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Surgical Intervention as a Strategy for Treatment of Obesity

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A very large number of weight-reducing surgical techniques have been developed over the last 25 years. Today only a handful of these techniques can be recommended. Gastric bypass, vertical banded gastroplasty, and variable banding can all be recommended although gastric bypass should be reserved for heavier patients. For the heaviest, biliopancreatic diversion or biliopancreatic diversion with duodenal switch might be considered. The controlled intervention study Swedish Obese Subjects has shown that most but not all cardiovascular risk factors are improved over 10 years by surgically induced weight loss. Quality of life as well as cardiac structure and function are dramatically improved. The average weight loss for gastric bypass and vertical banded gastroplasty was 16% after 10 years. No non-surgical treatment available today can achieve such results, not even over 2 years. Surgical treatment for obesity needs to become much more common, particularly in obese patients with metabolic disturbances.

Key Words: Obesity; surgical intervention.

Introduction

Previous articles have illustrated that conventional treatment of obesity is associated with poor long-term results *(1,2)*. Recent publications from the intervention study Swedish Obese Subjects (SOS) have shown that conventional treatment results are particularly poor when originating from settings not specialized in the treatment of overweight and obesity *(3,4)*. Drug treatment of obesity results in 8–12% weight loss under conditions in which placebo gives 4–6% weight loss. Although this is encouraging, much more efficient drugs are needed in the future. For a long time, these circumstances have constituted incentives for surgeons to develop techniques resulting in malabsorptive or restrictive effects on food intake. Several techniques achieve weight loss through both these mechanisms and most likely also by changing the gastrointestinal signaling systems.

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Literally dozens of surgical antiobesity techniques have been described. I am an internist and not a surgeon, and therefore the text herein focuses on results rather than surgical procedures. For technical procedures and unusual methods, the reader is referred to textbooks on obesity surgery *(5)*. I examine the outcome of the eight techniques most commonly used over the last 30 yr and review studies comparing conventional and surgical treatment. An overall aim is to illustrate that bariatric surgery is safe and so far more long-term efficient than any other technique available for the treatment of obesity. Some parts of this article overlap with a similar review in Swedish to be written by The Swedish Council on Technology Assessment in Health Care and with a chapter in International Textbook of Obesity *(6)*.

Methods

Intestinal operations are illustrated in Fig. 1, gastric operations in Fig. 2 and combined gastric and intestinal operations in Fig. 3.

Intestinal Operations

The jejuno-colic shunt (Fig. 1A) was first described by Payne et al. *(7)* in 1963. The jejunum was divided 37–75 cm from the ligament of Trietz. The proximal segment was connected end-to-side to the transverse colon while the distal segment of the divided jejunum was closed. The operation resulted in large weight reductions and dramatic improvement in blood lipids. However, the technique was soon abandoned owing to severe diarrhea and hepatic failure. Thirteen years later, DeWind and Payne *(8)* described the end-to-side jejunoileal bypass (JIB) (Fig. 1B). The jejunum is divided 35–37.5 cm from the ligament of Trietz. The proximal end is anastomosed to the ileum 10–12 cm from the ileocecal valve. The distal part of the divided jejunum is closed. Several variants of the JIB have been described *(9–11)*.

Gastric Operations

Horizontal gastroplasties (HGPs) were introduced by Pace et al. *(12)* in 1979. After having removed three central staples, a double staple row was applied horizontally across the upper part of the stomach resulting in a ≤50-mL pouch with a 9-mm central opening (Fig. 2A). The stoma between the pouch and remaining stomach was rapidly dilated and thus the long-term results were poor. Attempts were undertaken to circumvent this problem by means of an intact

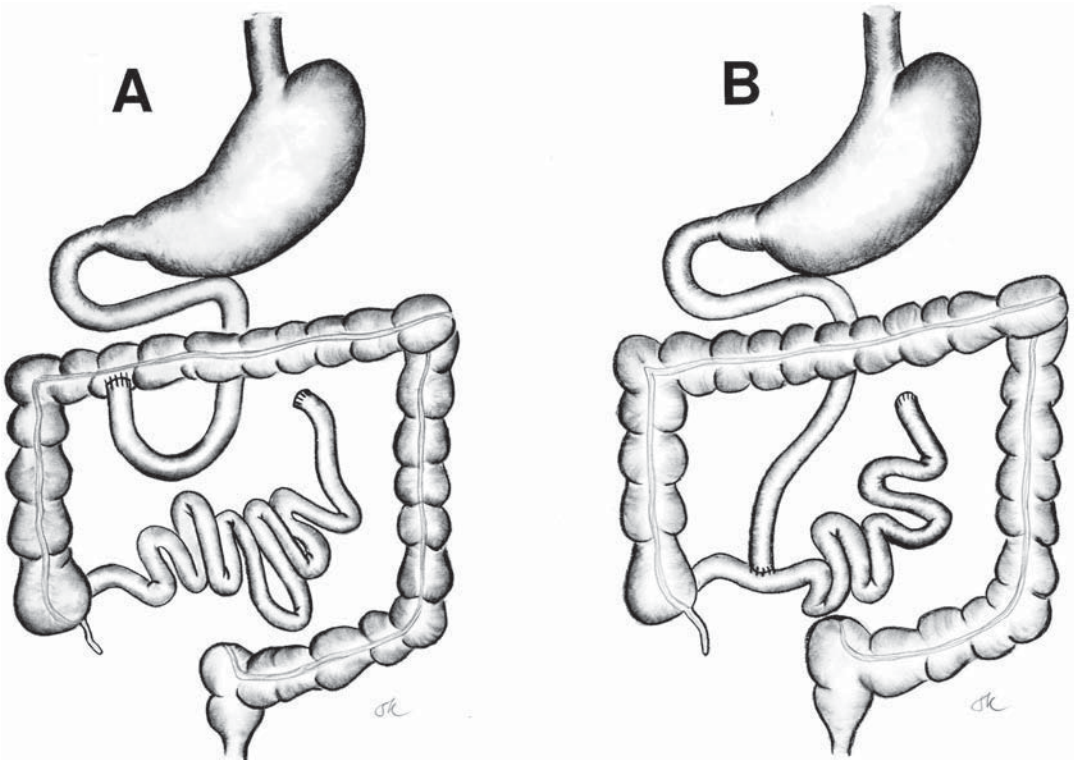

Fig. 1. Intestinal operations for weight control. (**A**) Jejunocolic shunt; **(B)** Jejunoileal bypass (JIB). Copyright Sofia Karlsson and Lars Sjöström.

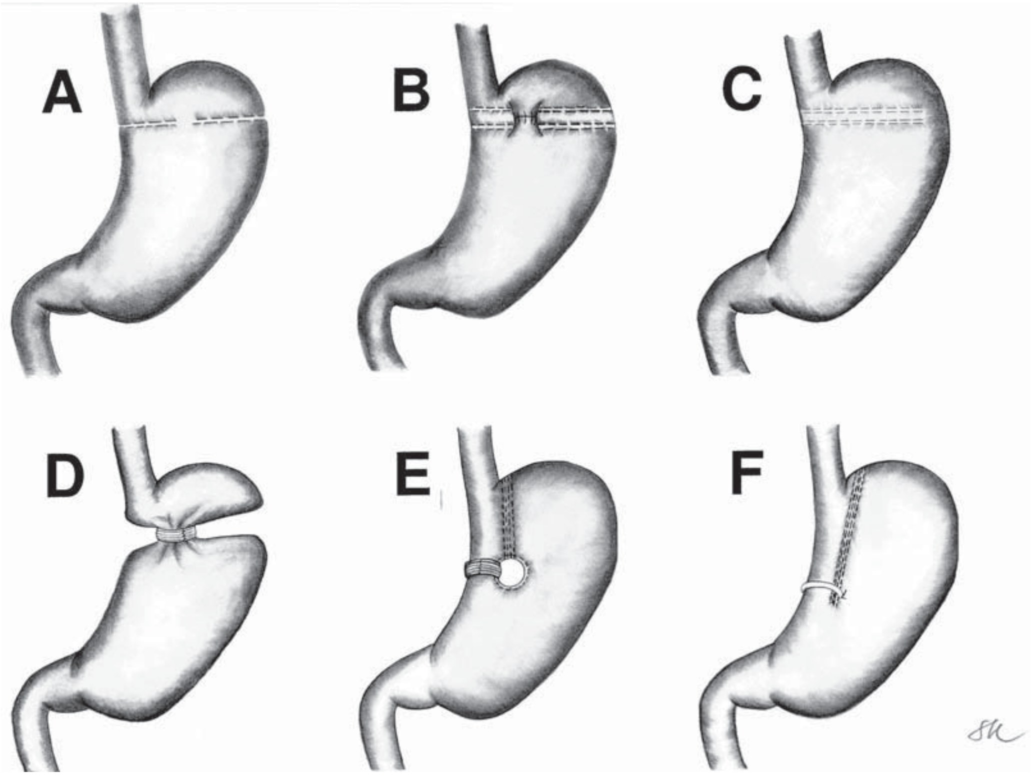

Fig. 2. Gastric operations for weight control. **(A)** Horizontal gastroplasty; **(B)** horizontal gastroplasty with gastro-gastro-stomy; **(C)** Gomez' horizontal gastroplasty; **(D)** gastric banding; **(E)** vertical banded gastroplasty (VBG); **(F)** silastic ring VBG. Copyright Sofia Karlsson and Lars Sjöström.

