.83 [2.55, 3.11]	3.10 [2.84, 3.37]	3.25 [2.97, 3.52]	3.08 [2.69, 3.48]	3.32 [3.04, 3.60]	3.04 [2.87, 3.22]	2.95 [2.74, 3.15]	3.32 [3.04, 3.60]	3.04 [2.87, 3.22]	2.95 [2.74, 3.15]	3.21 [3.03, 3.39]		
TG (mmol/L)	1.53 [1.29, 1.77]	0.98 [0.75, 1.21]	1.17 [0.95, 1.38]	1.36 [0.90, 1.82]	1.04 [0.58, 1.50]	1.32 [0.84, 1.80]	1.67 [1.45, 1.89]	1.30 [1.06, 1.55]	1.58 [1.36, 1.81]	1.55 [1.31, 1.79]	1.28 [0.92, 1.63]	1.44 [1.19, 1.69]	1.59 [1.44, 1.74]	1.25 [1.07, 1.43]	1.44 [1.19, 1.69]	1.59 [1.44, 1.74]	1.25 [1.07, 1.43]	1.50 [1.34, 1.65]		

The table displays mean group values [CI]. Values with similar superscripts across columns are significantly different to one another (p<0.05). Letters represent significant differences between groups. Numbers represent significant differences within groups. BL: Baseline. Y1: Year 1. Y5: Year 5. RYGB: Roux-en-Y gastric bypass. HDL: High-density lipoprotein. LDL: Low-density lipoprotein. TG: Triglycerides. WL: Weight loss.

510 Table 5. Change in comorbidities at the 5-year follow-up in each treatment group.

	RYGB	WL camp	Residential	Outpatient	p-value (4 gr)	Lifestyle combined	p-value (2 gr)
<u>Asthma</u>							
Resolved	53.8% (7)	0% (0)	25% (1)	50% (3)	p=0.427	30.8% (4)	p=0.428
Diagnosis	0% (0)	20% (1)	6.9% (2)	0% (0)	p=0.139	5.8% (3)	p=0.550
<u>Arthritis</u>							
Resolved	25% (2)	50% (1)	20% (1)	20% (1)	p=1.000	25.0% (3)	p=1.000
Diagnosis	7.7% (2)	0% (0)	16.0% (4)	15.8% (3)	p=0.787	14.3% (7)	p=0.484
<u>DM2</u>							
Resolved	40.0% (2)	0% (0)	33.3% (2)	33.3% (1)	p=1.000	27.3% (3)	p=1.000
Diagnosis	0.0% (0)	16.7% (1)	7.4% (2)	4.8% (1)	p=0.179	7.4% (4)	p=0.292
<u>Coronary disease</u>							
Resolved	0% (0)	0% (0)	0% (0)	0% (0)		0% (0)	
Diagnosis	2.9% (1)	12.5% (1)	0.0% (0)	4.2 % (1)	p=0.258	3.2% (2)	p=1.000
<u>Hypertension</u>							
Resolved	78.6% (11) ^{abc}	40.0% (2)	17.6% (3) ^a	12.5% (2) ^b	p<0.001	18.4% (7) _c	p<0.001
Diagnosis	4.8% (1) ^a	66.7% (2) ^a	11.8% (2)	11.1% (1)	p=0.060	17.2% (5)	p=0.380
<u>Sleep apnea</u>							
Resolved	81.8% (9) _a	50.0% (1)	40.0% (2)	0.0% (0)	p=0.168	37.5% (3) _a	p=0.074
Diagnosis	8.3% (2)	0.0% (0)	18.5% (5)	13.0% (3)	p=0.636	14.3% (8)	p=0.715
<u>Cholelithiasis</u>							
Resolved	100.0% (3)	50.0% (1)	50.0% (2)	100.0% (3)	p=0.373	66.7% (6)	p=0.509
Diagnosis	6.3% (2)	0.0% (0)	0.0% (0)	0.0% (0)	p=0.415	0.0% (0)	p=0.139
<u>Eating disorder</u>							
Resolved	33.3% (2)	12.5% (1)	50.0% (2)	50.0% (3)	p=0.901	54.5% (6)	p=0.620
Diagnosis	6.9% (2)	16.7% (1)	13.8% (4)	5.6% (1)	p=0.587	11.3% (6)	p=0.706
<u>Mental disorder</u>							
Resolved	27.3% (3)	100.0% (2)	50.0% (6)	36.4% (4)	p=0.298	48.0% (12)	p=0.295
Diagnosis	29.2% (7)	20.0% (1)	9.5% (2)	16.7% (2)	p=0.353	13.2% (5)	p=0.186

Data is shown as percentage (n). Resolved: Patients who had comorbidity at baseline, but had remission within the 5-year follow-up. Diagnosis: Did not have the comorbidity at baseline, but developed it within the 5 years. Values with similar superscripts across columns are significantly different to one another (p<0.05). DM2: Diabetes Mellitus type 2. RYGB: Roux-en-Y gastric bypass. WL: weight loss.

