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CLINICAL RESEARCH

Bariatric Surgery versus Lifestyle Interventions for Morbid Obesity—Changes in Body Weight, Risk Factors and Comorbidities at 1 Year

Catia Martins · Magnus Strømmen · Ola A. Stavne · Randi Nossum · Ronald Mårvik · Bård Kulseng

Abstract
Background Few studies have looked at non-surgical alternatives for morbid obese patients. This study aims to compare 1-year weight loss and changes in risk factors and comorbidities after bariatric surgery and three conservative treatments.
Methods Patients with morbid obesity (BMI>40 or BMI> 35 kg/m^2 plus comorbidities) on waiting list for bariatric surgery, were non-randomly allocated to (A) bariatric surgery or to one of three conservative treatments; (B) residential intermittent program; (C) commercial weight loss camp and (D) hospital outpatient program. Body weight, risk factors and comorbidities were assessed at baseline and 1 year.
Results Of 206 participants, 179 completed the study. All treatments resulted in significant weight loss, but bariatric surgery (40±14 kg, 31±9%) led to the largest weight loss (P<0.0001). There were no differences in weight loss between B and C (22±13 kg, 15±8% vs. 18±12 kg, 13± 8%), but these resulted in larger weight loss compared with D (7±10 kg, 5±8%). There were no differences in changes in total or LDL cholesterol, triacylglycerols or glucose between groups; however, the increase in HDL cholesterol was significantly larger in groups A and C. There were no differences in comorbidities resolution between groups A and B, C and D combined (except hypertension, which was better in group A).
Conclusion In conclusion, although bariatric surgery leads to a greater weight loss at 1 year compared with conservative treatment, in patients with morbid obesity, clinical significant weight loss and similar improvements in risk factors and comorbidities resolution can also be achieved with lifestyle interventions.

Keywords Obesity · Weight loss · Lifestyle modifications · Obesity surgery

C. Martins (✉) · M. Strømmen · B. Kulseng
Obesity Research Group,
Department of Cancer Research and Molecular Medicine,
Faculty of Medicine,
Norwegian University of Science and Technology,
Trondheim, Norway
e-mail: catia.martins@ntnu.no

M. Strømmen
Department of Neuroscience, Faculty of Medicine,
Norwegian University of Technology and Science,
Trondheim, Norway

C. Martins · M. Strømmen · R. Mårvik · B. Kulseng
Centre for Obesity, Department of Surgery,
St. Olav Hospital—Trondheim University Hospital,
Trondheim, Norway

O. A. Stavne
Røros Rehabilitation Centre,
Rørøs, Norway

R. Nossum
Clinical Services,
St. Olavs Hospital—Trondheim University Hospital,
Trondheim, Norway

Introduction

Obesity has reached epidemic proportions over the recent decades. The most recent data points to more than 1.6 billion overweight adults (body mass index (BMI)≥25 kg/m^2) and at least 400 million clinically obese (BMI≥30 kg/m^2) worldwide [1]. The public health consequences of this phenomenon are huge since obesity increases all-cause mortality and is an independent risk factor for type-2 diabetes (DM2), cardiovascular disease (CVD) and hypertension. Morbid obesity, defined as a BMI≥40 kg/m^2, is associated with a

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significantly higher prevalence of comorbidities [2] and rates of premature mortality twice as those seen in less severe degrees of obesity [3]. The associated socio-economic costs are extremely high and likely to increase [4]. The good news amidst this alarming picture is that small, but sustained weight loss can have large health benefits [5].

Diet, exercise, and behaviour modification, usually referred to as conservative treatment, remain the cornerstone of obesity treatment. Although conservative treatments of obesity can result in short-term weight loss of approximately 10% body weight, this is usually not sustained in the long-term [6]. This has led some to consider bariatric surgery as the only sustainable treatment for morbid obesity [7]. However, not all patients with morbid obesity want bariatric surgery [8], those who want are not always eligible, and less than 1% of those are treated annually [9]. Therefore, non-surgical alternatives for morbid obesity, which facilitate long-term weight loss maintenance, need to be developed.

Moreover, new evidence seems to suggest that a substantial weight reduction, similar to that observed with bariatric surgery, can be achieved with an intensive behavioural intervention, with around 25% of patients with morbid obesity reaching a non-obese weight [10] and maintaining a reduced weight in the long-term [11]. The present study aims to compare weight loss and changes in risk factors and comorbidities after bariatric surgery and three different conservative treatments in morbidly obese patients at 1 (data presented here) and 5 years (data under collection).