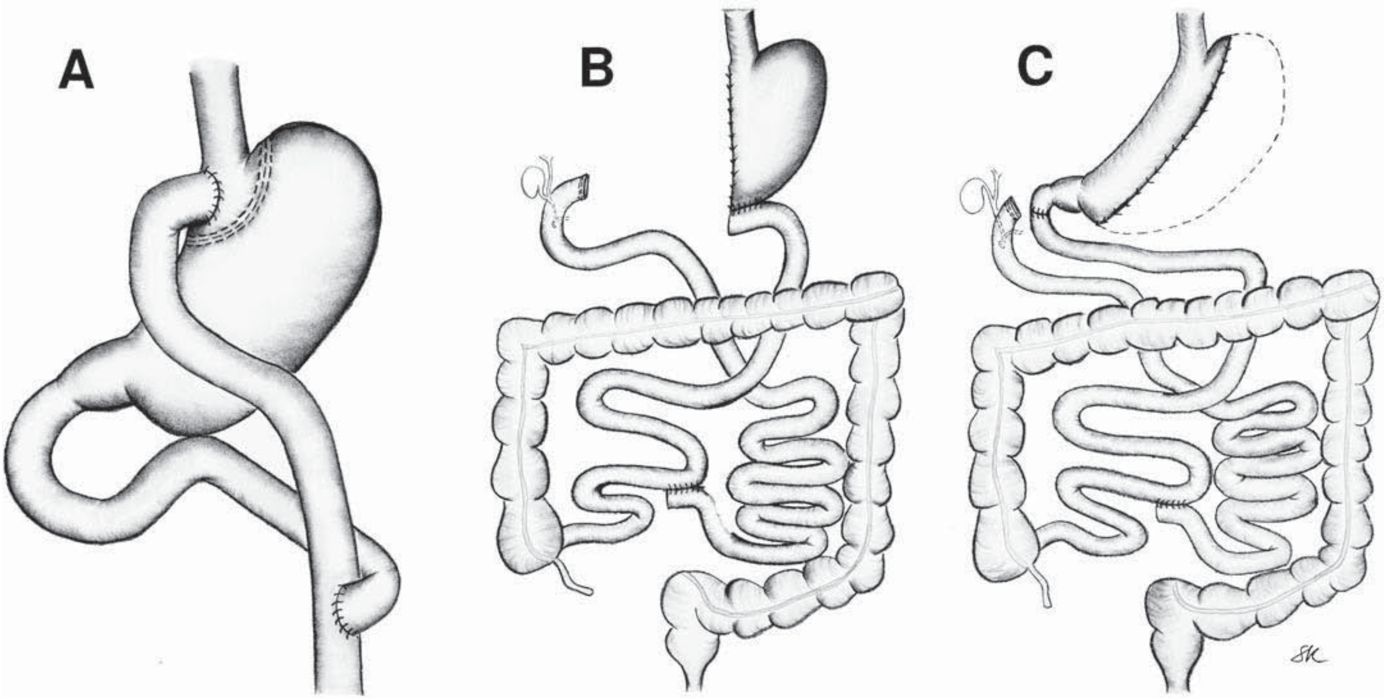

Fig. 3. Combined intestinal and gastric operations for weight control. (**A**) Roux-en-Y gastric bypass (GBP); (**B**) biliopancreatic diversion (BPD); (**C**) Biliopancreatic diversion with duodenal switch (BPD/DS). Copyright Sofia Karlsson and Lars Sjöström.

staple row plus a gastro-gastro-stomy *(13,14)* (Fig. 3B) or by placing a reinforced stoma at the major curvature (Gomez' horizontal gastroplasty) *(15)* (Fig. 3C).

A gastric banding operation was first undertaken by Wilkinson in 1976 *(16)*, but the technique was not published until 8 yr later *(17,18)*. A band (usually silicon) is strapped around the upper part of the stomach resulting in a small pouch (20–25 mL) (Fig. 2D). This was the original gastric banding.

A variable gastric banding is achieved by placing a balloon on the gastric side of the band. The balloon is connected with an sc reservoir or port supplied with a self-healing membrane *(19,20)*. By percutaneous puncture of the reservoir, fluid can be added or removed from the system, thereby changing the size of the stoma.

Variable banding with the band positioned at the gastroesophageal junction (cardia) has been reported *(21)*. Weight loss seems to be as good as after ordinary banding and the operation is simpler to perform. Gastric erosions have been observed in 1 to 2% of patients with banding at the cardia *(22,23)*. Randomized comparisons between ordinary banding and high banding have not been performed.

Vertical banded gastroplasty (VBG) was introduced by Mason *(24,25)* in 1980 and published two yr later. After pressing together the anterior and posterior walls of the stomach, a hole is punched through both walls by means of a so-called end-to-end anastomosis (EEA)-stapler while the walls are stapled together (Fig. 2E). Thus, a channel through the stomach, with no contact with its interior, is created. The front and the back walls are then stapled together with four rows of staples from the punched channel to the angle of His. Finally, a polypropylene strip (1.5 cm wide) is brought through the punched hole and around the lesser curvature and sutured to itself so that its circumference is 5.0 cm (Fig. 2E). A circumference of 4.5 cm creates more vomiting and an increased frequency of staple row insufficiency whereas 5.5 cm has a lower weight-reducing effect than 5.0 cm *(25)*.

A variant on Mason's VBG operation is the silastic ring VBG *(26,27)*. With this technique, no hole is punched but a thin silicon tubing is threaded onto a suture circumscribing the outlet of the vertical pouch. Only the suture, not the tubing, penetrates the ventricle between the staple rows (Fig. 2F).

Combined Gastric and Intestinal Operations

The gastric bypass (GBP) technique was developed by Mason in the 1960s *(28,29)* and has subsequently been refined in several steps *(30–35)* so that the GBP of today is usually characterized by a pouch along the lesser curvature and a so-called Roux-en-Y arrangement of the jejunum (Fig. 3A) *(34)*. Thus, the jejunum is divided 45 cm from the ligament of Trietz, and the distal segment is brought up retrocolically and antegastrically for the lesser curvature gastrojejunal anastomosis to the pouch. Finally, the proximal segment of the divided jejunum is used for an end-to-side jejuno-jejuno-stomy 35–60 cm from the pouch (Fig. 3A).

The biliopancreatic diversion (BPD) was developed by Scopinaro *(36,37)* to overcome the serious side effects of

JIB related to bacterial overgrowth in its blind loop. Seventy-five percent of the distal stomach is removed and the remaining proximal stomach as well as the duodenal stump is closed (Fig. 3B). The ileum is divided 250 cm from the ileocecal valve and the distal segment (alimentary limb) is anastomosed to the remaining stomach. The proximal segment of the divided ileum (the biliopancreatic limb) is anastomosed to the side of terminal ileum 50 cm from the ileocecal valve. Thus, digestion of food by means of juices from the upper intestinal tract can occur only in the most distal 50 cm of the ileum.

The distal gastric bypass Roux-en-Y (DGBP) is a mixture between GBP and BPD. It can be described as a GBP with a distal entero-entero anastomosis or as a BPD without gastrectomy.

GBP, BPD, as well as DGBP are associated with risk for marginal ulcerations in the gastroenteric anastomosis *(38)*. To avoid this problem and to preserve a normal pyloric function, the biliopancreatic diversion with duodenal switch (BPD/DS), also called distal gastric bypass with duodenal switch, was introduced by Hess *(39)* in 1988 *(40,41)* (Fig. 3C). The duodenum is first exposed and divided 4 cm distal to the pylorus. The distal segment of the duodenum (with papilla Vateri) is closed. Then a retrocolic EEA is performed between the proximal duodenum and the alimentary enteric limb obtained in the same way as in BPD operations. The stomach is sectioned vertically to yield a pouch (140 ± 40 cc) along the lesser curvature from the cardia to pylorus. Finally, the biliopancreatic limb is anastomosed to the ileum about 100 cm from the ileocecal valve.

Laparoscopic Procedures

Nonadjustable banding by means of laparoscopic technique was first undertaken in 1993 by Fried and Peskova *(42)*. Later, several reports on laparoscopic procedures for nonadjustable *(43)* and adjustable *(44–46)* banding appeared. Interestingly, the necessary abdominal insufflation during laparoscopy disturbs the hemodynamic *(47)* and respiratory *(48)* function less in obese than in lean individuals.

Hans Lönroth is the pioneer in the development of laparoscopic techniques for VBG (the first operation was done in 1993 *[49]*), and GBP *(50)*. In a nonrandomized comparison between traditional open VBG and laparoscopic VBG, it was demonstrated that laparoscopic patients had much less pain and a less disturbed lung function postoperatively *(49)*. A laparoscopic technique for distal gastric bypass has been developed in the pig *(51)*.

Comparisons of Bariatric Techniques with Respect to Weight Loss and Side Effects

Available comparisons of bariatric techniques are given in Table 1, which illustrates the development of surgery for weight control over the last 30 yr.

Jejunocolic Shunt vs Other Techniques

No comparisons between jejunocolic shunts and other techniques are available. Even in cases in which blood lipids improved markedly, other side effects of the jejunocolic shunt were so serious that the technique was abandoned after a few years *(7,52,53)*.

JIB vs GBP

One randomized *(31)* and two prospective non-randomized *(30,54)* comparisons were published between 1977 and 1981 (Table 1). In the Griffen et al. *(31)* study, 32 patients were randomized to GBP and 27 patients to JIB. On average, body weight was 152 kg and age was 33 yr. The 1-yr follow-up was 68%. Weight loss was similar in GBP (51 kg) and JIB (58 kg) patients (not significant). Although early side effects were more common in GBP-treated patients, late complications were much more common in JIB patients. At operation, all patients within both groups had some degree of liver steatosis. Some patients accepted a liver biopsy after 1 yr. Of 12 GBP patients, 2 were unchanged whereas 10 were improved with respect to steatosis. By contrast, 12 of 15 JIB patients had deteriorated in their steatosis whereas the remaining 3 were unchanged. One JIB patient died in liver coma, and in another the shunt had to be removed owing to threatening liver insufficiency.

Although difficult to evaluate for several reasons, the two nonrandomized studies *(30,54)* with a total of 506 starting patients followed for up to 3 yr are consistent with Griffin et al.'s *(31)* study: similar weight reductions with GBP and JIB but more complications with JIB. Both techniques result in reduced serum levels of triglycerides and cholesterol, the latter lipid being more reduced by JIB *(54)*.

JIB vs Gomez' Horizontal Gastroplasty

Only one nonrandomized comparison of JIB and Gomez' horizontal gastroplasty (GHGP) is available *(55)* (Table 1). JIB resulted in a larger weight loss than GHGP (33 vs 16% after 2 yr) but had more complications. However, this study adds a temporal aspect to Griffin et al.'s *(31)* data on liver steatosis. A nonspecified number of JIB patients demonstrated deterioration in liver steatosis after 9 mo, improvements after 18 mo, and normalization after 30 mo *(55)*. It is not clear to me to what extent the same patients were examined on the three occasions.

Prospective Noncomparative Studies on JIB

Some 40 noncomparative JIB studies have been published. At the National Institutes of Health (NIH) consensus conference on surgical treatment of obesity in 1991, O'Leary *(56)* summed up the JIB literature as follows:

1. Patients experience excellent weight loss.
2. Patients usually are satisfied and psychosocial adjustments are satisfactory.

