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INFLUENCES OF MAJOR WEIGHT LOSS IN WOMEN TREATED WITH BARIATRIC SURGERY ON THEIR PARTNERS' AND CHILDREN'S WEIGHT AND PSYCHOSOCIAL FUNCTIONING

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Influences of major weight loss in women treated with bariatric surgery on their partners' and children's weight and psychosocial functioning

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We have a hunger of the mind which asks for knowledge of all around us, and the more we gain, the more is our desire; the more we see, the more we are capable of seeing.

Maria Mitchell, astronomer (1818-1889)

ABSTRACT

The overall aim of the current PhD thesis was to explore how families of female bariatric surgery patients are affected by the surgery. The focus of the thesis was on differences in weight status in siblings born before and after maternal bariatric surgery, and on changes in weight and psychosocial functioning in partners and children of women undergoing Roux-en-Y gastric bypass (RYGB).

Study I explored differences in BMI and prevalence of overweight and obesity at the ages of four, six and 10 in children born before and after maternal bariatric surgery. Results showed that at no age did the children born after surgery have a lower prevalence of overweight or obesity, and that there was no association between differences in maternal BMI at week 10 of the two pregnancies and differences in siblings' BMI at age four.

Study II focused on changes in female RYGB patients' partners in terms of BMI, waist circumference, sleep quality, body dissatisfaction and symptoms of anxiety and depression. The results showed significant reductions in BMI and waist circumference in the partners. However, psychosocial variables, as measured by questionnaires, remained unchanged in the men.

In Study III, differences in weight status, body esteem and self-concept in children of female RYGB patients were explored. It was found that the children had a reduced relative risk of overweight after maternal RYGB. The results also showed that the boys improved their age-adjusted body esteem slightly, whilst the girls did not.

Study IV investigated changes in eating behaviour and food choices in female RYGB patients and their families. The women were shown to increase their cognitive restraint, decrease their uncontrolled and emotional eating, and reduce their intake frequency of soft drinks and sweets after surgery. Their partners, however, reported no changes in their eating behaviour and food choices. The boys' eating behaviour improved following maternal RYGB, but the same was not true for the girls in the sample. The children who were overweight or obese at baseline also improved their eating behaviour in comparison to the normal weight children.

In conclusion, this thesis shows that women's gastric bypass surgery may be associated with positive changes in her partners' and children's weight, especially if they are themselves overweight. Changes in psychosocial functioning are smaller and more complex in the current sample, and require further study.

LIST OF SCIENTIFIC PAPERS

I. Willmer M, Berglind D, Sørensen TIA, Näslund E, Tynelius P, Rasmussen F. Surgically induced interpregnancy weight loss and prevalence of overweight and obesity in offspring. Plos One. 2013; Dec 12;8(12):e82247. (Available from: http://www.plosone.org/article/info%3Adoi%2F10.1371%Fjournal.pone.0082247)

II. Willmer M, Berglind D, Thorell A, Sundbom M, Uddén U, Raoof M, Hedberg J, Tynelius P, Ghaderi A, Näslund E, Rasmussen F. Changes in BMI and psychosocial functioning in partners of women who undergo gastric bypass surgery for obesity. Obes Surg. 2014 Aug 23. [Epub ahead of print]

III. Willmer M, Berglind D, Tynelius P, Ghaderi A, Näslund E, Rasmussen F. Children’s weight status, body esteem and self-concept following maternal gastric bypass surgery.

IV. Willmer M, Berglind D, Tynelius P, Ghaderi A, Näslund E, Rasmussen F. Changes in eating behaviour and food choices in families where the mother undergoes gastric bypass surgery.

CONTENTS

LIST OF ABBREVIATIONS

AGB	Adjustable Gastric Banding
BES	Body Esteem Scale
BES-APP	Body Esteem Scale-Appearance
BES-ATT	Body Esteem Scale-Attribution
BES-W	Body Esteem Scale-Weight
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
BPD	Biliopancreatic Diversion
BPD-DS	Biliopancreatic Diversion with Duodenal Switch
BYI-S	Beck Youth Inventories-Self-Concept
ChEAT	Children’s Eating Attitudes Test
DEXA	Dual-Energy X-ray Absorptiometry
FFQ	Food Frequency Questionnaire
GEE	General Estimating Equations
GLP-1	Glucagon-Like Peptide-1
HADS	Hospital Anxiety and Depression Scale
HADS-A	Hospital Anxiety and Depression Scale-Anxiety
HADS-D	Hospital Anxiety and Depression Scale-Depression
JIB	Jejunoileal Bypass
KSQ	Karolinska Sleep Questionnaire
LGA	Large for Gestational Age
MBDS	Male Body Dissatisfaction Scale
PYY	Peptide YY
SGA	Small for Gestational Age
SLT	Social Learning Theory
SOS	Swedish Obese Subjects
T2DM	Type 2 Diabetes Mellitus
TFEQ	Three-Factor Eating Questionnaire
TFEQ-CR	Three-Factor Eating Questionnaire-Cognitive Restraint
TFEQ-EE	Three-Factor Eating Questionnaire-Emotional Eating

TFEQ-UE	Three-Factor Eating Questionnaire-Uncontrolled Eating
VBG	Vertical Banded Gastroplasty
VLCD	Very-Low-Calorie Diet
WHO	World Health Organization

1 INTRODUCTION

The Introduction of this thesis provides a brief historical perspective on obesity and an overview of its consequences and treatment options, as well as a review of previous research on the topic of familial effects of bariatric surgery.

1.1 OBESITY

Obesity has been defined by the World Health Organization (WHO) as “abnormal or excessive fat accumulation that presents a risk to health” (1). In the following sections, I will give a brief outline of this condition, its consequences and treatments.

1.1.1 Historical Perspective

Obesity is far from a modern condition, although its status as a major public health problem is fairly recently acquired (2). The famous statuette “Venus of Willendorf”, one of several similarly aged small figures depicting unmistakeably obese women, is believed to be between 25 000 and 30 000 years old and shows us that not even the people of the Stone Age were unfamiliar with the phenomenon.

Later, in about 400 BC, Hippocrates was also well aware of the problem of obesity and stated that:

“It is very injurious to health to take in more food than the constitution will bear, when, at the same time one uses no exercise to carry off this excess…” (3)

His recommendations for those seeking to lose weight included vigorous exercise before eating, having only one meal per day, and walking around naked.

In Roman times, the famous physician Clarissimus Galen (131-201 A.D.) had somewhat similar ideas, proposing that “stout” people could be made “moderately thin in a short time” if they followed a regime of running, taking massage, and bathing (4).

In fact, most of the ancient cultures – Egyptian, Chinese, Indian, Greco-Roman, Arabic – have left writings showing that obesity existed in their societies, and that it was recognised as a potential health hazard (4).

Fast-forward to the 17th century, and scientists were starting to make discoveries as to why the ancient advice of dietary restriction and physical activity seemed to cause weight loss (Hippocrates’ advice about prolonged nudity seems to have fallen by the wayside at this point). The old humoral view of human health and disease was starting to be replaced by other ideas; namely that the human body could best be understood in mechanical or chemical terms (4). This century also saw the advent of pharmaceutical treatments of obesity – a 1682 textbook suggests that when a “spare diet” did not suffice, the obese individual may try taking pills made from, amongst other things, rhubarb, aloe and chicory (4).

In 1850, Thomas King Chambers gave a landmark series of lectures, *On Corpulence*, which was subsequently published in The Lancet [5]. In these, he stated that the most common cause of obesity was “a superabundant diet” and that an obese man was “prone to heart-disease, to apoplexy, and congestions”. He also noted the hereditary nature of obesity.

During the 20th century, medical science made numerous discoveries in the field of obesity research. The first metabolic chambers were built, allowing studies of human energy expenditure [4]. Micro- and macronutrients were studied in detail, and the relationships between different types of dietary fats and their associations with obesity and obesity-related disease were explored [6].

Genetic causes of obesity have kept researchers occupied ever since the discovery of the double-helix DNA structure and the mapping of the human genome. Whilst important discoveries have been made – 50 genetic loci conferring susceptibility to obesity have been identified – there have been no discovery of any genetic cause of obesity that would affect more than a very small minority of individuals in the general population [7].

1.1.2 Definition and prevalence

As mentioned above, the WHO defines obesity as “abnormal or excessive fat accumulation that presents a risk to health” [1] . Thus, any method of measuring obesity must aim to approximate the proportion of fat in the individual being measured. This is true whether that method is weighing, measuring waist circumference, using bioelectric impedance analysis (BIA), dual-energy X-ray absorptiometry (DEXA) scans or any other alternative that does not consist of physically removing the individual’s adipose tissue from their body in order to weigh it.

The currently most common way of diagnosing overweight and obesity in humans is to use the Body Mass Index (BMI). This method, originally invented by the Belgian mathematician Adolphe Quetelet in 1832 [8], is simply a weight-for-height index, calculated by dividing an individual’s weight in kilograms by their height in metres squared. It has been found that BMI is a good predictor of proportion of body fat, as long as age and gender are taken into account [9]. However, it is by definition unable to differentiate between weight resulting from excess fat tissue and weight resulting from highly developed musculature, sometimes causing misleading results on the individual level. It also fails to distinguish between different distributions of body fat. Furthermore, it has been shown that the relation between BMI and body fat percentage varies across different ethnic groups [10].

These potential sources of error have lead to some criticism, both of BMI as a method of defining obesity and of the universal WHO definition of overweight as a BMI greater than or equal to 25, and obesity as a BMI greater than or equal to 30 [1]. In spite of this, the Body Mass Index, with 25 and 30 as its cut-off points for overweight and obesity, respectively, remains the most widely used.

It is, of course, difficult to give a precise estimate of the current worldwide prevalence of overweight and obesity. A recent systematic analysis published in The Lancet estimated, on the basis of over 1700 individual studies, that the number of overweight and obese individuals increased from 857 million in 1980 to 2.1 billion in 2013. This translates into 36.9% of all men, and 38.0% of women. For children and adolescents in developed countries, the numbers are 23.8% for boys and 22.6% for girls. The same publication also gives estimates for each of the participating countries. For Sweden, the prevalence of overweight and obesity is estimated at 20.4% for boys, 19.3% for girls, 58.2 for men and 45.8 for women. For obesity only, the corresponding figures are 4.3%, 4.0%, 18.9% and 19.8%, respectively [(11)].

1.1.3 Effects of obesity

The hitherto discovered physical and psychological effects of obesity are generally well-known by researchers in the field, and only a very brief overview will be provided here. One of the strongest associations between obesity and any comorbidity is that of type 2 diabetes mellitus (T2DM) [(12, 13)]. This is especially true for visceral obesity, where excess adipose tissue is deposited around the internal organs of the upper body [(12)]. According to the WHO, as many as 64% of T2DM cases in American men, and 74% of cases in American women, could be avoided if there was no one with a BMI above 25 in the US [(14)].

The association between obesity and cardiovascular disease is also exceptionally strong, with visceral obesity again conferring an especially high risk [(12, 14)]. Evidence from large cohort studies suggest that more than a third of all incident coronary heart disease events can be attributed to excess weight [(15)].

Associations have also been established between obesity and gallbladder disease, certain cancers, sleep apnoea and osteoarthritis [(16-19)].

Obesity is also associated with a range of psychological disorders, such as depression [(20)], anxiety disorders [(21)], and eating disorders such as binge eating disorder [(22)] and night eating syndrome [(23)]. In several of these, the association may be reciprocal, partly due to the strong stigmatisation of obesity in society [(24)], which exacerbates and probably even causes some of the mental ill-health associated with obesity, as well as possibly perpetuating the actual obesity itself [(25-27)].

1.1.4 Obesity in pregnancy and consequences for offspring

Obesity poses a major health risk for both mother and child, from conception and all the way into the child’s adulthood [(28, 29)]. It is also a risk factor for infertility, as it interferes with ovulation, especially in women with early-onset and/or abdominal obesity [(28)].

Obesity is also a risk factor for emergency caesarean sections and other types of instrumental deliveries, as well as for shoulder dystocia, macrosomia and hypoglycemia in the newborn child [(30)].

The strongest predictive factor for future obesity in a newborn child is birth weight [31]. The intrauterine environment of a woman who is obese as she enters pregnancy will subject the growing foetus to high levels of free fatty acids and glucose, which have been associated with a higher birth weight in the child, as well as increased future risk of obesity, metabolic syndrome and cardiovascular disease [32, 33].

It has also been hypothesised that obesity in pregnancy induces epigenetic changes in the foetus, and that these changes predispose the infant to obesity, diabetes and the metabolic syndrome in later life [34]. However, the exact nature of these changes remains largely unknown [34, 35].

1.1.5 Non-surgical treatment

For thousands of years, it has been known that dietary restriction causes weight loss [4]. Although various dietary regimes (mainly differing with regards to proportions of macronutrients in the diet) have been proposed by researchers and commercial actors alike, a recent meta-analysis published in the Journal of the American Medical Association (JAMA) found minimal differences between these in terms of long-term weight loss [36].