Subjects and Methods

Participants

Two hundred and six white Caucasian participants (154 women and 52 men) were recruited for this study. The inclusion criteria were an age between 18 and 60 years old and a BMI>40 kg/m^2 (or BMI>35 kg/m^2 with comorbidities). The exclusion criteria included pregnancy, enrolment in another obesity treatment, previous bariatric surgery, drug or alcohol abuse and mental disorders and/or physical impairment, which could interfere with the ability to comply with treatment.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki. All participants gave written consent before enrolling in the study and approval was obtained from the regional Ethics Committee (Central Norway, Trondheim, Norway).

Study Protocol

This was a non-randomised study where patients with morbid obesity on the waiting list for bariatric surgery at the Centre for Obesity at St. Olav Hospital in Trondheim, Norway were given the option of continuing on the waiting list or enrolling in a conservative treatment. The conservative treatments available were: a residential intermittent program, a commercial weight loss camp and a hospital outpatient program. Participants could choose any of the conservative treatments depending on preference and availability to travel abroad (in the case of the commercial weight loss camp in Denmark). There were only 30 available places for the commercial weight loss camp, so that when this option was fully booked, participants would have to choose from the other two conservative treatments. Body weight was assessed before and after the intervention and at 1 year. Fasting blood samples were obtained at baseline and 1 year and analysed for total cholesterol, HDL cholesterol, triacylglycerols and glucose using standard laboratory techniques. LDL cholesterol was calculated using the Friedewald equation [12]. Changes in comorbidities at 1 year (resolution or not of asthma, arthritis, DM2, hypertension and sleep apnea) were also assessed.

Bariatric surgery (treatment A) consisted of a Roux-en Y gastric bypass and was performed at St. Olav Hospital by a trained surgeon. The different conservative treatments (B, C and D) offered are explained below.

Treatment B: Residential Intermittent Program

This intervention consisted of a "continuous care" weight loss program at Røros Rehabilitation Centre (RRC) (Norway), with intermittent stays at RRC as follow: 8–10 weeks at RRC, 8 weeks at home, 4 weeks at RRC, 4–5 months at home, and 2 weeks at RRS (and 2 weeks every 6 months after the first year up to 5 years). During the first visit at Røros, each patient had an individual consultation with a team of health professionals (dietician, physical activity (PA) therapist, psychologist, public health nurse, medical doctor and social worker). Patients took part in a structured PA supervised by a PA therapist (two sessions of group PA+one individual/day) and in a nutrition education program on how to estimate energy needs, energy intake from food, healthy eating, healthy cooking, etc. Participants had six meals/day (four main meals: breakfast, lunch, dinner and evening meal and two snacks). Some of the meals were provided by the kitchen, others were prepared by the participants in groups, with the help of a dietician and a chef.

The cornerstone of this program consisted of dynamic group-based psychotherapy. A great effort was put into translating new knowledge and practises acquired at RRC into the home environment and establishing long-term support at home. The overall aim was for patients to become capable of being in charge of their own lifestyle changes and, therefore, their own treatment.

Treatment C: Weight Loss Camp

This intervention consisted of 21 weeks of an intensive lifestyle modification program at a private health resort—Ebeltoft Healthcentre (Ebeltoft Kurcenter, Ebeltoft, Denmark). This program consisted of a conventional low-calorie diet, structured physical activity (PA) and cognitive therapy, and it was supervised by a multidisciplinary group that included dieticians, physical therapists and a psychotherapist. Participants also took part in an education program where they were taught how to calculate energy from food, to estimate portion sizes, and to use different behavioural strategies in their home environment to maintain the achieved weight loss. The cornerstone of the weight loss program was the daily intensive PA supervised by a PA therapist (at least 120 min/day). Moreover, on a weekly basis, the participants took part in sessions with focus on cognitive strategies with a psychotherapist. For more details about this program see Christiansen et al. [13].

This was followed by regular individual meetings (every 2 weeks) with a psychiatric nurse at the Centre for Obesity in St. Olav University Hospital, Trondheim, Norway. During these meetings, weight was recorded and participants discussed their progress with the nurse in terms of dietary intake/patterns, PA levels and behavioural modifications. For some participants, who lived very far away from the centre, some of these personalised meetings were substituted by phone contact.