Table 1
Evolution of Surgery for Weight Control as Reflected by Comparative Prospective Studies[f]

References	Random Yes/No Matched	Years of follow up	Conventional treatment	Intestinal operation[f]	Combined intestinal and gastric operations[f]			Gastric operations[f]			
				JIB	GBP	BPD	BPD/DS	HGP	VBG	Banding	Adjustable banding
1977, Alden *(30)*	No	1		O	O						
1977, Griffen *(31)*	Yes	1		O	O						
1979, Danish proj. *(96,97)*	Yes	3	X	O							
1981, Rucker *(54)*	No	1		O	O						
1981, Laws *(57)*	Yes	1			O			O			
1981, Lechner *(58)*	Yes	2			O			O			
1982, Deitel *(55)*	No	2.5		O				O			
1982, Pories *(13)*	Yes	1.5			O			O			
1982, Linner *(64)*	No	2			O			O			
1983, Lechner *(59)*	Yes	3			O			O			
1984, Backman *(63)*	No	1			O			O		O	
1984, Sugerman *(65)*	No	1			O			O – O[a]			
1984, Anderson *(98)*	Yes	2	X					O			
1986, Fobi *(35)*	No	2			O				O		
1986, Näslund *(14)*	Yes	2			O			O			
1986, Näslund *(60)*	Yes	2			O			O			
1987, Näslund *(61)*	Yes	3			O			O			
1987, Sugerman *(71)*	Yes	3			O				O		
1987, Gleysteen *(66)*	Yes	4			O – O[b]						
1987, Mason *(73)*	No	5			O				O		
1988, Anderson *(99)*	Yes	5	X					O			
1989, Sugerman *(71,75)*	No	2–4			O – O[c]				O – O[c]		
1990, Hall *(62)*	Yes	3			O			O	O		
1993, McLean *(72)*	Yes	3			O				O		
1995, Martin *(100)*	No	2–6	X		O						
1996, SOS *(67)*	No	2			O				O	O[d]	
1996, Chapin *(90)*	No	3–6				O			O		
1996, Lönroth *(49)*	No	Postop.							L – O		
1997, SOS *(116)*	Matched	1	X		O				O	O	
1998, SOS *(117,130)*	Matched	1–2	X		O				O	O	
1998, Lönroth *(74)*	No	0.5			L				L		
1998, Belachew *(81)*	No	3							O		L – O
1998, Fried *(79)*	No	3								L	L
1998, Marceau *(92)*	No	4–8				O	O				
1998, Rabkin *(93)*	No	4			O	O	O				
1999, Miller *(77)*	No	3									L – L[e]
1999, SOS *(3,118,119,126)*	Matched	2–5	X		O				O	O	
1999, Juvin *(78)*	No	Postop.									L – O
1999, Suter *(80)*	No	2							O		L
1999, Näslund *(84)*	No	3							L – O		
2000, SOS *(4,102,109,110,114,127,131)*	Matched	2–10	X		O				O	O	

[a]1984, Sugerman *(65)*, three different horizontal gastroplasties.
[b]1987, Gleysteen *(66)*, reinforced vs. non-reinforced stoma.
[c]1989, Sugerman *(71,75)*, “sugar-eaters” vs. “non-sugar-eaters.”
[d]1996, Lindroos *(67)*, VBG and banding groups are pooled.
[e]1999, Miller *(77)*, American *(19)* vs. Swedish *(20)* adjustable band.
[f]JIB, jejuno-ileal bypass. GBP, gastric bypass. BPD, biliopancreatic diversion. BPD/DS, biliopancreatic diversion with duodenal switch. HGP, horizontal gastroplasties, VBG, vertical banded gastroplasty. O = open surgery. L = laparoscopic surgery. X = non-surgical treatment.

3. Perioperative mortality can be limited to 0.5% and wound infections to 3%.
4. All patients develop diarrhea.
5. Electrolyte disturbances can be controlled.
6. Fifty percent of patients develop some kind of late metabolic complications.
7. Liver insufficiency, kidney stones, autoimmune arthritis, or skin diseases are seen among 20% of JIB-operated individuals, and these complications can appear late, often more than 10 yr after the operation.

GBP vs Horizontal Gastroplasty

GBP has been compared with horizontal gastroplasty (HGP) in randomized studies with follow-up periods ranging from 1 to 3 yr *(13,14,57–62)* and in nonrandomized studies with 1 to 2 yr of follow-up *(63,64)*. These studies were published between 1981 and 1990 (Table 1). Hall et al.'s *(62)* study is the largest (*n* = 204) and longest (3 yr). The median baseline weight was 112 kg, and after 3 yr the weight loss was 39 kg in the GPB group and 17 kg in the HGP group. Similar results have been observed in two other 3-yr studies: 38.4 vs 24.7 kg *(60,61)* and 44.2 vs 32.3 kg *(59)*. Results from the shorter and nonrandomized studies are in line with the 3-yr studies.

In most studies HGP has required a higher frequency of reoperations than GBP. Sugerman and Wolper *(65)* reported that 39 of 122 HGP patients required 43 revisions. On 10 occasions the HGP was converted into a GBP. The repaired HGBs resulted in many complications but not in improved weight loss. As compared to primary GBP operations, the conversions from HGP to GBP resulted in more complications but similar weight loss.

In a detailed report, Näslund *(14)* showed that dilatation of the stoma as well as the pouch was associated with a reduction in weight loss in HGP but not in GBP. Similarly, Gleysteen *(66)* followed randomized GBP patients over 4 yr without finding a difference in weight loss between patients with and without a reinforced gastrojejunostomy. Other mechanisms than pouch size and stomal diameter may thus be of importance for weight loss after GBP.

Lindroos et al. *(67)* reported similar energy intake at 6, 12, and 24 mo after GBP and gastroplasty operations but larger weight loss in GBP patients. Flancbaum et al. *(68)* found an energy expenditure higher than predicted in GBP individuals. It has been suggested that glucagon-like peptide-1 (GLP-1) release from terminal ileum is increased after operations, due to a faster food passage through the intestines *(69)*. GLP-1 may have multiple peripheral and central effects on energy balance *(69,70)*, and therefore an increased release may at least partly explain the larger weight loss after GBP.

GBP vs VBG

Three randomized 3-yr studies *(62,71,72)* as well as nonrandomized 8-yr *(4)*, 5-yr *(73)*, and 2-yr *(3,35)* studies have been published between 1986 and 2000 (Table 1). In none of the studies was VBG superior or equal to GBP as far as weight loss is considered. The percentage of weight losses (as roughly calculated on means) in GBP and VBG groups were 24 vs 16% *(4)* (8 yr), 34 vs 28% *(62)* (3 yr, silastic ring VGB), 32 vs 20% *(71)* (3 yr), 35 vs 30% *(35)* (2.5 yr), and 32 vs 22% *(3)* (2 yr). MacLean et al. *(72)* (3 yr) did not report weight losses but defined a satisfactory result as body mass index (BMI) <35. This was achieved among 83% of GBP patients with isolated pouch, in 58% of patients with ordinary GBP, and in 43% of those with VBG. In earlier studies, complications seem to have been more common in the GBP groups.

Laparoscopically performed VBG (*n* = 105) and GBP (*n* = 26) have been compared *(74)*. The weight losses were similar to those expected from open surgery with the two methods, and early complications were less common with the laparoscopic technique.

In the aforementioned randomized 3-yr report from 1987, Sugerman et al. *(71)* also reported that VBG resulted in larger weight losses among "nonsweet eaters" than among "sweet eaters." In a nonrandomized follow-up from 1989, nonsweet eaters selectively underwent VBG whereas sweet eaters were subjected to GBP *(75)*. As compared to randomized VBGs from 1987, the nonsweet eaters with VBG (1989) achieved a larger weight reduction whereas there was no difference in weight loss between GBP patients from 1987 and 1989. From these results, Sugerman et al. *(71)* have concluded that sweet eaters should undergo GBP rather than VBG. In the SOS study, a careful mapping of food intake before and after gastroplasty (VBG and banding) was not able to verify a relationship between sugar intake and weight loss *(67)*. More studies are needed to elucidate this question.

GBP vs Banding

No randomized studies are available comparing GBP to banding. In the SOS study, GBP was clearly superior to banding both at 2 *(3)* and 8 yr of follow-up *(4)*. One single nonrandomized small study found a larger 1-yr weight loss after banding (50 kg) than GBP (34 kg) *(63)*.

VBG vs Banding

No randomized studies are available comparing VBG to banding. From the SOS study, 2- *(3)* and 8-yr *(4)* data have been reported. In the 2-yr report, results from 191 banding patients were compared with results from 534 VBG patients. At 8 yr the corresponding numbers of patients were 86 and 227. Body weights of banding and VBG patients were 120.2 and 120.6, respectively, at baseline, 94.6 and 93.0 at 2-yr, and 101.6 and 101.5 kg at 8 yr. Thus, the initial weight loss as well as the subsequent modest relapse were quite similar with the two techniques, but banding was associated with a higher frequency of reoperations *(76)*.

Banding with Variable Bands

As described in Methods, one American *(19)* and one Swedish (*20)* band are in use. The two devices seem to result in similar weight losses *(77)*. Laparoscopic compared to open adjustable gastric banding is associated with a three times shorter hospital stay *(78)*. Compared to laparoscopic nonadjustable banding, laparoscopic adjustable banding results in similar postoperative morbidity and weight loss but less vomiting and food intolerance *(79)*. Compared to open VBG, laparoscopic banding is associated with less postoperative morbidity and shorter hospital stay and with similar weight loss after 18 mo *(80)*. In one large nonrandomized study, results from 350 laparoscopic adjustable bandings undertaken from 1993 to 1997 were compared with the outcome of 200 open adjustable bandings and 210 open VBGs undertaken from 1991 to 1993 *(81)*. The weight loss was similar in all three groups. Although most reports on laparoscopic variable banding are positive, some investigators are critical *(82)* and report a high frequency of anatomical and functional complications *(83)*.

Open vs Laparoscopic VBG

Open and laparoscopic VBG have been compared in two studies*(49,84)*, and in both studies, weight loss was similar with the two techniques. Laparoscopically operated patients had less postoperative pain, a faster mobilization, an improved respiratory status, and a shorter hospital stay.