The difficulty for most overweight or obese individuals does not lie in losing clinically meaningful amounts of weight, but in maintaining this weight loss long-term [37, 38]. In fact, the poor outcomes of diet interventions for weight loss have lead some researchers to question the ethics of recommending dietary restriction at all for obese individuals, seeing as the most likely outcome is that they will lose some weight, regain it, and start over again in a weight cycling behaviour, with the feelings of failure and dysphoria which often accompany failed weight loss attempts [39].

As for pharmaceutical treatment options, these are currently very few. Certainly a wide range of drugs have been on both European and international markets at different points in time, and whilst often efficient from a weight loss perspective, many of them have been withdrawn after severe adverse effects have been brought to light, such as pulmonary hypertension (fluramine-phentermine), intracranial bleedings (phenylpropanolamine), myocardial infarctions (ephedrine) and depression and suicide (rimonabant) [40].

There is currently only one weight loss drug available in Sweden which has been approved by the European Medical Agency; this is orlistat, known as Xenical in its prescription form and Alli in its over-the-counter incarnation [40]. It is a gastrointestinal lipase inhibitor, which works by blocking approximately a third of the dietary fat ingested [41]. Its long-term effects are modest – the combination of orlistat medication and a low-fat diet leads to a mean extra weight loss of 3.4 kg during a 12-month follow-up when compared to dietary restriction only in a recent systematic review [41]. Orlistat is also known to have a number of side effects, ranging from the unpleasant (steatorrhea and other gastrointestinal problems) to the potentially fatal (severe liver damage, acute pancreatitis, precancerous colon lesions) [40].

1.1.6 Surgical treatment

As with non-surgical treatment, the idea of treating obesity by surgery is far from new. The Talmud tells of a rabbi Eleazar, who suffered from morbid obesity and was relieved of "many basketfuls of fat" after being given a sleeping potion in what sounds like a very early and rather gruesome version of liposuction [(4)]. However, bariatric surgery as it is known today (surgery performed on the stomach or intestines of an obese patient in order to induce weight loss) is a somewhat younger business.

1.1.6.1 Surgical methods

The first type of bariatric procedure to be widely performed was the jejunoileal bypass (JIB) (**figure 1**), which was used predominantly during the 1970's and early 1980's [(42)]. It was a malabsorptive procedure which, whilst leading to substantial long-term weight loss, was also associated with relatively high rates of serious side effects, such as liver failure, serious nutrient deficiencies, and sometimes fatal electrolyte imbalances [(42)]. A 1985 review reported that more than half of patients had to be readmitted to hospital due to complications of the surgery, and 17% had to have the procedure reversed within a 13-year-period [(43)].

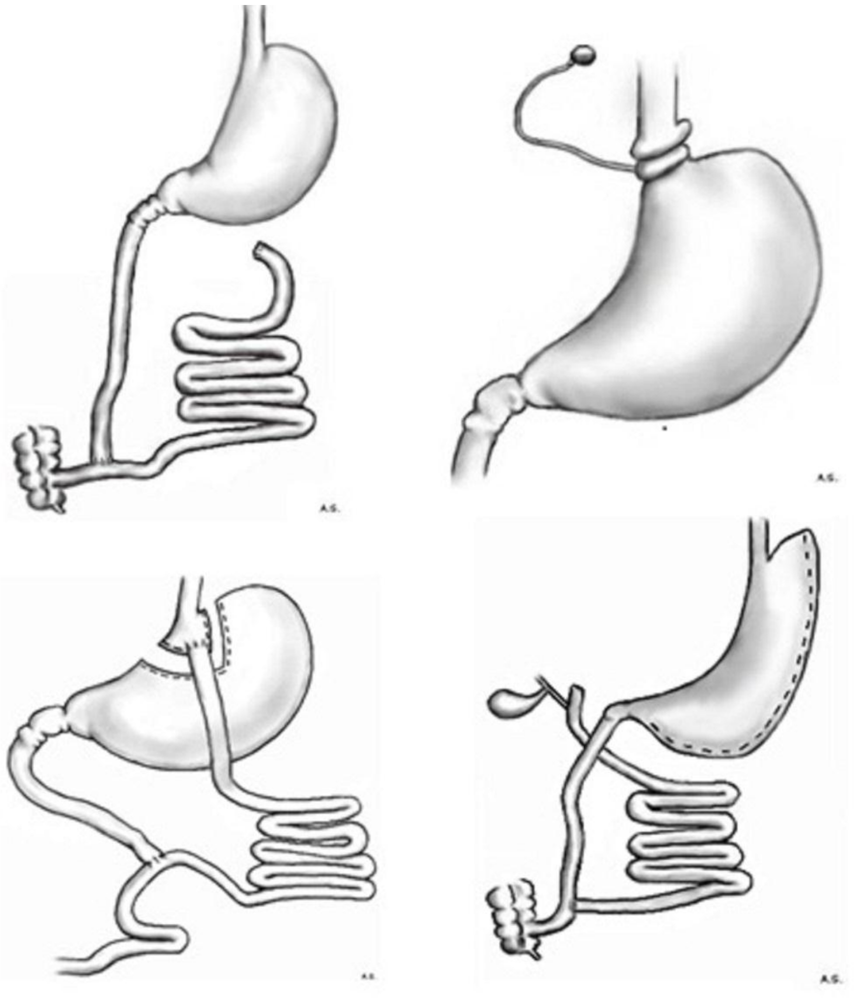
Vertical banded gastroplasty (VBG) was developed in the 1970's and early 1980's. It restricts food intake through a vertical transection of the upper part of the stomach, creating a small pouch. The outlet of the pouch is then restricted by a band [(42)]. As the VBG does not interfere with the absorption of nutrients or the digestion of food, many of the problems of the JIB could be avoided. The VBG was widely performed during the 1980's and 1990's, but long-term follow-up showed that weight regain was common, and that side effects such as frequent vomiting and acid reflux persisted in a significant proportion of patients [(44)]. With the advent of the adjustable gastric band method, the use of VBG as a bariatric procedure became rare [(42)].

The adjustable gastric banding (AGB) was developed in the late 1970's and early 1980's (**figure 1**). It is a purely restrictive and reversible procedure, and gained great popularity in the 1990's and early 2000's [(42)]. However, long-term follow-up revealed substantial problems with band slippage, erosion and regain of weight, leading to high rates of re-operations and conversions to other types of bariatric procedures. Consequently, AGB is currently used sparingly in Sweden and other countries [(42, 45)].

The Roux-en-Y gastric bypass (RYGB) was created as an alternative to the JIB. The RYGB combines elements of both restriction and malabsorption by creating a small pouch in the proximal part of the stomach, which is then connected directly to the middle portion of the jejunum, bypassing the rest of the stomach and the duodenum (**figure 1**). The RYGB, especially in its laparoscopic version, is associated with a relatively low risk of complications – a Swedish study, using data on more than 26 000 patients from the Scandinavian Obesity Surgery Register, found an overall risk of 3.4% for serious postoperative complications within 30 days of surgery [(46)].

The most common complications of RYGB include leakage, bleeding, small bowel obstructions and strictures [46, 47]. Deficiencies in nutrients such as iron and vitamin B_{12} are also common, and patients are recommended to use supplements for life [48, 49].

Even though the RYGB is currently the most common method of bariatric surgery, both in Sweden [50] and internationally [51], other methods are being developed. One of these is the sleeve gastrectomy, which consists of a stomach resection along the greater curvature, resulting in a sleeve-like appearance of the stomach. The procedure was originally developed as the first in a two-step procedure for those with extremely high BMI values, and was intended to facilitate sufficient weight loss for a regular bariatric procedure such as RYGB. However, it is now increasingly being used as a stand-alone procedure, with positive results [52]. Complications include bleeding, staple line leaks and ruptures, and nutritional deficiencies [53].



Drawings by A. Stockeld

Figure 1. Different types of bariatric surgery methods. Top left: jejunoileal bypass; top right: adjustable gastric banding; bottom left: Roux-en-Y gastric bypass; bottom right: biliopancreatic diversion with duodenal switch.

Finally, the biliopancreatic diversion with duodenal switch (BPD-DS) should be mentioned (**figure 1**). Developed in the late 1990's, it is an alternative to RYGB often used for super-obese patients (BMI ≥50) as it results in the highest degree of weight loss of all bariatric procedures currently in use (54). It consists of both a sleeve gastrectomy and an intestinal bypass (55). Peri-operative mortality and other complications have been reported to be similar to those associated with RYGB, although with a higher risk of nutritional deficiencies and gastrointestinal complications in some studies (48, 56, 57).

1.1.6.2 Effects of surgical treatment

The Swedish Obese Subjects (SOS) study compares 2010 obese individuals undergoing bariatric surgery (AGB, VBG or RYGB) with 2037 matched obese control individuals receiving usual (non-surgical) care (58). At the 15-year follow-up, the surgery patients had lost between 13% (with AGB) and 27% (with RYGB) of their starting weight, whilst the control group remained within 3% of their starting weight (58). After 16 years of follow-up, the adjusted risk reduction for overall mortality in the surgery group was almost 30% when compared to the control group. After two years of follow-up, 72% of the surgery patients with T2DM at baseline had achieved remission, although approximately half of these had relapsed after ten years. However, it is likely that these relapses occurred mainly in the AGB and VBG patients, where weight regain is more common, although no such comparative data was given. Bariatric surgery also reduced the risk of developing T2DM by 78% after 15 years of follow-up. Results from the SOS study also show a decreased incidence of cancer in the women, but not the men, in the surgery group compared to the control group. The bariatric surgery patients also reported significant improvements in health-related quality of life ten years after surgery (58).

Other studies of the long-term effects of bariatric surgery have reported similarly positive results concerning weight loss (59, 60), T2DM (61, 62), cardiovascular disease (63, 64) and health-related quality of life (65, 66).

For the vast majority of bariatric surgery patients, the operation induces significant changes in eating behaviour and food choices. Dietary recommendations differ somewhat depending on type of surgery, and since the vast majority of bariatric procedures in Sweden is made up of RYGB (50), I will focus on this type of surgery.

Dietary recommendations after RYGB focus on ensuring adequate intake of nutrients, whilst maintaining a negative energy balance in the weight loss phase (67). Protein intake is an important factor after RYGB in order to increase satiety and minimise loss of lean mass (68). As the RYGB patient's stomach has been replaced by a small pouch, portions must be kept small, resulting in an eating pattern of frequent, small meals (69). This eating pattern also optimises the secretion of postprandial hormones such as glucagon-like peptide-1 (GLP-1) and peptide YY (PYY), both of which have been shown to increase after RYGB and contribute to weight loss by reducing hunger and increasing satiety (70). It is important that the patient avoids energy-dense, nutrient-poor food items and snacks, as these may hinder weight loss, contribute to early weight regain, and contribute to nutritional deficiencies by competing with nutrient-dense foods [67]. Foods high in simple sugars, such as soft drinks, sweets, milkshakes and biscuits, may also cause what is known as dumping syndrome – palpitations, nausea, flushing and a host of other unpleasant symptoms caused by high-osmolarity foods entering the small intestine [71]. It has been proposed that a certain degree of dumping is desirable after RYGB, as it may condition the patient to lose interest in high-sugar foods, but several studies have failed to find an association between dumping symptoms and weight loss or eating behaviour [72, 73].

When it comes to compliance with the dietary recommendations, previous studies show that RYGB patients tend to avoid sugar-sweetened drinks, sweets and biscuits, increase their intake of protein-rich foods and decrease the energy-density of their diet [74-76]. Furthermore, RYGB patients have been shown to increase their dietary restraint and decrease emotional and uninhibited eating after surgery [69].

1.2 INTERPREGNANCY WEIGHT LOSS AND DIFFERENCES IN SIBLING BMI

Whilst it has been established that obese women are more likely than normal weight women to give birth to large babies, who themselves have an increased risk of both childhood and adult obesity [77, 78], it is less well explored whether maternal weight loss between two pregnancies will result in a decreased risk of obesity in the second child. Jain *et al* used register data to identify women who had gained ≥ 2 BMI units, lost ≥ 2 BMI units or stayed within 2 BMI units between two pregnancies, and evaluated how weight change affected the women's risk of giving birth to children who were either large for gestational age (LGA) or small for gestational age (SGA). They found that interpregnancy weight gain was associated with an increased risk of giving birth to a LGA baby, and that interpregnancy weight loss was associated with a decrease in the same risk. However, interpregnancy weight change was not associated with the risk of having a SGA infant. [79].

Villamor and Cnattingius also found that weight gain between pregnancies was associated with an increased risk of LGA infants. Additionally, they found increased risks of gestational hypertension and gestational diabetes with only 1-2 BMI units increase between pregnancies, even in women who were not classified as overweight for either of their pregnancies [80].