Treatment D: Hospital Outpatient Program

Participants attended a 6-month weight loss program at St. Olav Hospital, Trondheim (Norway) followed by a 6-month weight maintenance program. The weight loss program consisted of regular individualised meetings with the physiotherapist in order to increase PA levels (three times/week in the first 2 months; two times/week in the last 4 months+1 h/week self-training) and group meetings every week (2.5 h) with one of three health professionals: occupational therapist (to discuss habits and plan daily activities), dietician (to increase knowledge on the nutritional composition of different foods, healthy alternatives and cooking techniques) and social worker (psychosocial interview). Participants had to attend at least 80% of the meetings to continue in the program (two participants were excluded for this reason).

After the 6-month weight loss program, participants could take part in group weekly meetings with a physiotherapist at a community training centre close to their area of residence and in group meetings every 2 months at St. Olav Hospital, with the team of health professionals involved in the weight loss phase. The aim of these meetings was to maintain participants motivated to keep their lifestyle changes.

A flow diagramme of the study can be seen in Fig. 1.

Statistical Analyses

The statistical analysis was carried out using SPSS 15.0 (SPSS Inc., Chicago, IL). All variables were checked regarding their normal distribution using the Shapiro–Wilk test. Statistical significance was assumed at $P<0.05$, unless otherwise stated.

The primary analysis was on an *intention-to-treat* basis, using the last observation carried forward approach to replace missing values (five participants were not used in this analysis: three had severe adverse events unrelated to the study (one had ileus, one started cancer treatment and the other died of cancer) and two were excluded due to very low attendance to the intervention program). Four women became pregnant during the first year and for them weight before pregnancy was used in the intention-to-treat analysis (ITA). A secondary analysis focused on weight loss on those who completed the study.

We used one-way ANOVA to examine differences in weight loss between groups; where ANOVA indicated a significant group effect, we performed post-hoc pairwise comparisons with the Bonferroni test. Since there were significant differences in baseline weight ($F(3, 175)=6.484$, $P<0.0001$) among groups and baseline weight correlated with 1 year weight loss ($r=0.33$, $P<0.001$), we also performed analysis of covariance to control for this variable (with Bonferroni as a post-hoc test). Analysis of covariance was also used to look at differences between groups in plasma lipids and glucose changes at 1 year. Differences in comorbidities resolution between intervention groups was assessed by χ^2. However, due to few observations per cell in some groups, we had to merge all lifestyle interventions into one variable and look only at differences between bariatric surgery and lifestyle intervention.

We analysed differences between participants who completed and withdrew with t tests for continuous variables (such as age) and χ^2 for categorical variables (such as sex and treatment group).

Results

Table 1 summarises the baseline characteristics of the participants by group. The study sample had a mean age of 40.9±9.5 years and a baseline BMI of 45.4±5.6 kg/m^2. Age did not differ among groups, but there were significant differences in baseline weight ($F(3, 175)=6.484$, $P<0.0001$) and BMI (($F(3, 207)=3.579$, $P=0.015$). The weight loss