Biliopancreatic Diversion

Scopinaro et al. *(85,86)* reported on 1968 BPD cases in 1996 and on 2241 BPD in 1998. In the latter report, operative mortality was low (0.5%) and excess body weight loss was 75%. The follow-up ranged from 1 to 21 yr. The occurrence of anemia during iron and folate therapy was <5%, stomal ulcers during H2-blocker therapy was 3.2%, and protein malnutrition was 3%. Although protein malabsorption figures are similar in smaller study groups, higher frequencies of stomal ulcers (10%) have been reported *(87–89)*. In these reports, weight loss was excellent: BMI was decreased from 48 to 33 *(87)*, 51 to 29 *(88)*, and 49 to 29 *(89)*, after 2 to 3 yr.

In a nonrandomized study, Chapin et al. *(90)* described results from 12 BPDs and 10 VBGs. The weight losses were 75 and 55 kg, respectively. Urinary calcium excretion and serum concentrations of calcium and vitamin D were lower in the BPD patients whereas serum parathyroid hormone, serum alkaline phosphatase, and urinary hydroxyproline:creatine ratio was higher in BPD. The data indicated that following BPD, secondary hyperparathyroidism attributed to hypocalcemia results from malabsorption of vitamin D although concurrent calcium malabsorption was not excluded.

Chapin et al.'s *(90)* study illustrates the importance of supplementation with fat-soluble vitamins, B_{12}, folate, and calcium, a fact that has always been stressed by Scopinaro *(86)*. Brolin and Leung *(91)* examined supplementation habits among 109 surgeons performing BPDs and GBPs. They found that most surgeons give multivitamin, iron, and B_{12} supplementation after both types of operations. BPD patients also obtain calcium and fat-soluble vitamins to a great extent (63–97% of patients) and 21% obtain protein supplementation. Brolin and Leung *(91)* concluded that most surgeons protect patients from developing severe metabolic deficiencies after BPD and GBP.

Marceau et al. *(92)* reported on a nonrandomized 4- to 8-yr comparison between 252 patients undergoing BPDs and 465 treated with BPD/DS. BPD/DS was associated with greater weight loss (46 vs 36 kg), fewer side effects (diarrhea, vomiting, bone pain), fewer abnormal laboratory values (serum calcium, parathyroid hormone, ferritin, and vitamin A), and a much lower annual revision rate owing to severe malabsorption (0.1 vs 1.7%). Rabkin *(93)* reported 4-yr BMI reductions that were similar after GBP (from 49 to 30; $n = 138$), BPD (from 45 to 29; $n = 32$), and BPD/DS (from 49 to 31; $n = 105$) *(93)*. Unfortunately, the side effects of all three operations were not compared in Rabkin's *(93)* study.

Hess and Hess *(94)*, who introduced BPD/DS, have published a noncomparative study on BPD/DS operations in 440 subjects with an average body weight of 183 kg (41% with BMI >50). The patients had lost 80% of the initial excess weight after 2 yr and 70% after 8 yr. Complications were seen in 9% of the patients including two patients dying postoperatively. No marginal ulcers and no cases of dumping syndrome were observed. Seventeen revisions were performed to correct excessive weight loss and low protein levels.

BMI Cutoffs

At the 1991 consensus conference, NIH recommended that obesity surgery be restricted to individuals with a BMI of ≥40 kg/m^2 but that a somewhat lower cutoff could be accepted in subjects with pronounced metabolic complications *(95)*. At that time the SOS project had already used the BMI cutoff of 38 kg/m^2 for women and 34 kg/m^2 for men for 4 yr. Our preliminary impression from SOS in the early 1990s did not make us change our cutoff, and today it is obvious that a cutoff of 40 kg/m^2 leaves a larger fraction of the obese population virtually without efficient treatment and often in bad shape even though new antiobesity drugs have been added to the therapeutic arsenal.

In a preliminary report, Näslund *(76)* analyzed the effects and complications in surgically treated SOS patients with BMI <40 and BMI of ≥40 kg/m^2. In absolute terms, weight loss was larger in the heavier patients, but this was not the case in relative terms. The frequency of complications was similar in both groups, and from a risk factor point of view both groups benefited similarly from surgical treatment.

Surgical Methods of Choice

The results I have discussed have shown that GBP and JIB result in similar weight loss. However, late side effects are more common and much more serious after JIB operations *(56)*. Most experts as well as NIH *(95)* are therefore discouraging the use of JIB.

GBP results in greater weight loss than VBG and gastric banding. The two latter techniques give similar weight reductions. Banding is associated with more reoperations than GBP and VBG. GBP is technically more demanding than VBG and banding, and it results in iron and B_{12} insufficiency, which must be treated. It is not known whether GBP will cause negative calcium balance or other malabsorptive problems in a 10- to 30-yr perspective. Such hypothetical problems are less likely with VBG and banding because these methods do not change the normal passage of food through the gastrointestinal tract. Finally, patients subjected to GBP cannot easily have their stomach examined endoscopically, which makes examinations of malignancy more complicated.

Taken together, these circumstances suggest that GBP should be reserved for individuals with a considerable degree of obesity (BMI of ≥40 kg/m^2) whereas VBG according to SOS experience can be used in the BMI interval of 34–45 kg/m^2. Banding in its original form as well as all forms of HGPs should not be used because of the increased need for revisions. Variable banding has not been evaluated in randomized studies but seems to have a place in the obesity therapy, particularly when used with laparoscopic techniques.

BPD is outstanding in achieving weight reduction, but it is also associated with malabsorption of protein, fat-soluble vitamins, and calcium. Treatment with this technique should be reserved for the heaviest (BMI >45 ?) and should only be undertaken by surgical departments (rather than individual surgeons) being prepared to take a lifelong responsibility for the patients. Experience with BPD/DS is still limited. This technique seems to be at least as efficient as the original BPD and is associated with less frequent and milder side effects.

Randomized studies comparing GBP, BPD, and BPD/DS are urgently needed. Whereas randomized studies were fairly common in the early days of bariatric surgery, no such studies have been published since 1993 (Table 1).

Surgically vs Conventionally Achieved Weight Loss

Three studies have compared surgical treatment with dietary treatment undertaken by more or less specialized obesity clinics *(96–100)* and one study has compared surgical treatment with treatment delivered by general practitioners at 480 primary heath care centers in Sweden *(101)*.

JIB vs Diet

In The Danish Obesity Project *(96,97)*, 202 patients were randomized at a ratio of 2:1 to JIB or diet treatment. Six patients never came to treatment. The remaining 130 surgically treated and 66 diet-treated patients were followed for 2 to 3 yr. After 2 yr, the weight loss was 42.9 kg in the surgically treated group and 5.9 kg in the diet group. Quality of life as well as blood pressure (BP) was markedly improved in the surgical group. However, the surgical group had many complications, some of which were serious.

HGP vs Very Low-Calorie Diet Followed by Diet

In another early Danish study, 60 patients were randomized to HGP or a very low-calorie diet (VLCD) followed by traditional dieting. A 2-yr *(98)* and a 5-yr *(99)* report have been published. Unfortunately, less than 50% of the patients had in fact been followed for 2 and 5 yr, respectively, when the reports were written. At 2 yr the weight loss was 30.6 kg in the gastroplasty group and 8.2 kg in the VLCD/diet group. Weight losses are not reported at 5 yr. Instead, a "cumulated success rate," defined as more than 10 kg of maintained weight loss, was given. This success rate was 16% in the patients undergoing HGP and 3% in the VLCD/diet group. As already discussed, HGPs are no longer used because of poor long-term results.

GBP vs VLCD and Diet

In a prospective, nonrandomized, nonmatched study, Martin et al. *(100)* compared GBP (n = 201) to VLCD followed by diet (n = 161). After VLCD, the diet group was offered one counseling session per week for 18 mo and then annual follow-ups. The follow-ups ranged from 2 to 6 yr. At 6 yr the follow-up rate was 34.5% in the GBP group and 19.7% in the VLCD/diet group. In the GBP group, BMI dropped from 49.3 to a minimum of 31.8 after 2 yr. At 6 yr BMI was 33.7 kg/m^2. In the VLCD/diet group the corresponding Fig.ures were 41.2, 32.1, and 38.5 kg/m^2. Compared to VLCD/diet treatment, GBP thus resulted in twice as large a decrease in BMI and a much smaller rate of relapse.

Swedish Obese Subjects

Aims of SOS

The main goal of SOS is to examine whether large and long-term intentional weight loss will reduce the elevated morbidity and mortality of obese subjects. Several secondary aims, related to the genetics of obesity, quality of life, and health economics, have also been defined *(101)*.

Study Design

SOS originally consisted of one registry study and one intervention study *(101)*. Later, one randomized reference study and one genetic sib-pair study were added. In the registry study, 6000–7000 obese men (BMI = 34) and women (BMI = 38) in the age interval of 37–60 yr will be examined (Feb. 2000, n = 6042) by GPs at 480 of the 700 existing primary health care centers in Sweden. From the registry, patients are recruited into the intervention study, consisting of one surgically treated group (goal $n = 2000$; Feb. 2000, $n = 1870$) and one matched control group (same numbers) treated conventionally at the 480 primary health care centers. The surgically treated patients underwent (variable) banding, VBG, or GBP.

SOS is a matched, not randomized, study because, in 1987, ethical approval for randomization was not obtained owing to the high operative mortality (1–5%) observed in most surgical study groups from the 1970s and 1980s. Thus, patients decide for themselves whether they want surgical or conventional treatment. When a surgical patient has been accepted according to a number of inclusion and exclusion criteria, a matching program taking 18 different matching variables into account selects the optimal control among eligible individuals in the registry study *(101)*. The selection is based on an algorithm moving the mean values of the matching variables of the control group toward the current mean values of the surgically treated patients. Thus, a group match rather than an individual match is undertaken. The participating centers cannot influence the matching program.

The surgically treated patient and the control subject start the intervention on the operation day of the former individual. Both patients are examined just before inclusion and then after 0.5, 1, 2, 3, 4, 6, 8, and 10 yr. According to the original protocol, the follow-up was planned to be 10 yr for both groups, but recently it was decided to add one 15- and one 20-yr examination. Centralized biochemistry is obtained at 0, 2, 10, 15, and 20 yr. All visits are automatically booked by a computer at the SOS secretariat, and all centers obtain the necessary forms, test tubes, and so on for a given visit some weeks before the booked appointment. If information is not coming back as expected from patients or centers, the program automatically sends out reminders or asks the staff of the secretariat to solve the problem by phone.