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514 Table 6. 5-year weight change in each treatment group with different analysis

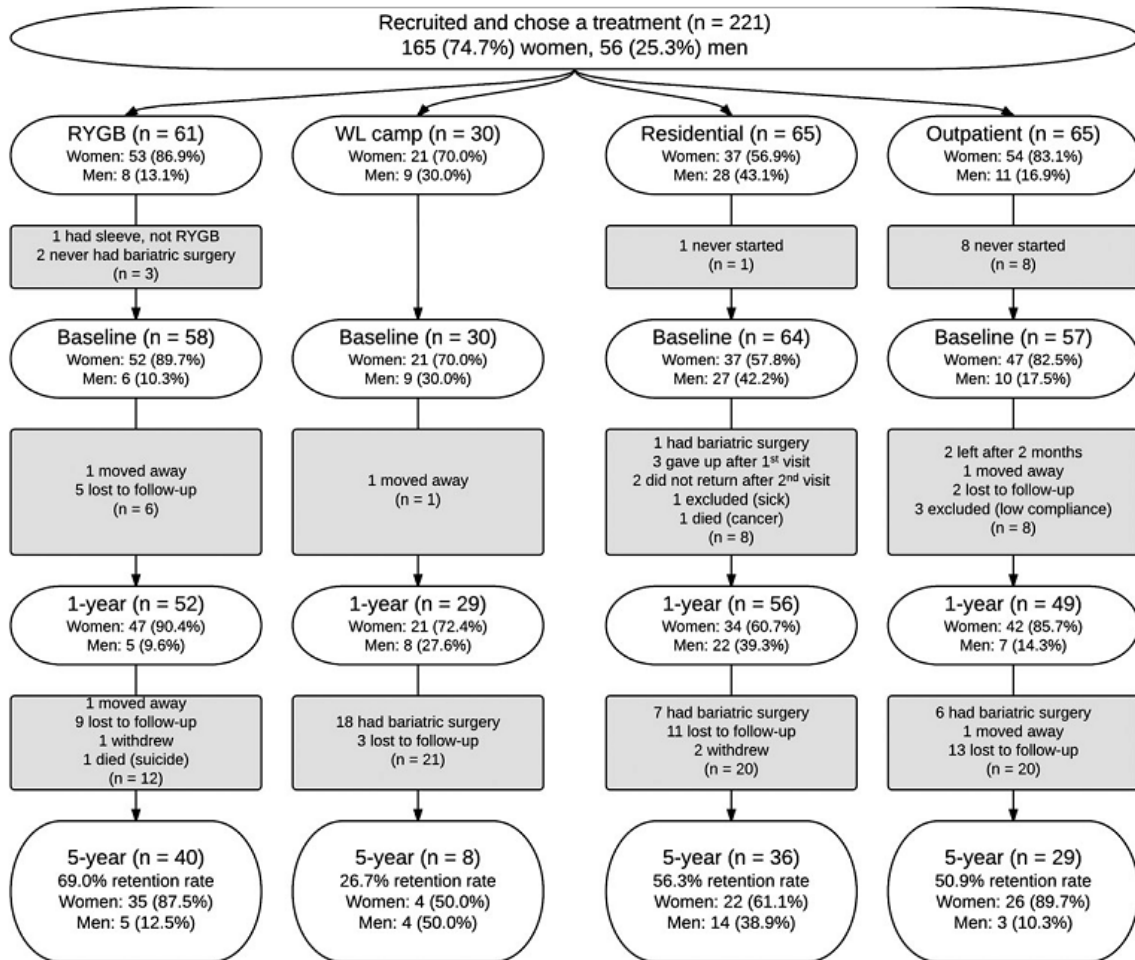
	RYGB	WL camp	Residential	Outpatient	Lifestyle combined
Completers (n = 113)	-30.9 kg * [-35.9, 25.9]	-13.3 kg § [-24.5, -2.1]	-5.5 kg § [-10.8, -0.2]	-4.1 kg [-10.0, 1.8]	-5.8 kg * [-9.7, -1.9]
LOCF (n = 163)	-35.0 kg * [-39.3, -30.8]	-13.4 kg § [-22.6, -4.3]	-6.0 kg * [-10.6, -1.5]	-3.7 kg [-8.4, 1.0]	-5.9 kg * [-9.1, -2.7]
BCF (n = 163)	-22.1 kg * [-26.7, -17.4]	-8.9 kg [-18.8, 1.1]	-4.0 kg [-8.9, 0.9]	-2.6 kg [-7.8, 2.5]	-4.0 kg § [-7.4, -0.5]

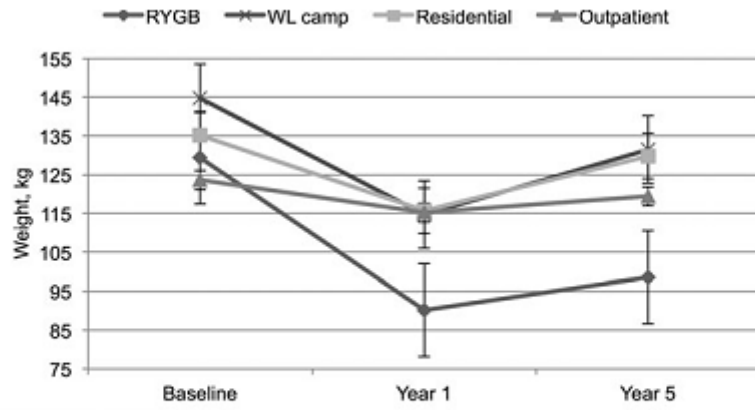
Data is presented as mean change [CI]. Values with § (p<0.05) or * (p<0.01) represent significant 5-year changes from baseline weight within each treatment group. BCF: Baseline carried forward. LOCF: Last observation carried forward. RYGB: Roux-en-Y gastric bypass. WL: Weight loss.

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RYGB	129.4 [123.1, 135.8] ¹²	90.1 [83.7, 96.5] ^{abc13}	98.6 [92.2, 104.9] ^{abc23}
WL camp	144.8 [130.6, 159.1] ¹²	114.7 [100.5, 128.9] ^{a13}	131.5 [117.3, 145.7] ^{a23}
Residential	135.2 [128.5, 141.9] ¹²	115.7 [109.0, 122.4] ^{b13}	129.8 [123.1, 136.5] ^{b23}
Outpatient	123.6 [116.1, 131.0] ¹	115.2 [107.6, 122.7] ^{c1}	119.4 [112.0, 126.9] ^c