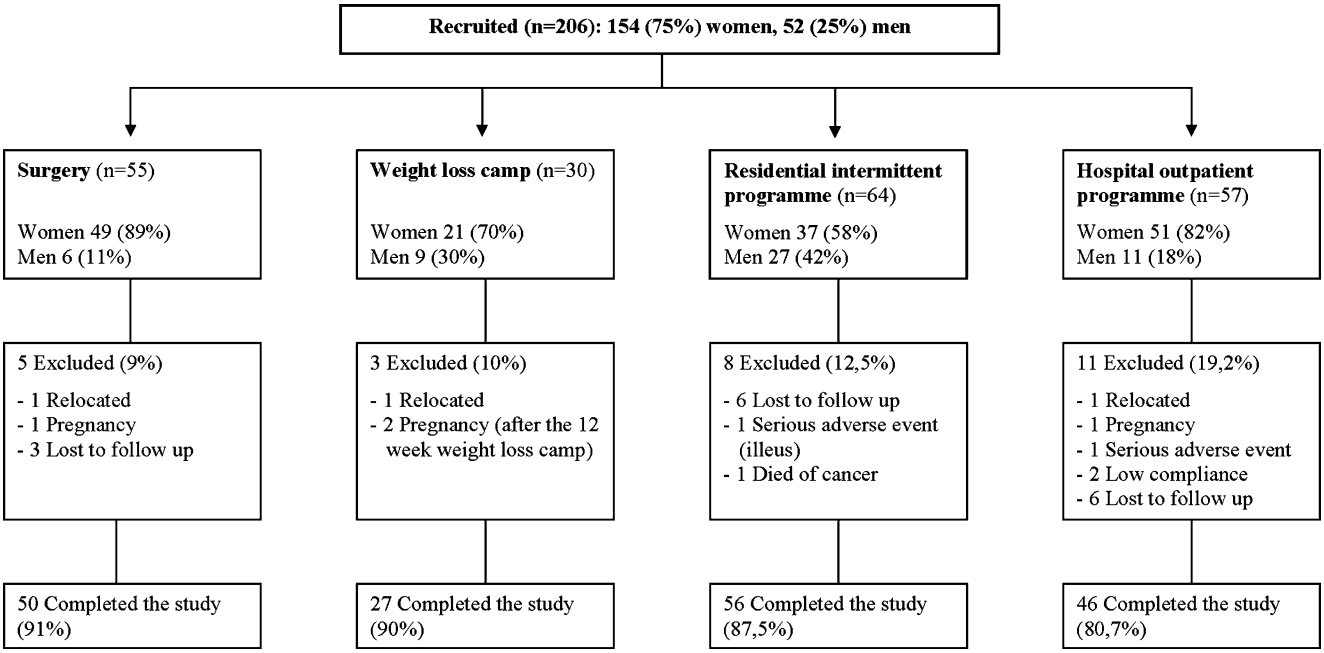

Fig. 1 Participant flow diagramme

camp group had a significantly higher baseline weight and BMI compared with the hospital outpatient group ($P<0.0001$ and $P=0.005$, respectively) and a higher baseline weight compared with the surgery group ($P<0.05$), but no difference in baseline BMI. The residential group also had a higher baseline weight compared to the hospital outpatient group ($P=0.009$), but no difference in baseline BMI.

Intention-to-Treat Analysis

One year weight loss after the different interventions can be seen in Fig. 2 and Table 3. There were significant differences in 1 year weight loss (both in kg and as a percentage (%) or initial body weight) among the different treatment groups ($F(3, 175)=69.17$, $P<0.0001$). Weight loss (kg and %) at 1 year was higher in the surgery group compared with all the conservative treatments ($P<0.0001$ for all). One year weight loss (kg and %) was on average two to three times greater in the weight loss camp and residential groups compared with the hospital outpatient group ($P<0.0001$ for both). Adjustment for baseline weight did not change these patterns (Fig. 2).

The percentage of participants who lost 5, 10, 15 or 20% or more of their initial body weight, within each treatment program can be seen in Table 2. A total of 98 and 89% of the participants who underwent surgery achieved a 10 and 20% weight loss at 1 year, respectively, compared with 68 and 18% after the residential intermittent program, 70 and 23% after the weight loss camp and 20 and 4% after the hospital outpatient program, respectively.

Analyses of Completers

There were no significant differences in baseline weight or BMI, age, gender or treatment group between those who completed the study and those who withdrew.

A secondary analysis of the data from participants who completed the study was also performed and showed the same patterns in terms of magnitude of weight loss and statistical significance to those already described in the ITA (Table 3).

Table 1 Baseline characteristics of the participants

Characteristics	Surgery	Residential intermittent program	Weight loss camp	Hospital outpatient program
Age (years)	40.0 (8.3)	42.0 (9.8)	38.4 (10.1)	41.4 (9.9)
Weight (kg)	131 (18)	137 (20)	144 (20)	126 (17)
Body mass index (kg/m^2)	45.2 (5.4)	45.3 (5.5)	48.3 (6.6)	44.3 (5.3)

Values are mean (SD)

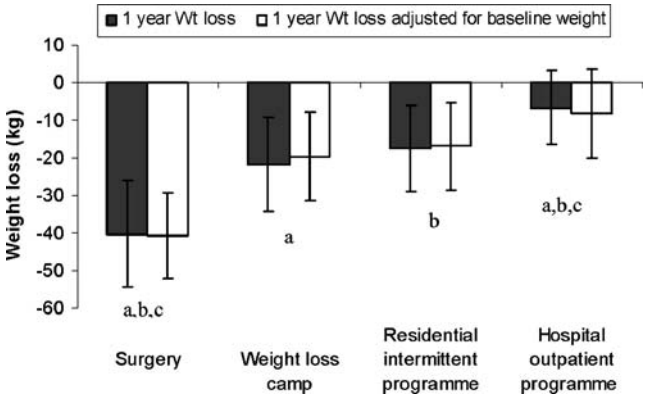

Fig. 2 Intention-to-treat analysis for absolute weight loss at 1 year (*black bars*) and weight loss at 1 year adjusted for baseline weight (*white bars*) after different interventions. *Bars with the same letter* represent significant differences in 1-year weight loss between treatment groups