Over the years, several interim reports with different numbers of patients have been published from the ongoing SOS study. Herein, reference is given to published reports rather than to currently (February 2000) available patients, unless stated otherwise.

Weight Loss in SOS

In one 2-yr report on 767 surgically treated patients and 712 obese control subjects, weight loss was 28 ± 15 kg (mean ± SD) and 0.5 ± 8.9 kg, respectively *(3)*. The percentage of reductions after GBP, VBG, and banding were 33 ± 10, 23 ± 10, and 21 ± 12%, respectively. Similar 2-yr changes in body weight were recently reported for 1210 surgically treated and 1099 control subjects in SOS *(102)*.

The energy intake before and during weight loss was studied by means of a validated dietary questionnaire *(103,104)* in 365 patient undergoing VBG or banding and in 34 patients undergoing GBP *(67)*. Although the weight loss was 38.6 kg in the GBP group but only 26.7 kg in the combined VBG and banding group, the energy intake before and after surgery did not differ between the groups (Fig. 4). As already discussed, this finding indicates that GBP is associated with increased energy expenditure, perhaps owing to an increased secretion of GLP-1.

In another report, 346 surgically treated patients and 346 control subjects were followed for 8 yr *(4)*. At 8 yr, 251 surgically treated patients (73%) and 232 control subjects (67%) had completed the study. All dead individuals are included among noncompleters because mortality figures are not yet released from the safety monitoring committee of SOS. Weight changes of completers in the four groups are shown in Fig. 5. As in the 2-yr report, there was no significant weight change in the control group whereas the surgically treated groups reached minimum weights after 1 yr. As expected, GBP was more efficient than VBG and banding. Between the end of yr 1 and the end of yr 8, a slow relapse was seen in all the surgically treated groups. However, compared to the inclusion weight, the surgically induced weight loss was still 20.1 ± 15.7 kg (16.5%) after 8 yr, whereas the control subjects had increased their body weight 0.7 ± 12.0 kg. The difference in the 8-yr body weight change between the two groups was highly significant ($p < 0.001$).

Figure 5 illustrates also that conventional, nonpharmacologic treatment of the severely obese is, on average, almost meaningless when undertaken by nonspecialized treatment units. This implies personal tragedies for millions of obese persons not having access to specialized treatment and immense consequences from a public health point of view.

Surgical Complications in SOS

Four postoperative deaths in 1870 operated patients have occurred in the SOS study (0.21%, February 2000). Three of these fatal cases were owing to leakage that was detected too late. One death was caused by a technical mistake during the laparoscopic operation.

Peri- and postoperative complications have been calculated for 1164 patients followed for 4 yr (*[76]*; unpublished observations). During the primary hospital stay, the following complications occurred: bleeding (0.5%), embolus and/or thrombosis (0.8%), wound complications (1.8%), deep infections (leakage, abscess) (2.1%), pulmonary (6.1%), other complications (4.8%). There were 193 complications and 151 patients (13%) had complications. In 26 patients (2.2%), the postoperative complications were serious enough to require reoperation.

Over 4 yr 12% of the 1164 patients underwent an additional operation, usually owing to poor weight loss but in some cases owing to vomiting or other side effects. Usually

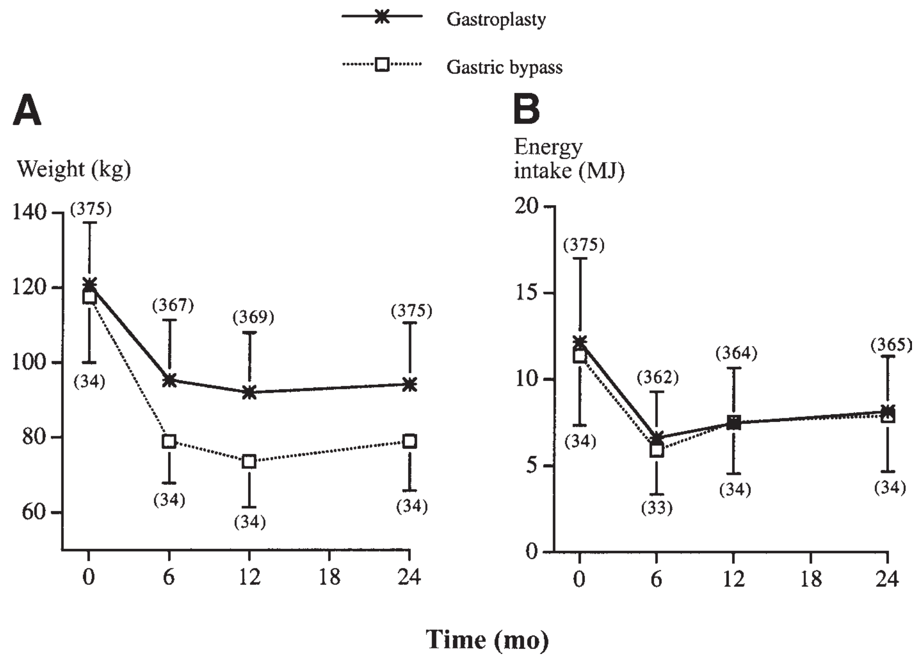

Fig. 4. Weight loss **(A)** and energy intake **(B)** over 2 yr in SOS patients operated by means of gastroplasty and gastric bypass. The gastroplasty operations were banding and VBG was pooled. Datsa are the mean ± SD. Values in parentheses indicate the number of patients at each examination. Energy intake, estimated with validated technique *(102,103)*, did not differ between groups at any time point. Body weights were significantly lower in gastric bypass patients at all time points after surgery (p <0.0001), whereas body weight before surgery did not differ significantly between groups. (Reproduced from ref. *67* with permission.)

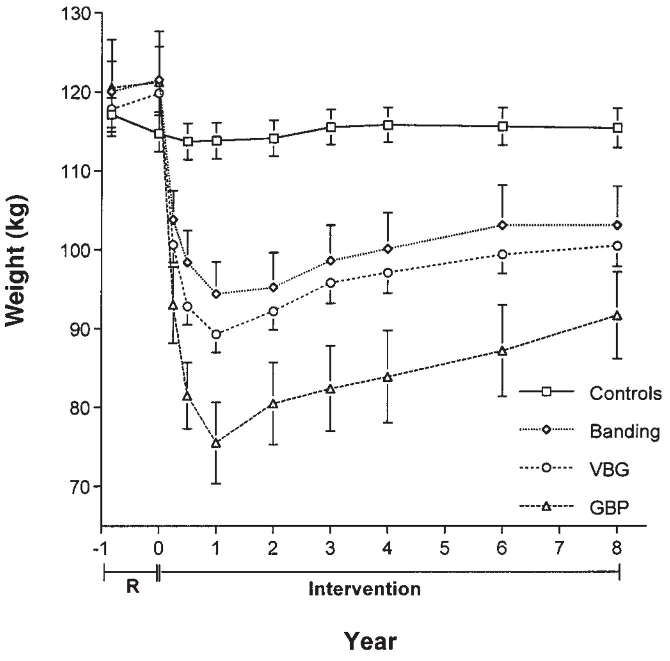

Fig. 5. Weight change (95% confidence interval [CI]) in 232 obese control subjects and 251 surgically treated patients from matching until end of yr 8 in the SOS intervention study. Analysis was based on completer population. R, Registry study with collection of matching variables; banding, n = 63; VBG, n = 164; GBP, n = 24. Each of the surgical groups had a significantly (p < 0.01) larger weight reduction than the control subjects. (Reproduced from ref. *4* with permission.

banding and VBG were converted to GBP, but in some cases the original operation was repaired.

Over the 4 yr several other operations were done in both groups. In the control group, 10.1 operations per 100 person-years were done whereas the corresponding figure in the surgical groups was 15.2. Operations owing to ventral hernia, gallbladder disease, intestinal obstruction, and surplus of skin were more common in the surgical group, and, on average, operations owing to malignancy, gynecologic disorders, and all other reasons taken together were more common in the control group.

Risk Factors at Baseline in SOS

In an early cross-sectional analysis of 450 men and 556 women from the registry study of SOS, it was shown that compared to randomly selected control subjects, most cardiovascular risk factors were elevated in the obese (Table 2) *(101)*. The exception was total cholesterol, which was similar in obese and nonobese males and lower in obese women compared with reference women.

Later, risk factors were analyzed in relation to body composition in 1083 men and 1367 women from the SOS registry study *(105)*. This analysis revealed one body compartment risk factor pattern and one sc adipose tissue distribution risk factor pattern. Within the first pattern, risk factors were positively and strongly related to the visceral adipose tissue mass and, somewhat weaker, also to the sc adipose tissue mass. Some risk factors, such as glucose and triglycerides in men and insulin in women, were negatively

Table 2
BMI and Risk Factors in 50-Yr-Old Men and Women from SOS and in 50-Yr-Old Randomly Selected Reference Subjects[a]

	SOS males	Ref. males	p<	SOS females	Ref. females	p<
n	102	220		121	398	
Age, yr	48–52	50		48–52	50	
BMI	37.3 ± 3.9	24.0		41.4 ± 4.4	24.8	
Ssytolic, mmHg	146 ± 16	137 ± 22	0.001	147 ± 18	140 ± 22	0.01
Diastolic, mm Hg	94 ± 9	90 ± 14	0.01	89 ± 9	85 ± 11	0.001
Blood glucose mmol/L	5.9 ± 2.0	4.7 ± 1.3	0.001	5.5 ± 1.6	4.2 ± 0.9	0.001
Insulin, mU/L	31 ± 25	9.6 ± 8.0	0.001	22 ± 12	14 ± 5	0.001
Triglycerides, mmol/L	2.7 ± 2.0	1.3 ± 0.8	0.001	2.0 ± 1.0	1.3 ± 0.6	0.001
HDL chol, mmol/L	1.2 ± 0.4	1.6 ± 0.4	0.001	1.4 ± 0.4	—	
Total chol, mmol/L	6.2 ± 1.2	6.4 ± 1.3	n.s.	6.1 ± 1.1	7.2 ± 1.1	0.001

[a]Risk factor levels for other age groups, *see* ref. *100*. From Sjöström, L. et. al. *(100)*, with permission.

related to lean body mass. In addition, the sc adipose tissue distribution was related to risk factors both with and without taking the body compartments into account statistically. A preponderance of sc adipose tissue in the upper part of the trunk, as indicated by the neck circumference, was positively related to risk factors, whereas the thigh circumference was negatively related to risk factors. These two risk factor patterns have also been observed longitudinally; that is, changes in risk factors and changes in body composition and adipose tissue distribution are related *(106)* in the same way as in the cross-sectional observations *(105)*.