Studies specifically investigating the pregnancy outcomes of women who have undergone bariatric surgery in comparison with obese control women have reported that women who have undergone bariatric surgery seem to have a decreased risk of preeclampsia, gestational diabetes and LGA infants, but possibly an increased risk of preterm birth and maternal anemia [81, 82].

Kral *et al* and Smith *et al* (using the same material) compared groups of children born before or after maternal BPD with regards to rates of overweight and obesity, as well as metabolic markers such as insulin sensitivity, blood lipids and ghrelin levels, and found marked improvements in all of these variables in the children born after maternal surgery [83, 84]. Finally, Guenard *et al* investigated epigenetic differences in 25 sibling pairs from the same material (with 25 children born before maternal surgery and 25 after) [85]. The results showed significant positive differences in the expression of genes involved in diabetes-related cardiometabolic pathways in the children born after surgery.

Barisione *et al* also investigated children born before and after maternal BPD, and asked the mothers to retrospectively state whether their children had been normal weight, overweight or obese at the ages of one, six and twelve. They reported that whilst there were no differences at ages one and six between siblings born before or after maternal surgery in these ratings, more children born before surgery than after surgery were rated by their mothers as having been overweight or obese at the age of 12 [86].

1.3 FAMILIAL EFFECTS OF MATERNAL BARIATRIC SURGERY

Research on how the family is affected by maternal bariatric surgery is scarce. The current PhD project investigates effects on spouses with regards to BMI, sleep quality, body dissatisfaction, eating behaviour, food choices, and symptoms of anxiety and depression, and effects on children with regards to weight status (prevalence of overweight and obesity), body esteem, self-concept, eating behaviour and food choices. In this section, I will give a brief overview of these concepts and any previous relevant research.

1.3.1 Changes in spousal BMI

When looking at non-surgical weight loss interventions, several previous studies have found a household ripple effect, whereby the untreated spouses of participants in weight loss interventions also lose weight, and that the magnitude of the untreated partner's weight loss usually follows that of the treated partner [87-89].

There are two previous studies on the effects on spousal BMI after bariatric surgery. Madan *et al* investigated changes in BMI in 59 spouses before and one year after their partner underwent bariatric surgery [90]. Interestingly, they found that obese spouses were more likely than non-obese spouses to gain weight during this period – 50% of the obese spouses gained at least 4.55 kg, 17% lost at least the same amount, and 33% stayed within 4.55 kg of their baseline weight. For the non-obese spouses, the corresponding figures were 17%, 28%, and 55%, respectively.

The only other published study that we have been able to locate which addresses this question is by Woodard *et al*. It investigated changes in BMI, as well as a range of other variables, in 35 adult family members (of which 26 were spouses) of RYGB patients. In contrast with the Madan study, they found that one year after RYGB, obese spouses of the patients had decreased their own BMI with a mean 1.7 units, whilst there was no significant change in the BMI of non-obese spouses. The obese spouses' waist circumference had also decreased by a mean 11 cm [91].

1.3.2 Changes in children's BMI and prevalence of overweight and obesity

As with spouses, research on non-surgical populations shows that involvement of the family can be an important factor in weight loss interventions, resulting in more positive results than treatment of only one family member [92, 93].

Studies concerning the effect of parental bariatric surgery on children's weight are few, and their results are inconsistent. The study by Woodard *et al* discussed above also included 15 children. It found that the obese children displayed a trend towards a lower-than-expected BMI one year after parental RYGB, but this was not statistically significant [91].

Hirsch *et al* conducted a case-control study comparing the BMI of children living in a household where an adult had undergone bariatric surgery with control children living with obese adults who had not had bariatric surgery [94]. The results showed that for overweight boys, those living in surgery households had a lower-than-expected BMI after parental surgery, whilst the corresponding control children had a higher-than-expected BMI. For girls and children in other weight categories, there were no significant differences.

1.3.3 Changes in spousal sleep quality

It is well established that it is not uncommon for individuals with obesity to suffer from sleep disorders such as obstructive sleep apnoea, snoring, excessive daytime sleepiness and obesity hypoventilation syndrome [18], and that these problems are often greatly improved or even eliminated by bariatric surgery [95, 96]. However, we have only been able to find one previous study on how these improvements in RYGB patients' sleep quality may affect that of their partners; the Woodard *et al* study referenced above [91]. It showed improvements in patients', but not spouses', duration of sleep and sleep quality after surgery. Studies on non-surgical populations have shown that partners of obstructive sleep apnoea sufferers also report bad sleep quality [97, 98], and that treatment of the sleep apnoea seems to also improve the patients' partners' sleep quality [99].

1.3.4 Changes in spousal anxiety and depression

As described above, the relationship between depression and obesity has been shown to be bidirectional [20]. It has also been shown that marital or cohabiting partners show similarities in depressive symptoms [100], and that these symptoms also correlate in changes over time [101]. Patients who lose weight through bariatric surgery report improvements in depressive symptomatology [65], but we have been unable to find any studies investigating either whether spouses of obese individuals suffer from symptoms of depression to the same extent as the obese individuals themselves, or whether bariatric surgery patients' improvement is mirrored by a similar change in their partners. The only exception is Woodard *et al*, who administered the SF-36 questionnaire to the adult family members participating in the study described above, and found no changes in their scores one year after RYGB [91].

As with depression, similarities in symptoms of anxiety can be observed in spouses [102]. Anxiety in RYGB patients has been shown to improve following surgery in most, but not all studies [103-105]. However, it remains to be discovered whether this improvement also affects anxiety in spouses. Again, we have been unable to find any previous research investigating whether treatment of anxiety in one spouse produces any effects in the other.

1.3.5 Changes in body dissatisfaction in spouses

Body dissatisfaction in men has been studied to a lesser extent than in women, leading to a relatively small body of previous research, especially for middle-aged men [106, 107]. The studies that do exist indicate that men experience comparatively less body dissatisfaction than women, and that obese men experience more body dissatisfaction than normal weight men, but less than obese women [108]. Whilst women generally tend to desire a thinner body, men are more affected by the muscular body ideal and it has been found that about the same proportion of men wish to lose weight and gain weight (in the form of increased muscle mass) [107].

Whilst it has been shown that both men and women improve their body dissatisfaction following bariatric surgery [109, 110], we have been unable to find any previous research investigating spousal similarities in body image or body dissatisfaction. The same is true for any research on a possible "ripple effect" whereby changes in one partner's body dissatisfaction may influence the other's.

1.3.6 Changes in body esteem in children

The concept of body esteem has been defined as the "self-evaluation of one's body or appearance" [111]. It has also been described as the physical counterpart of self-esteem [112]. It has been found to be a multi-dimensional construct – Mendelson *et al* found three domains of body esteem in their samples of 8-to-15-year-olds after hypothesising that "feelings about one's weight may be differentiated from feelings about one's general appearance, and the embarrassment caused by social stigma attached to overweight may be independent of other aspects of body esteem" [112]. The dimensions they found were weight, appearance and attribution.

Body image is often used interchangeably with body esteem, although the two concepts are not strictly speaking the same. Body image is a somewhat broader construct, encompassing perceptions of weight-related physical appearance as well as affective feelings about one's body [113], but it seems reasonable to believe that they are closely enough correlated to be used interchangeably in terms of references to previous research.

Children who are overweight or obese generally report lower body esteem than normal weight children, and this is especially true for girls [112, 114]. It also seems like body esteem often decreases with increasing age, and that girls, again, are especially vulnerable to this phenomenon [114, 115].

The relationship between children's body esteem or body image and that of their parents seems difficult to disentangle. Most studies have found associations between parental – most often maternal – body dissatisfaction or body image and that of their child, most often daughters. Usmiani and Daniluk found a correlation between mothers' and daughters' body image, but only for those daughters who had started menstruating [116]. Kichler and Crowther found no such correlation, but did find an association between negative communication in the family, such as weight-teasing and encouragement to diet, and girls' levels of body image dissatisfaction [117]. Cooley *et al* also reported that mothers' negative comments were associated with lower body image in their daughters [118], whilst Wertheim *et al* found that dieting encouragement from either parent was a predictor for body dissatisfaction in both sons and daughters [119]. Finally, Lowes and Tiggeman found that mothers' levels of body dissatisfaction predicted those of their children, and that children who perceived their mothers to strive for thinner figures had higher levels of body dissatisfaction themselves [120].

In adults, body image has been shown to be lower in obese than in non-obese samples [121, 122], and to become progressively worse as BMI increases [123]. Furthermore, it has been found that obese women suffer from more body image dissatisfaction than obese men [121, 122].

We have been unable to find any previous research on how bariatric surgery and the resultant changes in parental body image affect children's body esteem or body image.

1.3.7 Changes in self-concept in children

Self-concept has been described as "the totality of an individual's thoughts and feelings having reference to himself as an object" or as "the concept the individual has of himself as a physical, social, and spiritual or moral being" [124]. Self-esteem forms the evaluative part of the self-concept, and is thus not conceptually the same, but the two constructs often seem to be used synonymously [125, 126].

It has been shown that eight-year-old children who reported that their mother dieted frequently were more likely to report dieting behaviour themselves, and that this in turn was associated with lower self-esteem [127]. However, we have been unable to find any previous research either on direct associations between parental and child self-concept, or on how parental bariatric surgery affects children's self-concept or self-esteem.

As with many other psychosocial variables, self-concept has been shown to improve substantially in the majority of patients undergoing bariatric surgery [128].

1.3.8 Changes in eating behaviour in spouses and children

Several previous studies have shown that the eating behaviour of bariatric surgery patients changes after surgery, with an increase in cognitive dietary restraint and decreases in emotional and uncontrolled eating [69, 129, 130].

We have only been able to find one previously published study on the effects of bariatric surgery on the patients' partners' eating behaviour. Woodard *et al* investigated eating behaviour in spouses of RYGB patients using the Three-Factor Eating Questionnaire (TFEQ) and found significant decreases in uncontrolled and emotional eating [91]. Studies on non-surgical populations have found spousal correlation for eating behaviours such as susceptibility to hunger, restraint and emotional eating [131], but we have been unable to find any studies investigating this correlation longitudinally.

When it comes to children's eating behaviour, Watowicz *et al* found that children of bariatric surgery patients, when compared with age- and gender-matched control children of obese parents who had not undergone bariatric surgery, were more likely to report that they ate two or more helpings of food and that they often ate at the wrong time of the day [132]. Woodard *et al*, by contrast, found that a greater proportion of children stated that they were currently on a diet one year after parental RYGB, but found no other changes in the children's eating behaviour [91].

Results from studies on associations between parental and child eating behaviour seem somewhat more consistent than those for body image, with a majority of studies finding an association between parent and child eating behaviour. For example, this has been shown for mothers' dieting behaviour and daughters' unhealthy weight control behaviours [133, 134], degree of dietary restraint displayed by mothers and that of their 10-year-old daughters [135], and for maternal weight concern and the weight concern of their five-year-old daughters [136].

The above studies focus on attitudes, behaviours or concerns modelled by the mother with regards to her own body and eating behaviour, which may then be perceived and copied by the child. However, there is also evidence that parental attitudes and practices towards the child's own eating can influence the child's eating behaviour. Girls as young as five have been shown to be aware of parental dietary restriction and pressure to eat more, and the former was also associated with uninhibited eating in the same sample [137]. Parental restriction of children's food intake has also been shown to lead to a higher intake of unhealthy snack foods by the child [138].

Walters-Bugbee *et al* compared the feeding practices of women who had undergone bariatric surgery with women who were waiting to do so, and found that the women who had undergone surgery were significantly more likely to consciously model healthy eating for their children [139]. However, no other differences in feeding practices were found between the groups.

1.3.9 Changes in food choices in spouses and children

Spousal resemblance in food preferences, as well as actual dietary intake, has been shown in previous research [140-142].

Correlations between parental and child intake of sugar-sweetened soft drinks [143], sweets [144] and fruits and vegetables [145] have also been established. This has also been shown for household availability of the same foods [143, 144, 146].

When it comes to specific studies of changes in the households of bariatric surgery patients, the study by Walters-Bugbee *et al* referenced above also investigated differences in household availability of various foods in the home of women who had undergone bariatric surgery and women who were waiting to do so. However, the adjusted analysis showed no differences in this regard [139].

Whilst it has been shown that the food selection of bariatric surgery patients changes quite drastically after surgery, as described above, there is scant previous research on whether these changes also affect the rest of the family. Woodard *et al* found no changes in spouses' or children's intake frequency of dairy, fruits and vegetables, meats, carbohydrates or fast food [91]. Watowicz *et al* found that children of bariatric surgery patients were more likely to report that they ate fast food on most days, that they drank sugar-sweetened soft drinks several times a week, and that they never ate vegetables, when compared to age- and gender-matched control children living with obese parents who had not undergone bariatric surgery, although these differences did not quite reach statistical significance [132].