Changes in Weight in the Residential Intermittent Program

Changes in weight in the residential intermittent group throughout the year can be seen in Fig. 3. There was a significant effect of time on body weight in this group ($F(2.5, 135.0)=84.5$, $P<0.0001$). Participants lost significant amounts of weight during every stay at the residential intermittent program: 13.2±4.4, 3.4±2.4 and 1.6±2.1 kg during their first, second and third visits, respectively ($P<0.001$ for all). They lost a further non-significant 3.4±8.2 kg ($P=0.061$) during their first home stay, maintained their weight during their second home stay (+0.7±8.5 kg, $P>0.05$) and put on 2.6±4.5 kg weight during their third home stay ($P=0.002$), resulting on an average 1-year weight loss of 18.3±11.0 kg ($P<0.0001$).

Changes in Weight in the Weight Loss Camp

Changes in weight in the weight loss camp group throughout the year can be seen in Fig. 4. There was a significant effect of time on body weight in this group ($F(1.4, 36.6)=102.7$, $P<0.0001$). Participants lost 25.2±7.4 kg ($P<0.001$) during the stay at the weight loss camp and gained 4.4±8.6 kg ($P=0.039$) afterwards, resulting on an average 1-year weight loss of 20.8±12.5 kg ($P<0.0001$).

Changes in Weight in the Hospital Outpatient Program

Changes in weight in the hospital outpatient group throughout the year can be seen in Fig. 5. There was a significant effect of time on body weight in this group ($F(1.3, 37.0)=18.1$, $P<0.0001$). Participants lost 9.3±7.9 kg ($P<0.0001$) during the weight loss program, which lasted the first 6 months and maintained (+2.6±6.3 kg, ($P>0.05$) their weight during the weight loss maintenance program (last 6 months), resulting on an average 1-year weight loss of 6.7±9.8 kg ($P=0.005$).

Changes in Lipids and Plasma Glucose

Changes in the fasting levels of lipids and glucose at 1 year (as a percentage (%) of baseline) are presented in Table 4. Total cholesterol plasma levels were only significantly reduced at 1 year in the hospital outpatient group (−5.2%, $P<0.05$), while a significant reduction in LDL cholesterol was only observed in the surgery group (−8.5%, $P<0.05$). However, there were no significant differences in total or LDL cholesterol changes at 1 year among treatment groups when adjusted for baseline levels. HDL cholesterol increased significantly in the surgery group (35%, $P<0.0001$), residential intermittent group (11%, $P<0.01$) and weight loss camp (15%, $P<0.01$) and decreased in the hospital outpatient group (−10%, $P<0.0001$). There were no differences between the surgery and the weight loss camp groups in terms of the increase in HDL plasma levels, but surgery lead to a larger increase in HDL plasma levels compared with the other two lifestyle interventions and the weight loss camp lead to a larger increase in HDL compared with the hospital outpatient group. Triacylglycerol levels were significantly reduced in the surgery and residential intermittent program groups, but there were no significant differences between intervention groups. Glucose plasma levels were significantly reduced in the surgery and weight loss camp groups, but again there were no significant differences between intervention groups.

Resolution of Comorbidities

Comorbidities resolution at 1 year in the different treatment groups can be seen in Table 5. No significant differences

Table 2 Percentage of participants who lost 5, 10, 15 and 20% or more of their initial body weight within each treatment group (intention-to-treat analysis)

Percentage of weight loss	Surgery (%)	Residential intermittent program (%)	Weight loss camp (%)	Hospital outpatient program (%)
5% weight loss	100	82	97	50
10% weight loss	98	68	70	20
15% weight loss	96	55	50	7
≥20% weight loss	89	18	23	4

Values are mean (SD)

Table 3 One-year weight loss after different interventions (intention-to-treat analysis and analysis of completers)