Risk Factor Changes in SOS

In a 2-yr report of 282 men and 560 women pooled from the surgically treated group and the control group, risk factor changes were examined as a function of weight change *(106)*. A 10-kg weight loss was enough to introduce clinically significant reductions in all traditional risk factors except total cholesterol (Fig. 6). Although it is known that total cholesterol is reduced short-term (1–6 mo) by moderate weight losses *(107,108)*, Fig. 6 illustrates that 30–40 kg of maintained weight loss is required to achieve a preserved reduction in total serum cholesterol after 2 yr.

In another 2-yr report on 767 surgically treated patients and 712 control subjects, the weight loss of the surgical group resulted in dramatic reductions in the incidence of hypertension, diabetes, hyperinsulinemia, hypertriglyceridemia, and low high-density lipoprotein (HDL)-cholesterol *(3)* (Fig. 7). In the case of diabetes, a 32-fold risk reduction was observed whereas the incidence of other risk conditions was reduced 2.6- to 10-fold. In analogy with Fig. 6, weight loss had no effect on the incidence of hypercholesterolemia (Fig. 7). To give a visual impression of the weight loss necessary to prevent the development of diabetes, the surgically treated group and the control group were pooled and the incidence of diabetes was plotted by decentiles of weight change *(109)*. As can be seen in Fig. 8, weight changes close to zero were associated with a 2-yr incidence of diabetes of 7–9%. A mean weight loss of 7% was still associated with a 2-yr incidence of diabetes of 3%, while no new cases of diabetes were seen for mean weight losses of 12% or greater.

In the 8-yr follow up *(4)*, the incidence of diabetes was still five times lower in the surgical group than in the control group (Fig. 9). However, there was no difference between the two groups with respect to the 8-yr incidence of hypertension (Fig. 9). This was the case with or without multiple adjustments in the completer population as well as in the intent-to-treat population *(4)*. In a follow-up study, the final BP was shown to be closely related to recent weight changes and the length of the follow-up but was more weakly associated with initial weight and initial weight loss (unpublished data).

Unpublished 10-yr data from SOS show that insulin, glucose, triglycerides, and HDL-cholesterol are improved by surgical treatment whereas BP and total cholesterol are not.

Although short-term weight losses improve all cardiovascular risk factors (cf. Fig. 6 and refs. *107* and *108*), several observational epidemiologic studies have shown an association between weight loss and increased total as well as cardiovascular mortality, even in those who are obese at baseline *(110)*. This discrepancy has usually been explained by the inability of observational studies to separate intentional from unintentional weight loss. Williamson et al. *(111,112)* has provided some evidence for this in women but not in men. The aforementioned 8-yr study *(4)* suggests another possibility: long term, some risk factors, such as BP, may relapse in spite of maintained weight loss.

A third explanation may be that nontraditional risk factors deteriorate during weight loss. Recently, 10-yr data from SOS have demonstrated that homocysteine increases with increasing weight loss, independent of method for

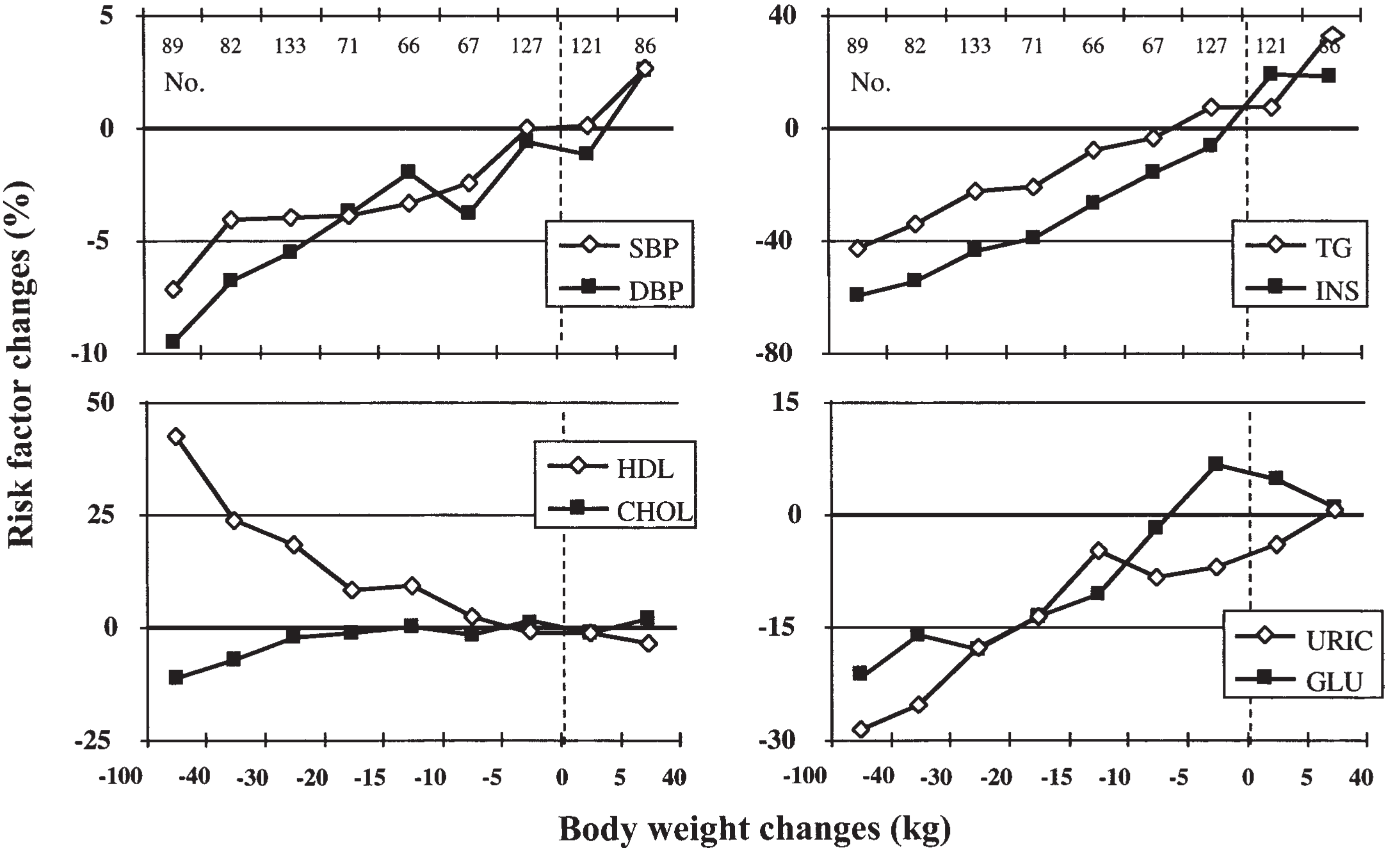

Fig. 6. Adjusted risk factor changes (percentage) in relation to body weight changes (kilograms) over 2 yr in 842 obese men and women pooled from the surgically treated group and the obese control group of the SOS intervention study. The percentage change of each risk factor was adjusted for the basal value of that risk factor, initial body weight, sex, age, and height. The number of subjects in each weight-changing class is shown at the top. SBP and DBP, systolic and diastolic blood pressure, respectively; HDL, serum HDL-cholesterol; CHOL, serum total cholesterol; TG, serum triglycerides; INS, serum insulin; URIC, serum uric acid; GLU, blood glucose. All serum samples were collected after overnight fast. (Reproduced from ref. *105* with permission.

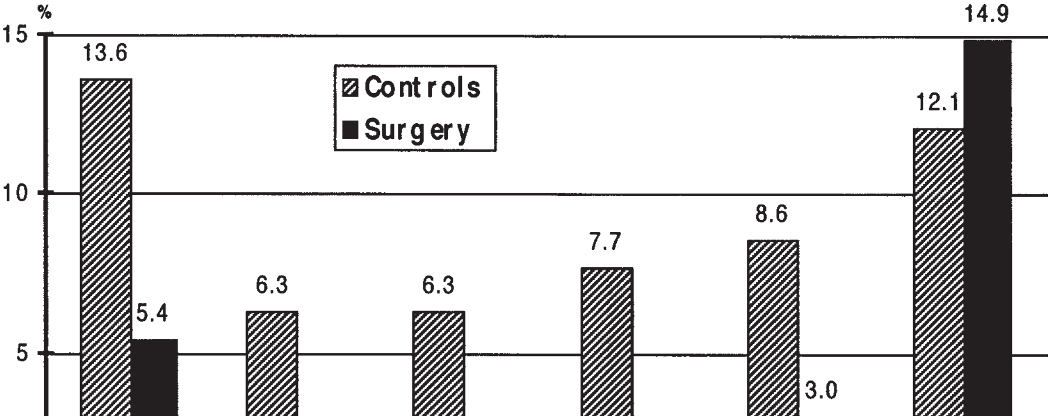

Fig. 7. Two-year unadjusted incidence of indicated conditions in 712 obese control subjects (▨) and in 767 surgically treated completers (j) from the SOS intervention study. Below bars, odds ratios (ORs) (95% CI) are adjusted for baseline values of age, sex, weight, smoking, and matching value of perceived health. p <0.001 for all differences between groups except hypercholesterolemia. Abbreviations are as given in Fig. 6. (Reproduced from ref. *3* with permission

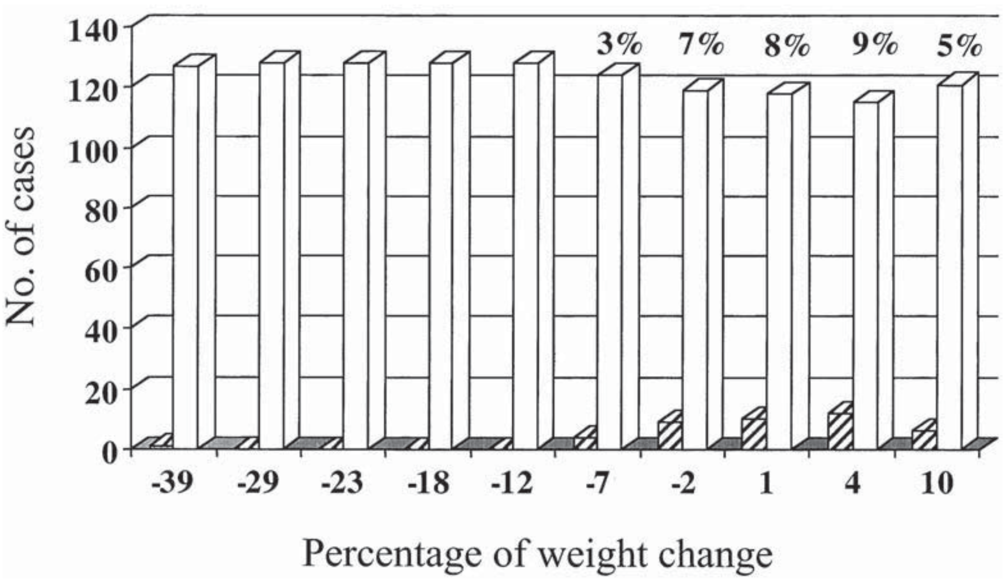

Fig. 8. Two-year incidence of diabetes by decentile of percentage weight change in the SOS intervention study. Pooled data are from 1281 obese control subjects and surgically treated subjects not having diabetes at baseline. ▨, New cases of diabetes. At the bottom, the average percentage weight change within each decentile is given. At the top, the 2-yr incidence of diabetes within each weight change decentile is given. (Data based on ref. *3* and figure reproduced from ref. *107* with permission.)