1.3.10 Social Learning Theory

Social Learning Theory (SLT) was introduced by Albert Bandura in 1977 [147]. It states that learning can occur not only through direct experience and reinforcement, but also through observing modelled behaviour by others. In order for modelled behaviour to result in successful learning, however, certain processes must occur. The first of these is *attention* – the observer must actually perceive and pay attention to the behaviour being modelled. The attentional process is in its turn influenced by several factors, such as repetition of the modelled behaviour (most easily achieved when the model is someone with whom the observer frequently spends time, such as peers or family members), the characteristics of the model (the behaviour of models who are perceived to have high status is more easily noticed), the complexity and nature of the modelled behaviour, and of course the cognitive abilities of the observer.

Secondly, observers must remember the modelled behaviour if they are going to learn it, meaning that processes of *retention* also play a part in observational learning. This means that modelled behaviour is observed, then stored in the observer's mind through either imaginal or verbal symbols, ready to be recalled and used when the model is no longer present. Rehearsal of observed modelled behaviour is also an important part of the retention process.

The third process is known as *motor reproduction processes*. These are dependent on the observer's own skills at reproducing the modelled behaviour and the more basic skills that it consists of, on being able to self-correct errors, and on receiving feedback on the performance.

Finally, *motivational processes* provide the observer with the incentives to adopt modelled behaviours. This is where reinforcement enters SLT. However, SLT considers reinforcement differently than other reinforcement-oriented theories, such as operant conditioning, which assumes that the modeled stimulus is followed by a response, which is in its turn followed by the reinforcing stimulus. In SLT, reinforcement does not have to be experienced directly by the observer. Seeing a model being reinforced for a certain response will enhance the observer’s attention to and retention of that model’s actions and thus make it more likely that the observer will give that same response at a later time. This is known as vicarious reinforcement. Vicarious reinforcement is in its turn dependent on several aspects such as the context in which it is observed, the model’s emotional reaction whilst receiving the reinforcement, and the perceived status of the model being reinforced.

Lastly, self-reinforcement is an important aspect of SLT. People are not just victims of external influences such as modelled behaviours, but have self-regulative powers that influence their actions in different situations and contexts. Individuals have internally set rules and standards for themselves, and are able to reward or punish their own actions and thoughts. By self-reinforcement, individuals motivate themselves to perform actions that are in themselves unpleasant or uninteresting. The standards by which an individual judges their own behaviour are influenced by the context in which it is performed, the behaviours of others in the same situation, and by the individual’s own performance during the same activities on previous occasions.

2 AIMS

The overall aim of the current PhD project was to contribute to and expand on current knowledge about how female bariatric surgery patients' children and partners are affected by the surgery. More specifically, the aim was to answer the following research questions:

- Are there differences in the BMI and prevalence of overweight and obesity in siblings born before and after surgically induced maternal weight loss (Study I)?
- How are partners of female RYGB patients affected in terms of BMI, symptoms of anxiety and depression, sleep quality and body dissatisfaction (Study II)?
- How are children of female RYGB patients affected in terms of weight status, body esteem and self-concept (Study III)?
- As female RYGB patients have been shown to change their eating behaviour and food choices following surgery, do these changes affect the eating behaviour and food choices of their families (Study IV)?

3 MATERIAL AND METHODS

The current project was based on two separate materials and data collection procedures. The material for Study I consisted of women, identified through register-linkage, who had given birth both before and after undergoing bariatric surgery. The material for Study II-IV consisted of families, all with at least one child between the ages of seven and 14, where the mother was recruited from RYGB waiting lists at five surgical clinics in Sweden. **Table 1** shows an overview of the four studies, and of the material and methods used in each study.

3.1 RECRUITMENT AND DATA COLLECTION FOR STUDY I

The women who were eligible for participation in the study were identified by creating a database by register-linkage. The registers used were the Swedish Medical Birth Register, which covers 99% of all births in Sweden [(148)], the Hospital Discharge Register, with information about all bariatric surgery procedures conducted in Sweden, the Cause of Death Register, the Cancer Register and the Register of the Total Population, containing demographic data on all current residents in Sweden. This register-linkage was made possible by using the personal identification number unique to each resident of Sweden.

This database, created by the Centre for Epidemiology at Sweden's National Board of Health and Welfare, allowed us to identify women treated by bariatric surgery, who had at least two children, one born before and one born after undergoing bariatric surgery.

The 797 women identified in this way all received a letter of invitation, outlining the research question, study design and implications of study participation. The letter also stated that the women would shortly be contacted by telephone and asked whether they wanted to participate. The telephone contact followed approximately ten days after the information letters had been posted.

The main issue in the recruitment of women proved to be establishing contact via telephone. This proved impossible for approximately 350 women. In the instances where telephone contact was not possible, another letter was sent to their officially registered address, again explaining the purpose of the study and including consent forms and a questionnaire, together with our contact details and an invitation to contact us by telephone or e-mail.

Once telephone contact was established, the woman was asked whether she was willing to participate. If she wished to participate, she was asked to provide information about any children she had who were over the age of 18, as we did not have any register-based information about adult children. The woman was also asked to provide the names of the hospitals where she had given birth to her children, for the purpose of acquiring information about the children's birth weight and any complications during the birth.

Table 1: Overview of the four studies.

	Study I	Study II	Study III	Study IV
Title	Surgically induced interpregnancy weight loss and prevalence of overweight and obesity in offspring.	Changes in BMI and psychosocial functioning in partners of women who undergo gastric bypass surgery for obesity.	Children's weight status, body esteem and self-concept following maternal gastric bypass surgery.	Changes in eating behaviour and food choices in families where the mother undergoes gastric bypass surgery.
Material	223 women with a total of 340 children (164 children born before maternal baratric surgery, 176 after).	37 women undergoing RYGB and their partners.	61 women undergoing RYGB, and their 81 children.	61 women undergoing RYGB, 37 partners and 81 children.
Outcomes	Sibling differences in prevalence of overweight/obesity and mean BMI at 4, 6 and 10 years.	Changes from 3 months pre-operatively to 9 months post-operatively in the women's and their partners' BMI, symptoms of depression and anxiety, sleep quality and body dissatisfaction (men only).	Changes from 3 months pre-operatively to 9 months post-operatively in the children's prevalence of overweight and obesity, body esteem and self-concept.	Changes from 3 months pre-operatively to 9 months post-operatively in the families' eating behaviour and food choices.
Measures	BMI, prevalence of overweight and obesity (cut-off points as defined by Cole *et al* [149]).	BMI, waist circumference, Hospital Anxiety and Depression Scale, Karolinska Sleep Questionnaire, Male Body Dissatisfaction Scale.	BMI, prevalence of overweight and obesity (cut-off points as defined by Cole *et al* [149]), Body Esteem Scale, Beck Self-Concept Inventory.	Three-Factor Eating Questionnaire, Children's Eating Attitudes Test, food frequency questionnaire.
Statistical Methods	Linear and logistic regression models with generalized estimating equations (GEE), fixed-effects regression models.	Linear regression models with GEE, McNemar's Test, fixed-effects regression models.	Poisson and linear regression models with robust variance (GEE).	Paired t-test, linear regression models with robust variance (GEE), McNemar's Test, fixed-effects regression models.

After the telephone contact, the women received consent forms in the post, together with a questionnaire containing questions about her pregnancies (her general state of health, prepregnancy weight and weight one year after giving birth, smoking, presence of complications such as gestational diabetes and preeclampsia, prematurity, the children's birth weight and length, perinatal complications, breastfeeding and the children's current height and weight) and about her bariatric surgery. We also sent separate information letters and consent forms to the children who were above the age of 18.

Most of the information gleaned from the questions included in the questionnaire was later acquired from registers or hospital records. The questions were included as a safety measure and with a thought of a possible validation study against the hospital records in order to see how accurate the women's recall was and how it changed over time. This remains a possible future project.

The women and adult children who did not return their questionnaires were reminded at least three times via telephone or post. Those women who found the questionnaire too long or difficult to complete were given the option of answering the questions over the telephone instead, or to only return the signed consent forms.

The telephone recruitment process commenced in March 2010 and was concluded in May 2011. We worked simultaneously with the acquisition of hospital records and growth charts. This was commenced as soon as the first signed consent forms reached us during the Spring of 2010, and was concluded approximately three years later. Growth charts were acquired from child health care centres, from school health care services, or from municipality and county archives, depending on the child's current age. Unfortunately, many of the growth charts for the older children had been destroyed by the archives.

In order to gain information on the women's bariatric procedures (type of bariatric surgery, complications, follow-up weights) we acquired hospital records from the surgical clinics where they had been performed. We also contacted the maternal health care centres where the women had received ante-natal care during each of their pregnancies in order to obtain information on their BMI in early pregnancy and their weight development during pregnancy, as well as any pregnancy complications. We acquired data on the birth weight and length of the children, as well as information on any perinatal complications, from the hospitals where they were born.

When the data collection was concluded, we had collected the necessary information for 223 women and a total of 340 children, of whom 164 were born before maternal surgery and 176 were born after maternal surgery. We also had 71 "complete sets" of child-mother-child triads, where we managed to acquire maternal BMI in both early pregnancies, as well as BMI data for both children at the age of four.

3.2 RECRUITMENT AND DATA COLLECTION FOR STUDY II-IV

Women who were eligible for participation were recruited from the waiting lists for RYGB surgery at the surgical clinics of five Swedish hospitals: Danderyd, Ersta, St Göran, Örebro and Uppsala. Together, these hospitals performed more than 2300 bariatric procedures in 2011 (when recruitment started) and more than 2000 in 2012 (when it was concluded) [(50)]. Inclusion criteria were defined as being cleared for a primary laparoscopic RYGB (no conversions of earlier procedures), having at least one child between the ages of seven and 14, and being able to speak, read and understand Swedish. The age span for the children was chosen so that they would, for the most part, be able to read and complete the questionnaires that were used in the study, but were still young enough to eat with their families and to be at least partly influenced by the food purchases made by their parents. If the women were married to or cohabiting with a partner, he was also asked to participate.

The data collection took the form of two visits to the participating families' homes, the first one approximately three months prior to the RYGB surgery, and the second approximately nine months post-operatively. In nearly all clinics performing bariatric surgery in Sweden, patients are required to adhere to a very-low-calorie diet (VLCD) for a period of time prior to surgery, as this has been shown to decrease the risk of complications during and after surgery [(150)]. The first home visit was scheduled well ahead of the start of the VLCD in order for the data to reflect the true pre-operative situation as closely as possible. The second visit was scheduled a year after the first in order to minimise seasonal variations both in mood and in food intake. The first home visit took place in April 2011, and the very last post-operative home visit was carried out in December 2013.

In total, 69 families were recruited into the study. However, by the time of the second data collection time point, three families had moved away and proved impossible to locate. Two women had decided not to undergo RYGB surgery, and one family declined continued participation in the study. In addition to this, some families failed to return their questionnaires, and there were varying amounts of missing data in the questionnaires that were returned. More detailed data on exact number of observations for the different outcomes is given in the relevant articles.

During the data collection visits, all participating family members were weighed using calibrated scales (VB2-200-EC, Vetek AB, Väddö, Sweden), their height was measured using a portable stadiometer (Seca 213, Seca, Chino, CA, USA), and their waist circumference was measured. Their body composition was also assessed using BIA (Quantum II, RJL Systems, Clinton Township, MI, USA). The psychosocial and behavioural variables of interest were measured using a range of questionnaires (described below).

At the time of the second home visit, the families were given one cinema ticket voucher per person participating in the study.

3.2.1 Psychometric instruments used

Descriptions and references on the various psychometric scales and instruments used in Study II-IV will follow below.

3.2.1.1 Hospital Anxiety and Depression Scale (HADS)

The HADS is a 14-item questionnaire, originally designed for the assessment of symptoms of anxiety and depression in outpatient (non-psychiatric) clinical settings (hence the word "hospital" in the title) [151]. However, it has been used in many other situations, and found to possess acceptable validity in a range of populations, including the general population [152].

The HADS consists of two subscales, HADS-Anxiety (HADS-A) and HADS-Depression (HADS-D). They have seven items each, such as "I feel tense or 'wound up'" (HADS-A) and "I look forward with enjoyment to things" (HADS-D), to which the subject responds by choosing one out of four alternatives indicating more or less agreement with the statement items.

The items are scored between zero (for the least symptom-indicative level of agreement) to three (for the most symptom-indicative level of agreement) and then added up for a total score between zero and 21 for each subscale. The cut-off points of eight and 11 for either scale have been found to be indicative of possible and definite "caseness" for either mood disorder, respectively [152, 153]. It is, however, not a diagnostic tool, but rather an instrument with the ability to indicate which individuals should be considered for further clinical investigation with these mood disorders in mind. The Swedish version of the HADS that was used in the present PhD thesis has been subjected to a factor analysis and found to have high validity [154].

3.2.1.2 Karolinska Sleep Questionnaire (KSQ)

The KSQ is a 13-item self-administered questionnaire measuring symptoms of insomnia, disturbed sleep, repeated awakenings, early awakenings, difficulties in waking up, insufficient rest, nightmares, snoring and daytime sleepiness [155]. The items group together to form an insomnia index, an index of awakening problems, a snoring index, and a sleepiness/fatigue index. This structure has been confirmed using factor analysis [156, 157].