Outcome	Surgery	Weight loss camp	Residential intermittent program	Hospital outpatient program
Intention-to-treat analysis				
1-year weight loss (kg)	40.3 (14.1)	21.7 (12.5)	17.6 (11.5)	6.7 (9.8)
1-year weight loss (%)	30.5 (9.4)	14.8 (8.0)	13.0 (8.2)	5.3 (7.4)
Analysis of completers				
1-year weight loss (kg)	41.0 (14.1)	20.8 (12.5)	18.1 (11.1)	6.6 (10.2)
1-year weight loss (%)	31.0 (9.2)	14.5 (8.1)	13.4 (8.0)	5.3 (7.8)

Values are mean (SD)

were observed between surgery and lifestyle (all combined) groups in the resolution of asthma, arthritis, DM2 or sleep apnea at 1 year, however, the surgery group experienced a larger resolution on hypertension compared with the lifestyle group (χ^2 (1)=11.05, p=0.001)).

Discussion

The main objective of this study was to compare weight loss and changes in risk factors and comorbidities at 1 year after bariatric surgery and three different conservative treatments in patients with morbid obesity, aiming at identifying the best non-surgical alternative for sustained weight loss in this patient group. As expected, bariatric surgery was associated with the greatest weight loss: 40 kg (31%), a magnitude that is in line with that reported in larger cohorts of bariatric surgery such as the SOS study [7]. However, all the conservative treatments lead to a significant 1-year weight loss. Within the conservative treatments studied, the residential intermittent program and the weight loss camp resulted in similar weight loss (22 kg (15%) and 18 kg (13%), respectively) that was significantly larger compared to what was observed in the hospital outpatient group (7 kg (5%)). Even though our conservative treatments resulted in only one-half to one-sixth of the weight loss induced by surgery, no significant differences between treatment groups were observed in the changes in total LDL cholesterol, triacylglycerols or glucose plasma levels at 1 year. Moreover, although surgery resulted in a larger increase in HDL cholesterol compared with the residential intermittent and the hospital outpatient programs, there were no differences between surgery and weight loss camp groups. In terms of the resolution of comorbidities at 1 year, only those with hypertension experienced a better outcome after surgery compared with after lifestyle intervention, with no differences being observed for asthma, arthritis, DM2 and sleep apnea.

Although the majority of non-surgical interventions to treat morbid obesity have yielded disappointing results, with weight regain occurring in the majority of the patients [13, 14], clinical significant weight loss is possible with conservative treatments and can be sustained in the long-term [10, 11, 15]. Anderson et al. reported a weight loss of 25% (35 kg) at 39 weeks in morbid obese patients enrolled on an intense behavioural program focusing on a low-energy diet plus PA [10]. Moreover, of the completers, 24% lost more than 45 kg (100-lb group), with an average weight loss of 62 kg (40% of initial body weight) at 56 weeks [10]. At 72 weeks of follow up, 59% of the weight loss was maintained in all the groups, and in the 100-lb group, 65% of weight loss was maintained after 95 weeks [10]. After 5 years follow up, the 100-lb group was shown to sustain an 18% weight loss [11]. Moreover,

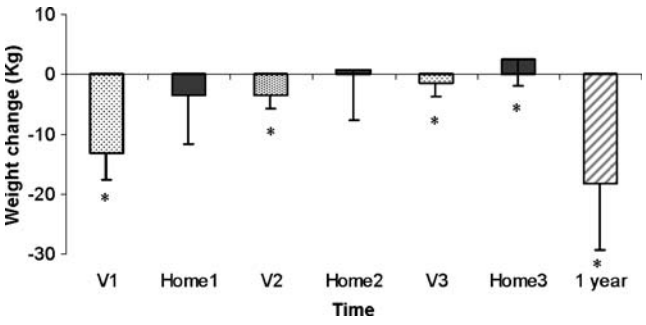

Fig. 3 Weight change during 1 year in the Residential intermittent group. *Dotted bars* represent stays at Røros rehabilitation centre (*V1* visit 1, *V2* visit 2, *V3* visit 3), *black bars* represent home stays and the *lined bar* cumulative weight loss at 1 year. Asterisks represent significant changes in body weight