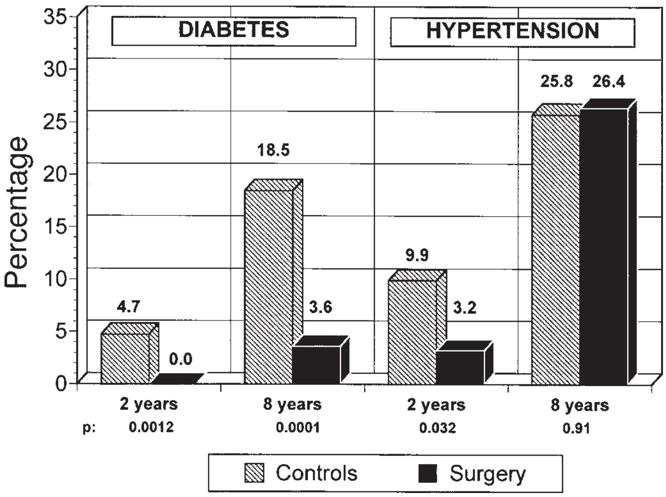

Fig. 9. Two-year and 8-yr unadjusted incidence of diabetes and hypertension in 232 obese control subjects (▨) and 251 surgically treated patients (j) from the SOS intervention study. Calculations are based on completer population. Almost identical ORs were obtained with and without adjustments in completer and intent-to- treat populations (not shown). (Reproduced from ref. *4* with permission.

weight loss (surgery or conventional), also when adjusting for changes in folate and B_{12} *(113)*. Homocysteine levels have been shown to be related to cardiovascular mortality *(114)*. Because homocysteine and folate are negatively related and folate intake is reduced during caloric restriction, our observations *(113)* suggest that all weight-reducing treatments, whether surgical or not, should be accompanied by substitution with multivitamin pills, folic acid, and possibly B_{12} in order to counteract an increased incidence of cardiovascular disease owing to hyperhomocysteinemia.

Effects on Cardiovascular System

In subsamples of the SOS study, cardiac function was examined at baseline and after 1 to 4 yr of follow-up. At baseline a surgically treated group (n = 41) and an obese control group (n = 31) were compared with a lean reference group (n = 43) *(115,116)*. Compared with lean subjects, the systolic and diastolic BP, left ventricular mass, and relative wall thickness were increased in the obese whereas the left ventricular ejection fraction (systolic function) and the E:A ratio (diastolic function) were decreased at baseline. After 1 yr, all these variables had improved in the surgically treated group but not in the obese control group. When pooling the two obese groups and plotting left ventricular mass or E:A ratio as a function of quintiles of weight change, a “dose” dependency was revealed; that is, the larger the weight reduction, the larger the reduction in left ventricular mass (Fig. 10) and the more pronounced the improvement in diastolic function (Fig. 11). Unchanged weight was in fact associated with a measurable deterioration in diastolic function over 1 yr.

In other small subgroups from SOS, heart rate variability from 24-h Holter electrocardiogram recordings and 24-h catecholamine secretion were examined *(117)*. Compared with lean subjects, our examinations indicated an increased sympathetic activity and a withdrawal of vagal activity at baseline in obese patients. Both these disturbances were normalized in the surgically treated group but not in the control group after 1 yr of treatment.

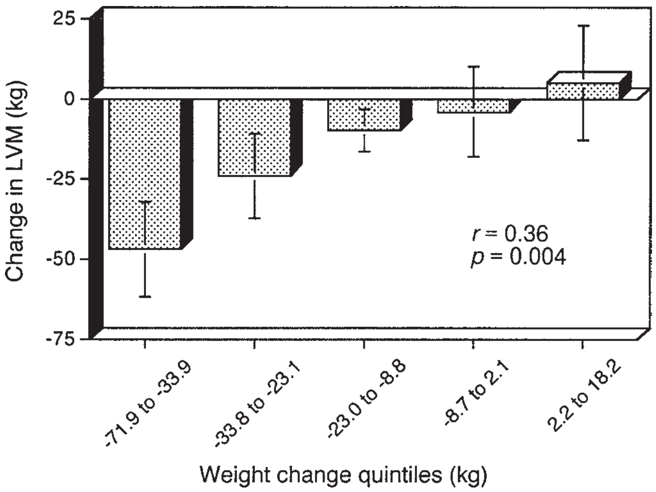

Fig. 10. Changes in left ventricular mass as a function of 1-yr weight change quintiles (kilograms) in the SOS intervention study. Data are the mean ± SEM. Pooled echocardiographic data of 38 surgically treated patients and 25 obese control subjects are shown. Correlation for a trend is based on individual observations ($n = 63$). (Reproduced from ref. *115* with permission.)

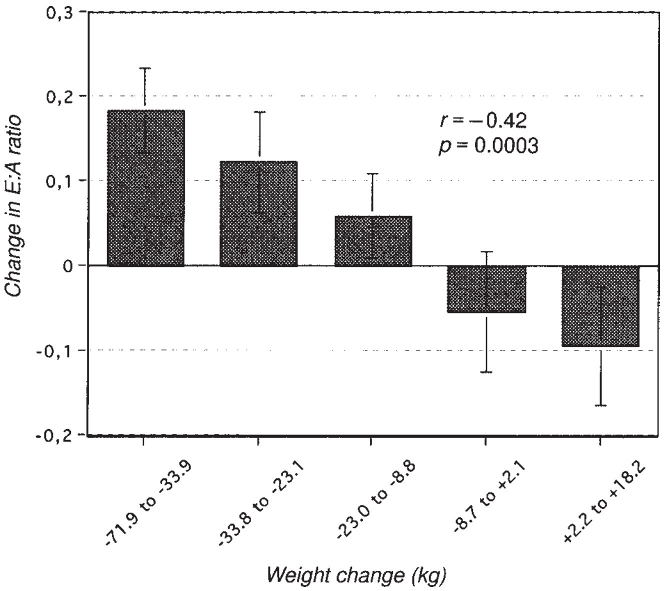

Fig. 11. Changes in diastolic function, as indicated by the E:A ratio, in relation to 1-yr weight change quintiles (kilograms) in the SOS intervention study. Data are the mean ± SEM. Pooled transmitral Doppler data of 41 surgically treated patients and 30 obese control subjects are shown. Correlation for a trend is based on individual observations ($n = 71$). (Reproduced from ref. *115* with permission.)

Furthermore questionnaire data from 1210 surgically treated patients and 1099 obese SOS control subjects examined at baseline and after 2 yr were analyzed with respect to various cardiovascular symptoms *(102)*. At baseline, the two groups were comparable in most respects. After 2 yr, dyspnea and chest discomfort were reduced in a much larger fraction of surgically treated patients compared with control subjects. For instance, 87% of the surgically treated patients reported baseline dyspnea when climbing two flights of stairs whereas only 19% experienced such dyspnea at the 2-yr follow-up. In the obese control group, the figures were 69 and 57%, respectively ($p < 0.001$ for difference in change between groups). Similarly, a high likelihood for sleep apnea was observed in 23% of surgically treated patients at baseline but only in 8% after 2 yr of treatment. In the control group, the figures were 22 and 20%, respectively ($p < 0.001$).

Physical inactivity was observed in 46% of the surgically treated patients before weight reduction but only in 17% after 2 yr. Corresponding figures in the obese control group were 33 and 29%, respectively ($p < 0.001$) *(102)*. Thus, physical inactivity not only contributes to the development of obesity but obesity prevents physical activity. This viscious circle is broken by surgical treatment.

Finally, the intima-media thickness of the carotid bulb was examined by means of ultrasonography at baseline and after 4 yr in the SOS intervention study *(118)*. A randomly selected lean reference group matched for gender, age, and height was examined at baseline and after 3 yr. As shown in Fig. 12, the annual progression rate was almost three times higher in the obese control group ($n = 9$) compared with lean reference subjects ($p < 0.05$). In the surgically treated group, the progression rate was normalized. Although results from this small study group need to be confirmed in larger trials, this study nevertheless offers the first data on hard end points after intentional weight loss.

We have also shown that pulse pressure increases more slowly in the surgically treated group than in the obese control group after a mean follow-up of 5.5 yr (unpublished data). In GBP individuals the pulse pressure is in fact decreasing. These observations are of interest because it has been shown that, at a given systolic BP a high pulse pressure is associated with increased arterial stiffness *(119)*, increased intima-media thickness *(120)*, and increased cardiovascular mortality *(121)*. Thus, pulse pressure changes (unpublished data) as well as ultrasonographic measurements *(118)* indicate that surgical treatment is slowing down the increased atherosclerotic process in the obese.

Economical Consequences of Obesity and Weight Loss in SOS

In cross-sectional studies of SOS patients, it has been shown that independent of age and gender, sick leave was twice as high and disability pension twice as frequent as in the general Swedish population *(122–124)*. The annual extra indirect costs (sick leave plus disability pension) attributable to obesity were estimated to be 6 billion SEK in Sweden, or 1 million US dollars per 10,000 inhabitants.