The items are scored by the respondent, using a six-point Likert-type scale, according to how often he or she experiences the different symptoms or problems (difficulties falling asleep, nightmares, sleepiness during work hours, etc). When adding the scores, the option "never" (indicating no symptoms) is given six points, and the items are then graded with falling values according to how often the subject experiences the problem, with "always" being given a zero scores. Thus, the higher the score, the higher the sleep quality.

3.2.1.3 Male Body Dissatisfaction Scale (MBDS)

The MBDS is a relatively new instrument, developed by Ochner *et al* in 2009 to specifically address areas of body dissatisfaction relevant to men [158]. It consists of 25 statement items addressing different body parts as well as desire to both lose weight (body fat) and gain weight (muscle mass), such as “I wish I could lose more fat”, “I think my pectoral (chest) muscles are well developed”, and “I wish I had better muscle definition”. The respondent states to which extent he agrees with each statement by choosing one out of five options on a Likert-type scale, ranging from “Strongly agree” to “Strongly disagree”. In addition, the respondent is asked to state how important each item is to him by giving it a value between one and 10. That number is then divided by ten, and the final score is arrived at by multiplying the item response (between zero and five) with the weighting value. Higher scores indicate more body dissatisfaction.

The MBDS has been shown to have acceptable validity and test-retest reliability [158]. It has also been translated into French, and shown to have acceptable validity in this version, too [159]. The MBDS did not exist in a Swedish version prior to the present PhD project, and was translated for the purpose of being used in Study II, using the method of translation and back-translation recommended by the WHO [160]. However, no validation study has yet been undertaken for the Swedish version of the MBDS.

3.2.1.4 The Body-Esteem Scale (BES)

The BES is a 23-item questionnaire, containing three subscales measuring three dimensions of body esteem; weight concerns (BES-W), appearance (BES-APP) and attribution (BES-ATT) [161]. The items are in the form of statements, such as “I feel I weigh the right amount for my height” (BES-W), “I like what I look like in photos” (BES-APP), and “My friends like my looks” (BES-ATT). The original BES only gave the respondent the choice between “yes” and “no” for each statement, in order to make it easily understandable for young children [161]. However, it was later developed into a version suitable for use with adolescents and adults, and the response format was then expanded to a five-point Likert-type scale ranging from “Never” to “Always” [111].

The Swedish version of the BES used in the present project was developed by Erling and Hwang [162]. It uses the questions from the original BES, which are more suitable for children, but with the Likert-type scale from the adult and adolescent version.

The BES has been shown to have good validity and reliability [111, 112, 114].

3.2.1.5 Beck Self-Concept Inventory (BYI-S)

The Beck Youth Inventories consist of five different self-administered scales, measuring symptoms of anxiety, depression, anger, disruptive behaviour and self-concept in children between the ages of seven and 14 [163]. The self-concept scale which was used in the current project consists of 20 statement items (such as “I work hard”, “I feel normal” and “I tell the truth”) measuring the respondent’s perceptions of their own competency, self-worth and positive relationships with others [163]. For each statement, the respondent indicates one out of four points on a Likert-type scale, ranging from “Never” (zero points) to “Always” (three points). The raw score acquired by summing these points is then transformed into a percentile rank, based on the results of a large general population sample of children (2360 Swedish school children were used to create the normative data for the Swedish-language version used in the current project). A score which falls between the first and the 10th percentile is categorised as very low self-concept, between the 11th and the 25th as somewhat low self-concept, between the 26th and 89th as average self-concept, and a score above the 90th percentile is considered indicative of a high self-concept.

The Beck Youth Inventories have been shown to have acceptable validity and reliability [(164)].

3.2.1.6 The Three-Factor Eating Questionnaire (TFEQ)

The TFEQ was constructed in the 1980's and was in its original version a 51-item questionnaire designed to measure three dimensions of eating behaviour: "cognitive restraint of eating", "disinhibition of eating control", and "susceptibility to hunger" [(165)].

However, later factor analysis resulted in a reduction in the number of items down to 21, with the three dimensions Cognitive Restraint (TFEQ-CR), measuring conscious restraint of food intake in order to lose weight or not to gain weight, Uncontrolled Eating (TFEQ-UE), measuring the respondent's tendency to lose control around food when feeling hunger or being exposed to external food cues, and Emotional Eating (TFEQ-EE), measuring the tendency to eat in response to emotional cues such as sadness, anxiety or boredom [(166)]. This version of the TFEQ has been shown to have acceptable validity, and was the version used in the current project [(166)]. It has been used with both obese (including RYGB patients) and non-obese Swedish samples [(69, 167, 168)].

The TFEQ, in its 21-item version, consists of six items in the Cognitive Restraint dimension (such as "I consciously hold back at meals in order not to gain weight"), nine items in the Uncontrolled Eating dimension (such as "Sometimes when I start eating, I just can't seem to stop") and six in the Emotional Eating dimension (such as "When I feel lonely, I console myself by eating") [(166)]. The respondent indicates their level of agreement with the statement or question by marking one of four options on a Likert-type scale. The responses are then scored, with a higher score indicating higher levels of cognitive restraint, uncontrolled or emotional eating.

3.2.1.7 Children's Eating Attitudes Test (ChEAT)

The ChEAT was adapted from the Eating Attitudes Test, a 26-item self-administered questionnaire designed to measure dieting behaviour, food preoccupation, anorexia, bulimia and concerns about being overweight in the adult population [(169)]. Reliability testing was performed when the instrument was being adapted for use by children, and was shown to be good [(169)]. A later validation study also showed good reliability and validity [(170)]. This was also the case for the Swedish version of the ChEAT used in the current project [(171)].

The items in the ChEAT are in the form of statements. The respondent indicates how often each statement is similar to their own behaviour or thoughts by marking one out of six options on a Likert-type scale ranging from “Always “ to “Never”. When scores are set, “Always” receives three points, “Very Often” two and “Often” one point. The remaining alternatives (“Sometimes”, “Rarely”, and “Never”) receive zero points, resulting in a possible score between zero and 78. A score ≥20 has been suggested as indicative of Anorexia Nervosa and an indication that further investigation should be implemented [169].

3.2.1.8 Food Frequency Questionnaire (FFQ)

The FFQ used in the present project was adapted from a version developed by the Swedish National Food Administration [172]. It contains questions on intake frequency of fruit, vegetables, whole-grain bread, fish and seafood, French fries, sausage, full-fat cheese, chocolate and other sweets, biscuits and cakes, sugar-sweetened beverages and type of dietary fat used for cooking and for sandwiches, as these foods have been found to reflect the amount of total fat, saturated fat, sugar and fibre in the diet, and that these nutrients in their turn are indicative of the degree of dietary healthiness in a Swedish population [172]. The FFQ was validated against repeated 24-hour recall interviews and was found to have acceptable validity [172]. The FFQ has also been further validated against an eight-day food diary using a sample of mothers and their children; again, the validity was found to be acceptable [173].

3.3 STATISTICAL ANALYSIS

The studies in the current project have a longitudinal design, i.e. analyses are based on repeated measurements within individuals (or, in the case of Study I, measurements on different children of the same mother).

All four studies used some form of linear, logistic or Poisson (relative risk) regression models estimated with generalized estimating equations (GEE). A complication when using repeated measurements within the same individuals is that observations are not independent. If this within-cluster correlation is not taken into account, standard errors and consequently p-values and confidence intervals will not be correct [174]. This may be addressed by the use of GEE, which allow outcomes to be correlated within an individual by using a so-called robust (or sandwich) variance estimator [174].

When the prevalence of an outcome is not rare, the odds ratio estimated by logistic regression will overestimate the relative risk (prevalence ratio). In Study III we therefore used a modified Poisson regression model with robust variance [175] to estimate relative risks.

When there are only two measurements within individuals, as in these studies, the fixed-effects regression model is a just a linear regression on the differences within the individual on the outcome and the independent variables. The strength of this longitudinal analysis is that all factors that remain stable (fixed) over time, whether measured or not, such as genetics and/or shared environmental factors, are controlled for [176].

Unadjusted within-individual comparisons were performed using McNemar’s test for binary outcomes [177] and paired t-tests for continuous outcomes.

All analyses in all studies were performed using STATA 12.1 (Stata Corp, College Station, Texas, USA).

3.3.1 Statistical methods used in Study I

Linear regression models with GEE were used to test the differences in mean BMI at ages four, six and 10 between the groups of children born before and after maternal bariatric surgery. The models were adjusted for maternal age and maternal education as well as for child's birth year, birth order, and sex.

For the 71 child-mother-child triads where we succeeded in acquiring BMI data for both pregnancies and both children, fixed-effects regression models, adjusted for children's sex, maternal age, smoking in pregnancy, birth order and prepregnancy BMI, were used to investigate the association between the difference in maternal BMI in approximately week 10 of the two pregnancies and the difference between the children's BMI at age four.

3.3.2 Statistical methods used in Study II

In Study II, linear regression models with GEE, as described above, were used to evaluate changes in the partners' BMI, waist circumference, HADS, MBDS and KSQ scores between the two time points. For dichotomous variables, such as prevalence of overweight and obesity, we used McNemar's test [(177)]. We also performed the analyses using only those men who were themselves overweight or obese at the time of the first data collection. Finally, we employed a fixed-effects regression model to analyse the association between changes in the woman's weight, HADS and KSQ scores and those of her partner. We performed this analysis both unadjusted and adjusted for the women's baseline BMI.

3.3.3 Statistical methods used in Study III

The children were categorised as normal weight, overweight or obese using the cut-off points established by Cole et al [(149)]. These cut-off points are sex-and-age specific and are designed to cut through BMI 25 (overweight) and BMI 30 (obesity) at age 18. A modified Poisson regression model with robust variance, adjusted for sex and age, was used to estimate differences in the children's relative risk of overweight and obesity [(175)].

Changes in the children's BES and BYI-S scores were evaluated with linear regression models with GEE, as outlined above. We also transformed the differences in BES and BYI-S scores into standard deviation (SD) scores in order to estimate their effect size.

3.3.4 Statistical methods used in Study IV

As no adjustments were deemed necessary for the evaluation of the differences in the parents' TFEQ and FFQ scores, these were performed using paired t-tests. For the changes in the children's ChEAT and FFQ scores, however, we used linear regression models with GEE in order to be able to adjust the models for the children's sex and age. We also used interaction terms to see whether any possible changes differed between boys and girls, and between normal weight and overweight/obese children.

We also used fixed-effects regression models to explore possible associations between changes in maternal TFEQ scores and in partners' TFEQ and children's ChEAT scores. As in Study III, we also transformed changes in scores of psychometric instruments into SD scores in order to assess effect size.

3.3.5 Missing data

All psychometric instruments used (HADS, KSQ, MBDS, BES, BYI-S, TFEQ, ChEAT, FFQ) had some missing values for some participants. These missing values were evaluated using multiple imputation models [(178)] assuming that data was missing at random (MAR). We used two approaches: 1) imputing missing items within a particular instrument and then summing to total scores and 2) imputing directly on missing total score level, also using auxiliary variables such as BMI and education in the imputation model. We used both chained equations with predictive mean matching and a multivariate normal regression model. The results, however, did not differ significantly from analysis of complete cases, and all articles subsequently only present those results.

3.4 ETHICAL CONSIDERATIONS

The studies included in the current PhD project were subjected to ethical evaluation and approved by the Stockholm Regional Ethical Review Board (reference numbers 2009/709-31/2; 2009/1472-31/3). However, it is still important to be aware of and to discuss any possible ethical issues in relation to the project.

3.4.1 Ethical considerations in Study I

For the women who participated in Study I, the main ethical issue was that of access to personal and potentially sensitive information. We identified the women through linkage of various registers (see Recruitment and data collection for Study I, above), and some of the women may have felt uncomfortable about being contacted by strangers who had access to information about them, such as the fact that they had undergone bariatric surgery, which may have been considered sensitive by some of them. Very few of the women voiced such concerns, and when this happened, the contact was ended quickly with no objections or pressure to participate from our side. Nonetheless, it is possible that the contact caused distress.

Some of the women, especially those who had undergone earlier versions of bariatric surgery, felt that the decision to undergo the procedure had been disastrous for their mental and/or physical health. On the one hand, they welcomed the possibility to talk to someone about these issues, even though this was not the purpose of the study, but on the other hand this also caused frustration for some of them, as we were unable to give medical advice or help them. Many of the women were happy that research was being conducted on their situation and on the effects their surgery might have had on their children.

When it came to the children of the women, the younger children (below the age of 18) did not give their consent to participate in the study, as the women's consent covered themselves and any minors. For these children, their participation only consisted of copies of their growth charts being sent to us by staff at their child health centres or school health services, and it is unlikely that they would even be aware of their participation, unless their mothers chose to tell them about it. For the children who were above the age of 18, separate written consent was required. In a few cases, adult children were unhappy that we had access to information about their mothers' surgery, but these were very rare.