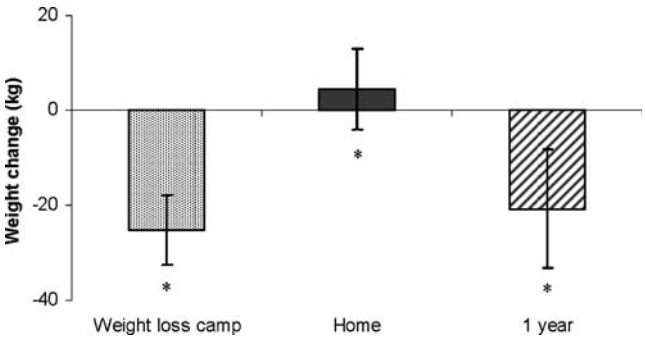

Fig. 4 Weight change during 1 year in the Weight loss camp group. *Dotted bar* represents stay at the weight loss camp, *black bar* represents home stay and the *lined bar* cumulative weight loss at 1 year. Asterisks represent significant changes in body weight

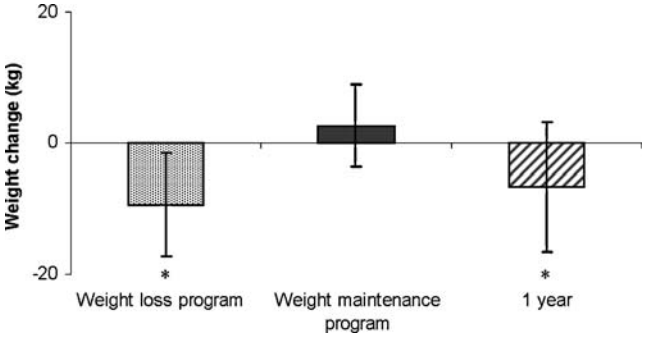

Fig. 5 Weight change during 1 year in the hospital outpatient program. *Dotted bar* represents weight loss program, *black bar* represents weight maintenance program and the *lined bar* cumulative weight loss at 1 year. Asterisks represent significant changes in body weight

Table 5 Resolution of comorbidities at 1 year after different weight loss programs

	Surgery	Residential intermittent program	Weight loss camp	Hospital outpatient program	All lifestyle interventions
Asthma	6 (40%)	1 (20%)	3 (38%)	3 (38%)	7 (33%)
Arthritis	3 (33%)	4 (57%)	4 (80%)	3 (33%)	11 (61%)
DM2	4 (67%)	4 (33%)	1 (33%)	2 (50%)	7 (37%)
Hypertension	16 (84%)	8 (31%)	7 (54%)	7 (44%)	22 (40%)*
Sleep apnoea	9 (69%)	4 (50%)	0 (0%)	1 (50%)	5 (42%)

Number (percentage) of patients diagnosed with the comorbidities at baseline that experienced resolution of the condition at 1 year

Significant differences between surgery and lifestyle (all combined) groups: *$P<0.01$

in what is probably the longest follow-up study looking at the impact of a conservative treatment on weight loss in morbid obese patients, Bjorvell and Rossner showed that the 13 kg weight loss achieved after 4 years of a nursing treatment program (6 weeks of treatment followed by regular support meetings for 4 years) were maintained at 10–12 years [15]. Although we were able to show a significant weight loss at 1 year with all lifestyle programs used in the present study, the magnitude of weight loss was much smaller compared with the studies described above. However, it needs to be said that those studies [10, 11, 15] used a very intensive approach with weekly meetings and midweek phone calls during the weight loss phase [10, 11], weekly boost meetings during the weight maintenance phase [10, 11, 15] and readmittance of patients who relapsed [15]. These approaches although possible to implement are extremely labour intensive and, therefore, require a large financial budget that not all centres can afford.

The concept of weight loss camps or residential programs for severely obese adult patients is relatively new and few data is available, particularly in the long-term. Short-term results are usually good, with an average 7% weight loss being reported after 3–4 weeks [16, 17] and 15% after 21 weeks [13] participation in residential weight loss programs consisting of diet, PA and behavioural modification in patients with morbid obesity. These changes have been shown to be maintained at 1 year [17], to be of small clinical significance at follow ups between 2 and 4 years [13] and to disappear almost completely at 5 years [18]. However, in all these studies there was no additional contact between patient and "health providers" after the stay at the weight loss camp.