The number of lost days owing to sick leave and disability pension the year before inclusion in the SOS intervention was almost identical in the surgically treated and the

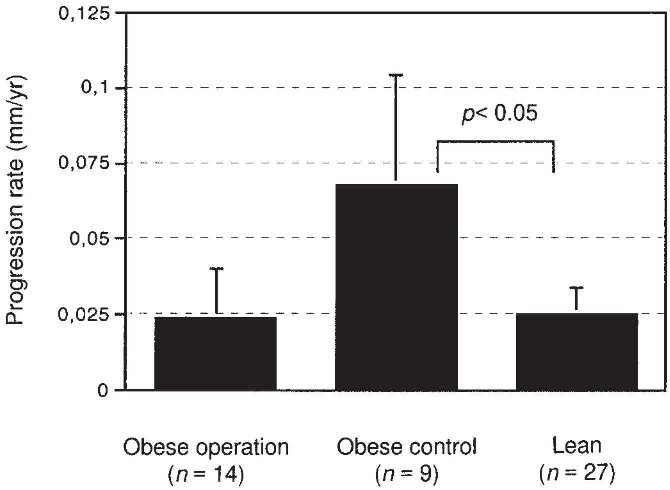

Fig. 12. Annual progression rate of intima-media thickness in the carotid artery bulb in surgically treated obese ($n = 14$), obese control subjects ($n = 9$), and lean controls ($n = 27$) matched for gender, age, and height. Data are the mean ± SEM. Progression rate was measured ultrasonographically over 4 yr in the two obese groups and over 3 yr in the lean reference group. The weight change was –22 ± 10 kg in the operated group and 0 ± 13 kg in the obese control group. (Reproduced from ref. *117* with permission.)

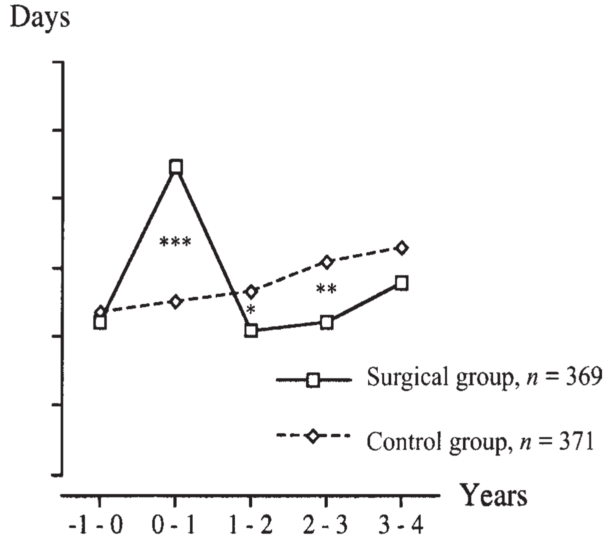

Fig. 13. Days of sick leave plus disability pension per year in 369 surgically treated and 371 obese control subjects the year before inclusion and over 4 yr after inclusion in the SOS intervention study. All data are adjusted for age, gender, and several predictive variables (*see* ref. *124*). During years 1–4, the number of days is also adjusted for days of sick leave plus disability pension the year before inclusion. Significant differences between groups are indicated as *p <0.05, **p <0.01, and ***p <0.001. (Reproduced from ref. *125* with permission.)

obese control groups (104 and 107 d, respectively, Fig. 13) *(125)*. The year after inclusion the number of lost days was higher in the surgically treated group but over yr 2–4 after inclusion the lost days were lower in the surgically treated group (Fig. 13). This was particularly evident in those individuals above median age (46.7 yr) (not shown) *(125)*.

The direct costs attributable to obesity in Sweden and their changes after weight loss are currently examined in the SOS study. So far we know that weight loss is associated with decreased costs for medication for diabetes and cardiovascular disease *(126)*.

Quality of Life in SOS Subjects Before and After Weight Loss

Cross-sectional information from 800 obese men and 943 women in the SOS registry study demonstrated that obese patients have a health-related quality of life that is much worse than in the age-matched reference groups *(127)*. In fact, health-related quality of life in the obese was as bad as, or even worse than, in patients with severe rheumatoid arthritis, generalized malignant melanoma, or spinal cord injuries. The measurements were performed with general scales such as the general health rating index, hospital anxiety and depression scale, mood adjective check list, and sickness impact profile in original or short form *(127,128)*, as well as with an obesity-specific psychosocial scale (*127*). All scales have been validated under Swedish measuring conditions.

In 2- *(129)* and 4 yr *(130)* reports, results from all measuring instruments are improving dose dependently; that is, the larger the weight loss, the larger the improvement in health-related quality of life, particularly in the obesity-specific psychosocial scale (Fig. 14).

Conclusions

The prevalence of obesity is high and increasing, and obesity is associated with a dramatically increased morbidity and mortality. Surgery is the only treatment of obesity resulting in more than 15% weight loss over 10 yr. This treatment has dramatic positive effects on most but not all risk factors over a 10-yr period. Large weight reductions achieved by surgery improve the cardiovascular system in several respects. Long-term direct and indirect costs seem to be reduced after surgical obesity treatment and quality of life is markedly improved.

Conventional treatment at specialized obesity units may achieve 5% weight loss over 2 to 5 yr of follow-up. This is not enough to keep risk factors down long term. Nonpharmacologic, conventional obesity treatment at primary health care centers is not associated with short- or long-term weight loss, and, unfortunately, most obese patients worldwide have no access to specialized obesity treatment.

Treatment with currently available antiobesity drugs results in 8–12% weight reduction over 2 yr compared with 4–6% in the placebo groups. This is encouraging even if more efficient drugs are needed in the future. So far no randomized drug trials with a duration longer than 2 yr have been published.

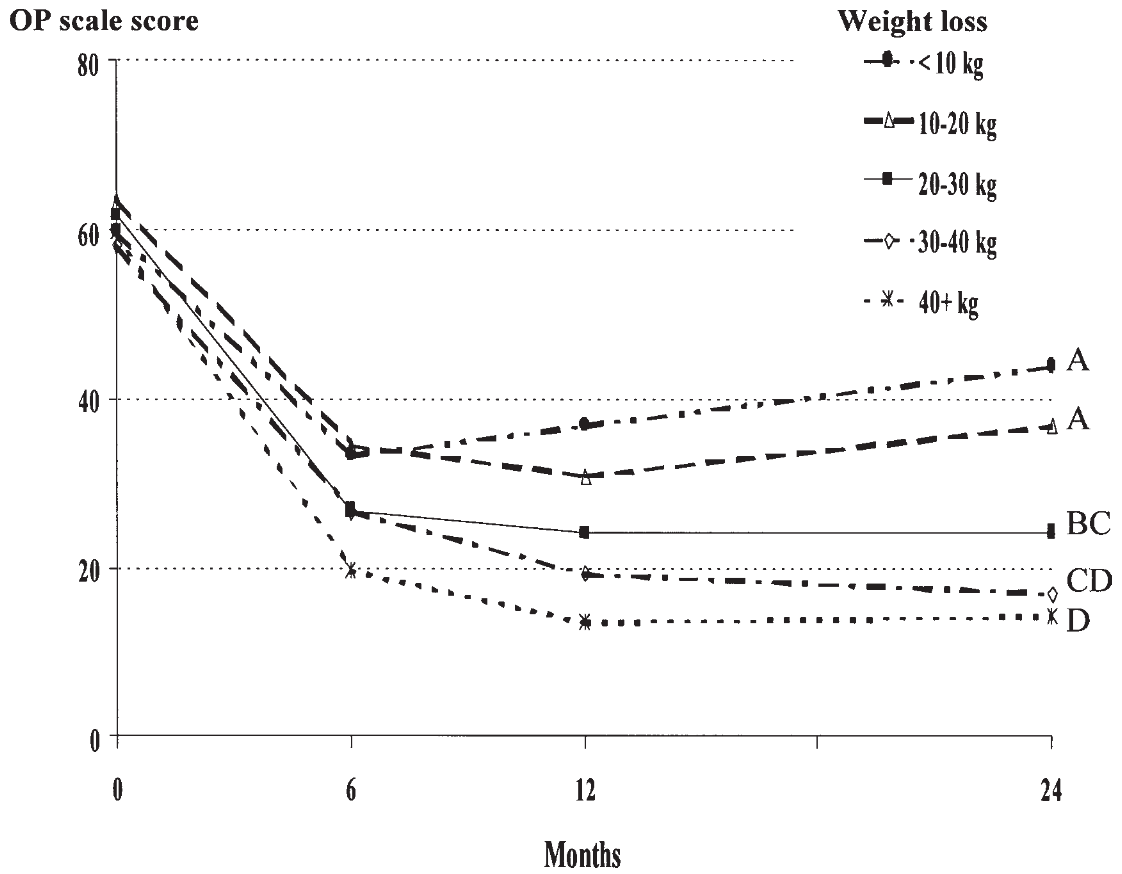

Fig. 14. Obesity-related psychosocial problems (OP) in everyday life by weight reduction during two years intervention in the SOS study. Indicated weight change classes are obtained after pooling 487 surgically treated patients and 487 obese control subjects followed for 2 yr. The psychosocial problems were estimated with the validated OP instrument *(128)*. High scores represent dysfunction. Groups with different letters were significantly different at 2-yr follow-up ($p < 0.05$, Tukey's range test). (Reproduced from ref. *129* with permission.)

Primary health care centers will constitute the worldwide basis for obesity treatment in the future. Within the next 5–10 yr, it is hoped that treatment given by these centers will improve with better programs and more efficient antiobesity drugs.

There is an urgent need for one specialized obesity center per approx 500,000 inhabitants. At these centers, internists, nurses and dietitians need to work full-time with obese subjects referred to them from the general practitioners. The demand for such treatment is almost unlimited. Obese patients of a region with 500,000 inhabitants will be in need of at least 20,000–30,000 visits annually.

While waiting for more efficient antiobesity drugs, the surgical treatment of obesity must increase dramatically. The real need is 500–1000 operations annually per 500,000 inhabitants in most Western countries even if the current request for operations is smaller. All obese patients with a BMI of 40 kg/m^2 need detailed information on surgical treatment options and many individuals with a BMI above as well as below 40 kg/m^2 will benefit from surgical treatment. Surgical treatment is especially important in obese patients with associated cardiovascular risk factors.

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