In conclusion, there were relatively few potential ethical considerations in this study, and on balance, it seems likely that the potential benefits of conducting research in this relatively new field far outweighed any possible negative consequences for the participants.

3.4.2 Ethical considerations in Study II-IV

With the second data collection, for Study II-IV, our main ethical concerns were that the children would somehow feel coerced or pressured to participate, or that they may in some way be negatively influenced by the methods used. As the parents gave consent both for themselves and for their children, we made sure to also ask the children whether they consented to being weighed, measured etc. Two children did not want to be weighed, which we naturally respected without asking again or trying to convince them.

When it comes to potentially negative effects of the methods used in the data collection, most Swedish children are weighed and measured regularly by the school health services, so it is unlikely that they would have been bothered by this, especially since they were given a clear opportunity to decline. As for the questionnaires, there is a theoretical possibility that the questions in, for example, ChEAT may have triggered eating disordered behaviours or thoughts in the children. However, previous research tells us that this is a very unlikely possibility [179]. Additionally, the participating families were encouraged to contact us if they had any questions or concerns. The research team includes professor of Clinical Psychology Ata Ghaderi, who would have been able to direct the families to suitable assistance if the need arose. It should also be added that the majority of the children took a keen interest in the data collection, asked numerous questions and seemed to enjoy their participation. Furthermore, a number of the participating women welcomed the data collection home visits as a convenient opportunity to speak to their children about the impending RYGB surgery and what it would entail.

On balance, the risks involved for the participating families must be considered minimal, and the potential benefits of the studies far outweigh any such risks.

4 RESULTS

I will now give an overview of the results for each of the studies included in the current PhD thesis.

4.1 MAIN RESULTS FOR STUDY I

The 223 women who participated in the study went from a mean BMI of 36.0 in the beginning of their pre-operative pregnancy to 31.7 in their post-operative pregnancy. We managed to ascertain type of bariatric surgery for 203 of the women, and most of these (147 women or 72%) had undergone restrictive surgery, such as VBG and AGB. They had a smaller mean weight loss than the 56 women (28%) who had undergone RYGB or JIB (2.0 BMI units vs 6.2 BMI units).

The children who were born before surgery were more likely to be LGA (16% vs 6%), less likely to be SGA 6% vs 14%), and more likely to have been exposed to maternal smoking during pregnancy 39% vs 29%). They were a mean 142 grams heavier at birth than their siblings born after maternal surgery.

When we evaluated differences in BMI at the ages of four, six and 10 between the groups of children born before and after surgery, it was found that the children born after surgery were consistently heavier than the children born before surgery. We performed the analyses for the whole age groups and stratified on sex, and found that the adjusted mean differences in BMI were largest for six-year-old boys (1.33 BMI units, p = 0.055), 10-year-old girls (1.90 BMI units, p = 0.077) and 10-year-old boys (1.60 BMI units, p = 0.177). They were smallest for six-year-old girls (0.27 BMI units, p = 0.681) and four-year-old girls (0.41 BMI units, p = 0.494), but at no age were the children born before surgery heavier than those born after surgery.

We then explored differences in prevalence of overweight and obesity at the same ages. The adjusted OR for overweight was above 1 for all age groups except for four-year-old girls, where it was estimated at 0.88, though far from significance with p = 0.736. In contrast, the OR for four-year-old boys was 2.34 (p = 0.066). For the 10-year-olds, the OR was 2.55 (p = 0.032). When stratifying the analysis on sex, the OR for the girls was 3.00 (p = 0.036) and 2.38 for the boys (p = 0.231).

Finally, we conducted a fixed-regression analysis with differences between maternal BMI at week 10 of the two pregnancies as the exposure variable and differences in the siblings' BMI at age four as the outcome variable. The fully adjusted model produced a regression coefficient of -0.01 (95% CI = -0.11; 0.09, p = 0.840). **Figure 2** shows the siblings' BMI at age four (on the y axis), in relation to the mothers' BMI in week 10 of the two pregnancies (on the x axis).

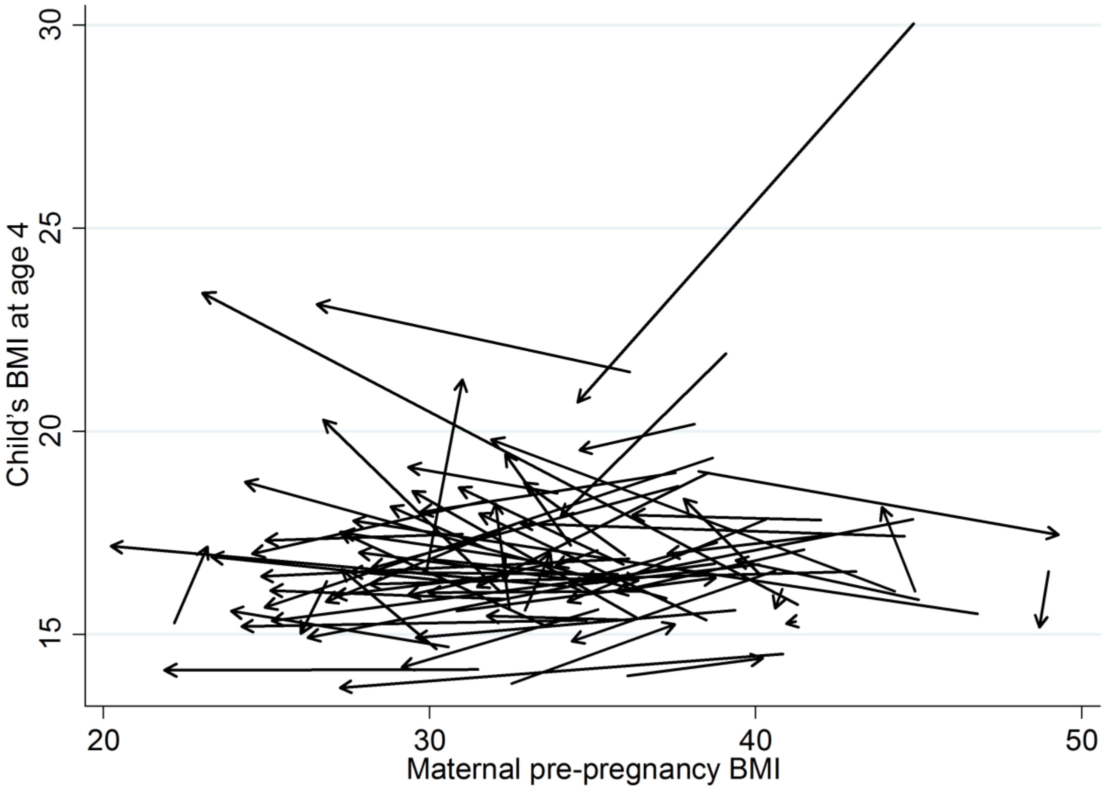


Figure 2. Scatterplot showing maternal BMI in week 10 of both pregnancies and siblings' BMI at age four.

4.2 MAIN RESULTS FOR STUDY II

The 37 women who were included in this study lost a mean 11.7 BMI units (33.2 kg) between the two data collection time points. Their partners lost a mean 0.9 BMI units (2.5 kg) and decreased their waist circumference by 4.7 cm during the same time period. When stratifying men by weight status at baseline (normal weight or overweight/obese), it became apparent that the observed weight loss was driven by the 26 men who were overweight or obese at the time of the first data collection time point. They had lost a mean 1.4 BMI units, or 4.5 kg, and their waist circumference had decreased by a mean 5.8 cm. These differences were all found to be significant when evaluated with linear regression models with GEE, as described above. We also used a fixed-effects regression model to see whether there was an association between the women's weight loss and that of their partners, and this showed that for every BMI unit the woman lost, her partner lost a mean 0.3 BMI units ($p = 0.007$). This relationship was strengthened slightly when adjusting for the women's baseline BMI ($\beta = 0.4$, $p = 0.002$). **Figure 3** shows a scatterplot of the association between the women's and their partners' weight changes.

As for prevalence of overweight and obesity, this did not change to any significant extent. Three of the men went from being obese to being overweight, and one went from normal weight to overweight.

Whilst the women improved their HADS and KSQ scores significantly in all dimensions, indicating less symptoms of anxiety and depression and improved sleep quality, we saw no changes in the partners' scores for the same variables, nor did we see any changes in their body dissatisfaction as measured by the MBDS. Furthermore, we saw no association between changes in the women's and the men's scores on the HADS and KSQ when evaluating this with fixed-effects regression models.

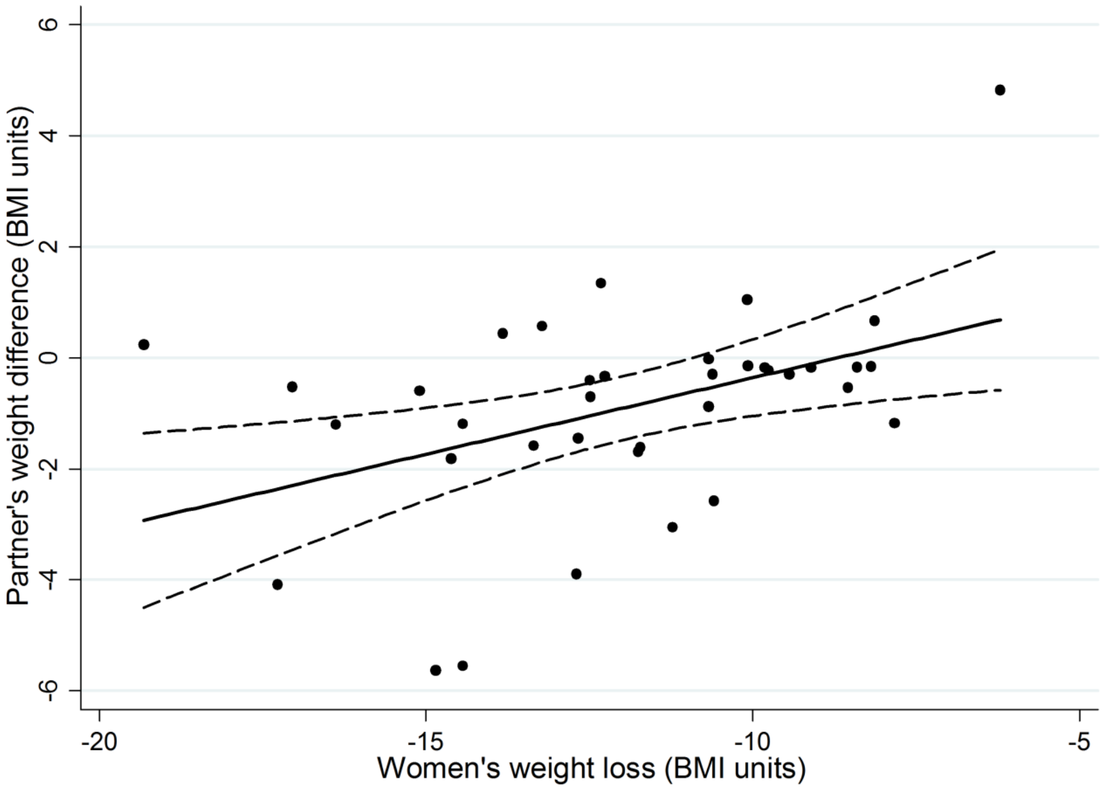


Figure 3. Scatterplot showing the women's weight loss following RYGB surgery, partners' weight change during the same time period, and the regression line with 95% confidence intervals. β = 0.3, p = 0.007.

4.3 MAIN RESULTS FOR STUDY III

The dataset for Study III included 61 women and 81 children (mothers and their children were included in the dataset if they had participated in both home visits and provided anthropometrical data for both occasions). We found that when adjusting the model for the children's sex and age, the prevalence of overweight and obesity went from 57.0% to 48.6%, reflecting a relative risk of 0.85 (95% CI 0.73; 1.00, p = 0.048). For obesity only, the prevalence went from 18.2% to 15.9%, giving a relative risk of 0.87 (95% CI 0.62; 1.24, p = 0.447).

We analysed the differences in the children's BES and BYI-S scores both for all children together, and stratified on sex and weight status at baseline (normal weight or overweight/obese). For the weight concerns dimension of the BES (BES-W), we found that the boys improved their score by a mean 1.8 points (SD score = 0.28, p = 0.058), whilst the girls' score decreased by 0.84 (SD score = -0.13, p = 0.307). This difference between the groups was shown to be significant when evaluated with an interaction term (difference = 2.64, SD score = 0.41, p = 0.016).

The children's mean BYI-S score were in the 75^{th} percentile before maternal surgery and in the 73^{rd} percentile afterwards, reflecting normal self-concept at both time points with no significant changes for any group.