In the present study, 14–16 weeks of intermittent stays at a residential facility and 21 weeks of a weight loss camp, followed by regular meetings with a psychiatric nurse, resulted in a 1-year weight loss of 13 and 15%, respectively. Since extending the length of treatment has been shown to significantly increase the magnitude of weight loss [19], and programs using a continuous care approach have been shown to result in long-term weight loss maintenance [10, 20], we hypothesise that our weight loss camp and residential "intermittent" program will lead to a better sustained long-term weight loss maintenance compared with previous studies on weight loss camps where treatment was discontinued. However, not all patients seem to need a continuous care approach to achieve long-term weight loss [21]. Dalle Grave et al. followed 1,000 morbid obese

Table 4 Changes from baseline (%) in lipids and plasma glucose at 1 year after different weight loss programs

	Surgery	Residential intermittent program	Weight loss camp	Hospital outpatient program
Total cholesterol	−3.7 (15.5)	−1.2 (14.6)	−1.6 (12.4)	−5.2 (11.0)[a]
LDL cholesterol	−8.5 (29.3)[a]	1.3 (27.7)	−3.7 (15.9)	−1.1 (16.9)
HDL cholesterol	34.7 (20.1)[d12]	10.8 (18.1)[b13]	14.6 (18.5)[b4]	−9.7 (9.5)[d1234]
Triacylglycerols	−29.5 (32.0)[d]	−21.0 (27.7)[d]	−10.1 (47.7)	−6.0 (22.0)
Glucose	−4.4 (19.0)[a]	−4.3 (18.4)	−10.2 (13.2)[a]	7.9 (26.2)

Values are mean (SD). Significant differences from baseline within groups: [a] $P<0.05$, [b] $P<0.01$, [c] $P<0.001$, [d] $P<0.0001$

Comparisons between groups were done after adjusting for baseline levels. Significant differences between groups: [1,2,4] $P<0.0001$, [3] $P<0.05$ (groups sharing the same number denote significant differences between groups)

patients enrolled on a continuous care program for 36 months (3–6 months initial intensive treatment followed by less intensive continuous care every 1–4 months). Although average weight loss was higher in continuers compared with dropouts (5.2 vs. 3%), dropouts satisfied with the results or confident to lose additional weight on their own reported a mean weight loss of 9.6 and 6.5%, respectively [21].

Although there was no significant difference in 1-year weight loss maintenance between the residential program and the weight loss camp, the "continuous care" approach in each group was very different (intermittent stays at the rehabilitation centre with specialists in nutrition, PA and psychology versus regular meetings with a research nurse). It remains to be seen if weight loss maintenance in these two groups will still be similar at 5-year follow-up, or if the results will somehow diverge and in which direction. A previous study in 200 overweight women, which had at least 5% weight loss, were then allocated to an intensive support program (implemented by nutrition and PA specialists) or an inexpensive nurse-led program (involving "weigh-ins" and encouragement) showed no difference in long-term weight loss maintenance (at 2 years) [22]. However, the participants from this study had a much lower degree of obesity compared with the participants of the present study (32 versus 45 kg/m^2).

The hospital outpatient group experienced, on average, only between half to one third of the weight loss observed with the other two conservative treatments, however, no significant weight regain was observed between the end of the 6-month weight loss program and the 1-year evaluation. Surprisingly, and from our knowledge, no study has previously compared outpatient with inpatient (weight loss camps or residential programs) treatment programs for morbid obesity. It may be that an inpatient approach is easier for patients with morbid obesity to achieve long-term changes in behaviour (regarding both eating and PA).

Although we are aware of the limitations of this study: non-randomization, lack of control group and a relatively short follow up, we believe that our findings are important in determining the effectiveness of non-surgical alternatives for the treatment of morbid obesity. In a study with this design and follow-up period, it would be unethical to randomise patients for surgery vs. conservative treatment, since the first is associated with a much higher risk of complications, or to keep a patient with morbid obesity under a minimal treatment control group for 5 years. Moreover, as both bariatric surgery and lifestyle interventions require a great personal effort, to randomise patients against their preferred treatment option would increase the risk of non-compliance and dropouts. Although non-randomization resulted in significant differences in baseline weight between some treatment groups, analysis of covariance adjusting for baseline weight did not change the outcome. Moreover, even though this study reports only a 1-year weight loss data, initial weight loss has been shown to be a significant predictor of long-term success [15, 23, 24].

In conclusion, clinically beneficial weight loss in patients with morbid obesity is possible through conservative non-surgical interventions, in particular residential intermittent programs and weight loss camps. Despite the much larger weight loss observed in the surgical group, small weight losses (5–15%) achieved through lifestyle interventions can result in a similar reduction in risk factors and resolution of comorbidities (with the exception of hypertension) at 1 year. However, a longer follow up (currently in progress) is needed to clearly establish the sustainability of these programs.

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