4.4 MAIN RESULTS FOR STUDY IV

The women's TFEQ scores indicated significantly increased cognitive restraint (by a mean 2.1 points, 95% CI 0.78; 3.43, p = 0.002), as well as decreased emotional eating (-5.3, 95% CI -6.66; -3.96, p ≤0.001) and uncontrolled eating (-7.78, 95% CI -9.62; -5.93, p ≤0.001). The men, however, did not change their scores significantly in any of the TFEQ dimensions, although their cognitive restraint increased by a mean 0.96 points (95% CI -0.11; 2.03, p = 0.079).

The children's ChEAT scores were analysed both for the entire group and stratified on sex and weight status, as described above. It was found that the boys in the sample had improved their score by 1.63 points (95% CI -2.90; -0.36, p = 0.012), whilst the girls' score showed a much smaller, non-significant change (-0.54, 95% CI -2.78; 1.70, p = 0.637).

When stratifying the analysis on weight status, it was found that the children who were overweight or obese at baseline had improved their ChEAT scores by a mean 1.69 points (95% CI -3.13; -0.25, p = 0.022), an improvement not shared by the normal weight children whose score only changed by a mean -0.37 points (95% CI -2.52; 1.78, p = 0.737).

The FFQ showed that the women had increased their intake frequency of fruits and vegetables by approximately two occasions per week (95% CI 0.57; 3.43, p = 0.007), halved their intake of sweets and baked goods from approximately 4 to 2 occasions per week (95% CI -3.37; -1.18, p ≤0.001) and almost completely stopped consuming soft drinks (from 2.2 times per week to 0.3 times per week, 95% CI -2.53; -1.17, p ≤0.001). The men, however, showed only very small and non-significant changes in their intake frequency of the same foods.

When analysing the differences in the children's FFQ scores, we found that the children who were normal weight at baseline had reduced their consumption of soft drinks by 1.25 occasions per week (95% CI -2.48; -0.01, p = 0.048), a change which was not seen in the overweight/obese children (difference = 0.14, 95% CI -0.61; 0.90, p = 0.710). There were no significant or meaningful changes in intake of other foods.

5 DISCUSSION

The aim of this thesis was to try and shed some light on different ways in which bariatric surgery may influence the patients' families. We attempted to do this by comparing weight development in children born before and after maternal bariatric surgery, and by investigating changes in families' eating habits and eating behaviour as well as various aspects of psychosocial functioning following RYGB.

5.1 DISCUSSION STUDY I

Previous studies, although few in number, have found that children born after maternal bariatric surgery (AS) are generally lighter and less prone to overweight and obesity than children born before surgery (BS). As mentioned in the Introduction, Kral *et al* came to this conclusion when studying 217 children (172 born BS and 45 born AS) born to 113 mothers who all underwent BPD [(83)]. They found that 60% of children born BS were overweight or obese, as compared to 35% of the children born AS. In a later study using the same material, they also found greater insulin sensitivity, improved blood lipid profiles, lower leptin levels and increased ghrelin levels in the children born AS [(84)].

Another study, by Barisione *et al*, explored weight differences in 84 children (45 born BS, 39 born AS) born to 37 women undergoing bariatric surgery [(86)]. They found that more children born before than after surgery were rated by their mothers as having been obese at 12 years of age. However, this study relied on retrospective, subjective data given by the mothers during telephone interviews, and thus may have some inherent methodological problems.

Study I of the present thesis aimed to contribute further knowledge on this topic. However, the resultant findings showed that the proportion of overweight four-year-old boys born AS was almost double that of the BS group, and the same was true for obesity in the same group. Amongst the ten-year-olds there was also a significantly higher obesity prevalence in the AS group. Furthermore, when using the 71 child-mother-child triads where we had complete data, we found no association between the degree of difference in the maternal prepregnancy BMI and that in siblings' BMI at age four.

A very important factor to consider is the type of surgery used. The fact that most of the women in our study (147, or 72%) underwent restrictive surgery (VBG, AGB, or horizontal gastroplasty) may have impacted the results in two ways.

Firstly, their mean interpregnancy weight loss was much smaller than that of the women whose bariatric surgery was conducted using RYGB or JIB (2.0 BMI units vs 6.2). The overall mean degree of weight loss between pregnancies in our sample was "only" 4.3 BMI units, with a mean BMI of 36.0 and 31.7 at the beginning of the pregnancies before and after surgery, respectively. As a BMI of 36 is barely above the commonly used limit for approval of bariatric surgery in Sweden (currently 35, in the presence of co-morbidities such as T2DM or joint pain), it is likely that at least some of these women gained large amounts of weight during their pregnancies which they were then unable to lose after giving birth. This would have lead them to seek bariatric surgery, lose weight and then become pregnant again – indeed, obesity-related infertility is one of the reasons women seek bariatric surgery [180].

In the case of AGB, it is also likely that some of the women had to have the band removed at some point after surgery, as this tends to be the case for a significant proportion of patients due to complications such as band erosion, esophagitis or band slippage [181]. We did our best to identify these women, but in many cases hospital records proved elusive, especially if the surgery took place a long time ago.

Secondly, it is possible that RYGB, but not purely restrictive procedures such as AGB, results in epigenetic changes in the mother, which may then be passed on to the child and make him or her less prone to developing obesity. As mentioned in the Introduction, Guenard *et al* have published a paper comparing methylation levels of genes involved in cardiometabolic pathways in 25 children born BS and 25 born AS and found differences favouring the children born AS, supporting this theory [85]. In addition to this, Kirchner *et al* compared DNA methylation in the blood of 18 obese RYGB patients after 14 days of pre-operative VLCD with levels found after RYGB surgery [182]. They found that RYGB produced differences in methylation above and beyond those caused by caloric restriction only (comparable with the result of a restrictive procedure such as AGB or VBG).

It is not immediately obvious why, in some age groups, the children born AS displayed much higher prevalences of overweight and obesity than the children born BS. A possible explanation, although one that cannot be proven or disproven within the present project, is that the women's feeding practices or the food availability in the household may have changed following surgery, and that this somehow affected their children's weight status negatively. The women may have continued to habitually buy high-sugar or other high-energy food items out of habit, which were then eaten by their children, as bariatric surgery patients often cannot tolerate these themselves.

The surgery may also have caused the women to develop feeding practices that might have increased the risk of overweight or obesity for the child born after surgery. For instance, cognitive restraint in relation to food intake usually increases after surgery. This was the case both in Study III of the current thesis and in other previous studies [91, 183]. Cognitive restraint, in its turn, has been shown to impact maternal feeding practices negatively, with mothers attempting to restrict and control the child's intake, thus increasing the risk of future obesity in the child [184-186]. It has also been shown that parental concern for the child's weight, and for their own weight, is associated with restraining the child's intake [185]. It does not seem unlikely that a woman who has undergone bariatric surgery in order to lose weight, even if (or perhaps especially if) the surgery did not have the intended effect, may attempt to restrain food intake more in the child born after surgery than in the child born before surgery. The reasons for this may be that she is scared (consciously or unconsciously) that the child will have to undergo bariatric surgery itself when older, that the child born before surgery is already overweight or obese and she does not want the same thing to happen again, or that she is simply more aware of which foods are "wrong" and wants to stop her child from consuming them. Faith and Kern also point out that for older children who are overweight and who need to lose weight or to keep their weight stable, restriction of access to energy-dense foods may be a beneficial thing [187]. They argue that parental restriction may be more detrimental to the future weight status of younger children, who have not yet established independent eating patterns, than to older children or adolescents who already suffer from obesity. This fits in well with the scenario in Study I.

5.1.1 Limitations

There are several limitations that should be taken into consideration when discussing the findings of Study I. The sample size was relatively small, despite our best efforts during the recruitment phase of the study. This was due to a variety of reasons; we only managed to reach approximately half of the women identified as eligible by register-linkage, as the remaining women had no telephone numbers publically listed; we had trouble locating growth charts for many of the older children, as these had often been lost or even destroyed by the archives; and it also proved problematic to locate ante-natal health records for some of the women in order to obtain information about their weight in early pregnancy. However, although sample sizes were reduced as a result of this, they were still larger than that in the studies by Kral *et al* and Barisione *et al* [83, 86]. It also seems unlikely that any of the reasons for the small sample size outlined above would have introduced any systematic bias into the recruitment process. Possibly, women with lower socioeconomic status may be more likely not to have publically listed mobile telephone numbers (as the most common reason for this is having unregistered, pay-as-you-go SIM cards, which do not require credit checks, as opposed to contract mobile telephone options, which are normally publicly listed). However, we tried to counteract this by also sending out the information in the post to the women we were unable to reach by telephone.

Another limitation is the heterogeneity of the participating women in terms of type of surgery used. As discussed above, it is possible that bypass procedures such as JIB, RYGB and BPD may influence the patient and her future offspring in different ways than purely restrictive procedures such as VBG and AGB. With this in mind, it seems possible that the results may have been different if only mothers who had undergone JIB, RYGB or BPD had been included in the study. In any case, a more homogenous sample would have been helpful when it comes to drawing conclusions from the results. However, this was impossible to achieve without samples becoming too small for any kind of meaningful analysis.

5.1.2 Directions for future research

As already mentioned, it would be of great interest to repeat Study I using only patients undergoing RYGB or BPD, if somehow a sufficiently large sample could be acquired. It would also be interesting to compare the results of the restrictive bariatric surgery patients in the current study with those of a larger RYGB/BPD sample. When it comes to the children, future research may want to investigate their weight development in adulthood, in order to find out whether the results persist.

5.2 DISCUSSION STUDY II-IV

As Study II-IV are based on various aspects of the same material, it seems natural to discuss these results together. This makes it possible to compare and relate findings across the different studies.

Study II and III were concerned with weight change in family members, amongst other outcomes, and found that participating male partners who were themselves overweight or obese (which was the majority of the men, around 70%) experienced significant weight loss and reduction of waist circumference.

The overweight or obese partners' mean 4.5 kg weight loss was equivalent to a mean 4.4% total weight loss. It is interesting to view this result in comparison to dietary interventions, which typically produce less than 5 kg weight loss long-term [188]. Although it may be a little misleading to compare the men's results, which were measured only nine months after the women's RYGB, with weight loss results after longer follow-up periods, the RYGB induces more or less permanent changes in the patients' eating habits, and so it seems reasonably likely that any ripple effects in the partners should also be permanent.

The results for the partners' weight change are in line with those of Woodard *et al*, who also saw a decrease in BMI for obese adult family members [91]. However, they are discordant with those of Madan *et al*, who reported that the obese partners of RYGB patients in their study *gained* weight during the follow-up. It is difficult to say what caused these discordant findings, but it is possible that the couples taking part in the Madan study had lower socioeconomic status than those in the present thesis, as socioeconomic status has been associated with greater readiness to make changes in lifestyle habits [189].

This apparent ripple effects on the partners of RYGB patients may be due to decreased intake of the high-energy foods that are commonly avoided by patients after surgery. Non-surgical weight loss interventions have been shown to influence untreated partners' weight, seemingly through the emulation of the treated spouse's new dietary habits [87, 88]. In the case of the current thesis, however, Study IV showed no changes in the partners' intake frequency of soft drinks, sweets, fruits or vegetables. However, it is possible that the *amount* the men regularly consumed of these foods may have changed, even though their habitual consumption frequency stayed the same. Reduced portion sizes is an important feature of the meal pattern after RYGB [67, 69], and it is possible that the women's decreased portion sizes after surgery influenced their partners to also reduce the amount they ate. This may explain both their weight loss and the lack of change in their FFQ results. However, there is also a possibility that the FFQ did not reflect their actual intake, as it has been shown in previous research that the use of FFQs to measure food intake is associated with a certain degree of misreporting, even with validated versions [190, 191]. It is also possible that their weight loss was due to other dietary changes than those measured by the FFQ used in Study IV, which only measured a very limited number of foods, indicative of overall healthy eating habits [172]. If the womens's physical activity increased following RYGB, the partners' physical activity may also have increased as a result, which could have been an explanatory factor for their weight loss. However, a study investigating changes in the physical activity levels of the women in Study II-IV showed no increases [192], and another study, yet to be published, on the same variables for partners and children shows no changes in the partners' physical activity, either.

The partners' weight loss results were partly replicated in the children, whose relative risk of overweight and obesity after maternal surgery was reduced by 15%. When analysing obesity separately, we found a decrease of 13%, although this did not reach statistical significance. However, this may have been caused by the small sample size and resultant low power as only 15 children were obese at baseline. The reductions in relative risk of overweight and obesity are partly in accordance with the results reported by Woodard *et al* who found that obese children had a lower-than-expected BMI one year after parental RYGB, although this difference did not quite reach significance, possible due to the very small sample size (only 15 children were included in that study, of whom 11 were obese) [91].

A case-control study by Hirsch *et al*, comparing the BMI development of children living in households where an adult had undergone bariatric surgery with that of children in households with obese adults who had not done so, found that overweight boys had a lower-than-expected BMI following parental surgery, in comparison with the corresponding control group, which had a higher-than-expected BMI [94]. Whilst there may be a parallel between these findings and those of Study III, where we also found a significant decrease in the children's relative risk of overweight, but not obesity alone, it does seem possible that the lack of significance for the decrease in obesity in our study may be due to low power rather than a true lack of effect, as already mentioned. Furthermore, in our sample of children the decrease in overweight risk was mainly driven by the girls, not the boys.

Whilst the children's decrease in relative risk of overweight was less pronounced in boys than in girls, the boys showed improvement in several of the psychosocial and food intake variables where there was no discernible difference for the girls. The boys' score on the weight concern dimension of the BES increased by 1.8 points (SD score = 0.41, approaching a moderate effect size), indicating higher body esteem in this dimension. The boys also improved their ChEAT score by 1.63 points (SD score = -0.39, again approaching a moderate effect size), indicating improved eating behaviour. Finally, they reported a reduced intake frequency of sugar-sweetened soft drinks by almost one occasion/week. However, the boys had unchanged scores (both in terms of statistical significance and effect size) on the BES-APP, BES-ATT, BYI-S and in terms of their sweets and fruit and vegetable intake. The girls, by contrast, had no significant changes in scores for any of the psychometric instruments used, or for the FFQ.

It is, of course, impossible to know for certain which mechanisms were behind these positive changes in the boys, but we may speculate that the mothers' improved body image and eating behaviour following surgery may have influenced boys more than girls in terms of positive changes in weight concern and eating behaviour. There is some support in previous research for the possibility that girls' body esteem, eating behaviour and weight concerns are determined by many factors, such as parents, siblings, peers, and media, whilst the same dimensions in boys may be determined by fewer factors (193, 194). It is thus possible that the girls, although exposed to the possible beneficial effects of improved maternal eating behaviour and body image, were still being negatively influenced by, for example, peers and media messages about the ideal thin body shape for women, and subsequently showed no improvements in their ChEAT or BES scores.

As discussed above (in relation to the results of Study I), increased cognitive restraint after surgery may lead women to also restrict their child's intake, which, in the case of older children who are overweight or obese, may be beneficial in terms of stabilising or decreasing their weight (187). In Study IV, we did find increased levels of cognitive restraint in the women after RYGB. It is also possible that the mothers were more likely to restrict daughters' intake than they were sons', resulting in a reduction in the age-adjusted prevalence of overweight of 11% for girls, and 6% for boys.

The reduction in overweight risk is, of course, positive, especially in this sample of children with much higher rates of overweight than what is seen in the general population of Swedish children (195, 196).

When stratifying the analyses on weight status, we saw an improvement in the ChEAT scores of the children who were overweight or obese at the first data collection time point, when compared with the children who were normal weight. The study by Walters-Bugbee *et al*, mentioned above, showed that mothers increased their conscious modelling of healthy eating habits following bariatric surgery (139). As discussed in relation to the results of Study I, it seems possible that the mothers of overweight or obese children may have taken extra care to model healthy eating behaviours to their children. This may also be the reason behind the increased fruit and vegetable intake in the overweight/obese children following surgery (although this increase was not statistically significant, $p = 0.133$).

Table 2 shows the participating children's BES and ChEAT scores before and after maternal RYGB, compared to those found in other studies. The BES scores are compared to those reported by Ivarsson *et al* for a sample of 405 adolescents with a mean age of 14.7 years (197). Somewhat worryingly, they show that the children in our sample had lower scores, indicating lower body esteem, on the BES-W and the BES-ATT dimensions than the children in the Ivarsson *et al* study. This is potentially of concern as the children in our study were a mean 4.7 years younger than the children in the Ivarsson study, and body esteem commonly decreases with age in adolescence (198). A probable reason for this is that the children in Study III had a high prevalence of obesity and overweight, which has been shown to affect BES scores negatively in previous studies (114).

Table 2. Overview of the questionnaire scores of the participating children in Study II-IV, compared to those found in general population samples.						
	Girls before maternal RYGB	**Girls after maternal RYGB**	**Girls norm**	**Boys before maternal RYGB**	**Boys after maternal RYGB**	**Boys norm**
BES-W	18.1	15.8	18.3 (197)	17.3	17.7	23.4 (197)
BES-APP	37.0	36.2	25.4 (197)	36.2	34.8	28.8 (197)
BES-ATT	8.3	8.3	11.3 (197)	8.2	7.9	11.3 (197)
ChEAT	5.6	5.3	3.9 (171)	6.0	4.4	2.7 (171)

BES-W: Body Esteem Scale-Weight; BES-APP: Body Esteem Scale-Appearance; BES-ATT: Body Esteem Scale-Attribution; ChEAT: Children's Eating Attitudes Test

Although the women's partners experienced a ripple effect in terms of weight loss following the RYGB surgery, this did not seem to also include body dissatisfaction, symptoms of anxiety and depression, eating behaviour or sleep quality. These variables in the men all had in common the fact that they were already relatively normative at baseline, whilst the women's were quite low when compared to those of non-clinical populations. **Table 3** shows the scores of the men and women participating in Study II-IV, compared to scores for the general population for the different psychometric instruments used. I was unable to find general population normative data for the KSQ, due to the fact that it is mainly used in clinical or at-risk populations with different types of sleep problems, but the results reported by the men at baseline were mainly indicative of good sleep quality. The men's HADS, MBDS and TFEQ scores at baseline were largely in line with those found in other populations. Therefore, it is perhaps not surprising that they did not report any great improvements after their partners' RYGB. The women, on the other hand, reported baseline HADS and TFEQ scores that indicated greater levels of anxiety and depressive symptomatology, slightly less cognitive restraint and more uncontrolled and emotional eating than those reported for general population samples. Nine months after surgery, however, their scores had changed to the point where they were equal or even better than those of the general population. This is in accordance with previous research on bariatric surgery patients, whose psychosocial functioning usually improves greatly after surgery (69, 129, 199).

Studies with longer follow-up times, primarily from the SOS study, show that results tend to gravitate slightly back towards pre-operative scores as the patients' weight loss slows down or regain occurs, but that they still remain significantly above baseline scores (200).

Table 3. Overview of the questionnaire scores of the adult participants in Study II-IV, compared to those found in general population samples.

	Women Study II-IV		Women norm	Men Study II-IV	Men norm
	Before RYGB	**After RYGB**			
HADS-A	6.4	5.0	5.0 [201]; 4.8 [154]	4.2	4.4 [201], 4.3 [154]
HADS-D	4.9	2.4	4.7 [201] 3.8 [154]	3.3	4.8 [201], 4.3 [154]
MBDS	N/A	N/A	N/A	47.3	51.2 [158]
TFEQ-CR	2.2	2.5	2.43 [202]	2.0	2.32 [202]
TFEQ-UE	2.4	1.5	1.94 [202]	1.8	1.94 [202]
TFEQ-EE	2.5	1.6	2.03 [202]	1.5	1.80 [202]

HADS-A: Hospital Anxiety and Depression Scale-Anxiety; HADS-D: Hospital Anxiety and Depression Scale-Depression; MBDS: Male Body Dissatisfaction Scale; TFEQ-CR: Three-Factor Eating Questionnaire-Cognitive Restraint; TFEQ-UE: Three-Factor Eating Questionnaire-Uncontrolled Eating; Three-Factor Eating Questionnaire-Emotional Eating

5.2.1 Social Learning Theory

As has been shown in this thesis, the mechanisms whereby a family member's bariatric surgery and subsequent behavioural changes may influence the rest of the family have been very sparsely explored in previous research. However, one may use SLT in order to try and form ideas about the mechanisms behind the observed changes in the spouses and children.

A concrete change in the bariatric patient's behaviour is a major reduction in portion size after surgery, as has already been discussed. This could be seen as a modelled behaviour, which is observed by her spouse. The surgery itself may serve to draw attention to the woman's eating behaviour, as it is likely that it will have been discussed in the family beforehand. The partner would also observe her weight loss, which is rapid and highly noticeable following bariatric surgery. This may act as vicarious reinforcement for her partner, who may then emulate the behaviour himself, thus achieving the weight loss seen in Study II.

As described earlier, the model's emotional response to the reinforcement may also affect the observer's likelihood of learning and mimicking the modelled behaviour. As body image and other psychosocial variables have been shown to improve following bariatric surgery, it is likely that the woman's response to her weight loss was perceived as very positive by her partner. This may further facilitate his observational learning. It is also possible that the partner perceives the woman's weight loss as making her more attractive to others, as obesity is generally seen as unattractive in Western society and female thinness is the ideal. The woman's heightened status after surgery may be an additional incentive for the man to emulate her behaviour, as the model's status is an important feature of observational learning.

We also saw a decrease in the children's relative risk of overweight. In the case of children who are themselves overweight or obese, they may be more inclined than normal weight children to emulate their mother's new eating behaviour as they see her reward – weight loss – as more valuable to themselves than normal weight children, who may have little interest in losing weight (even though many children who are, objectively, normal weight feel that they weigh too much and would like to lose weight [203, 204]). They may also experience a higher level of identification with their mother as they share the same weight status. Finally, as an adult, the mother is in a position of power in the family compared to her children, which means that her status may further strengthen the likelihood that her children will emulate her behaviour. It is also possible that girls identify more strongly with their mothers than boys do, which may explain why the decrease in relative risk of overweight was mainly driven by the girls in the sample.

However, one should keep in mind that the results of the present thesis were somewhat disparate, and that SLT by no means provides a clear picture of the underlying mechanisms. For example, girls were not affected in terms of body esteem or eating behaviour, whilst the boys were, and whilst normal weight children decreased their consumption of sugar-sweetened soft drinks, which must be considered a "healthy" behavioural change, they also decreased their consumption of fruit and vegetables – an "unhealthy" change. The reasons behind these results are probably multi-factorial in nature, and we would require extensive data from the families' home, work, school and social life to explain them completely. Nonetheless, SLT provides an interesting framework to try and at least start to put the results into context.

5.2.2 Limitations

One of the main limitations of Study II-IV is the small sample size, resulting in low power and difficulties with subgroup analyses. In spite of a data collection period of almost three years, we did not manage to recruit more participants to the project. For most of the clinics where recruitment took place, we were unable to collect data on the number of women who did fit the criteria but declined participation, as recruitment was handled by the clinic staff. Oral reports, however, told us that the majority of eligible women consented to participation, but that the rather strict criteria with regards to the required age span of the children made it difficult to find participants. Nonetheless, it would have been good to see if the few women who did decline were different from the participants in terms of education, BMI or any other variables.

The relatively short follow-up time of Study II-IV should also be mentioned as a potential limitation. It would be of great interest to be able to follow the observed changes over a longer period of time, as the women's weight loss stabilises.

When it comes to use of questionnaires, the risk of results being biased by social desirability and social approval should also be mentioned as a potential limitation, as this has been shown in previous research, both for adults [205] and, although less consistently, for children [206, 207]. Furthermore, a 2003 nation-wide Swedish survey of children's eating habits, using four-day food diaries, showed that 11-year-old Swedish children's mean consumption frequency of sugar-sweetened beverages was 5.3 times/week, which may be a reason to believe that the 2.4 times/week and 1.9 times/week reported before and after maternal surgery by the children in Study IV may be subject to certain underreporting. However, if the underreporting was consistent at both data collection time points, the change in intake frequency, which was the main outcome of interest in Study IV, should still be unaffected.

Finally, the lack of a control or reference group may be seen as a limitation in terms of which conclusions can be drawn from the results, and how far one can go in questions of causality. However, recruiting an adequate control or reference group would be practically almost impossible in the case of Study II-IV of the current thesis. We would need to somehow identify and recruit families where the women would qualify for RYGB, but not be interested in undergoing the procedure (at least not for the duration of the study). Furthermore, these women would be likely to differ from the RYGB families in various ways and thus introduce confounding to the analyses. Theoretically, we could have a waiting-list scenario where the control women would remain on the waiting list until the end of the study, but the waiting time would be long and we feel that this would be ethically objectionable, quite apart from the fact that very few women would agree to such conditions.

5.2.3 Directions for future research

As has already been mentioned in the Limitations section, the follow-up time of Study II-IV was relatively short, and it would be of great interest to see if and how the results change over a longer time period. As most of the few previous studies in this area have small samples, as does Study II-IV, it would also be very interesting to conduct similar studies with a larger sample size, especially for the spouses, whose weight loss is one of the most striking results of the project.

When it comes to the children, other methods of assessing food intake may help to shed light on the discrepant findings of Study IV. A food diary or repeated 24-hour recalls may be a suitable method, although time- and resource-consuming, and not without their own potential sources of error and bias [208, 209]. It is also possible that a more detailed assessment of dietary intake may shed some light on the mechanisms behind the partners' weight loss.

Identifying these mechanisms should be of major interest for future studies, as any interventions or ways to maximise this "bonus" weight loss for obese partners of RYGB patients are of great value on both the individual and societal levels.

6 CONCLUSIONS

The overall aim of this PhD project was to attempt to elucidate on how partners and children are affected in terms of weight and psychosocial functioning when the woman in the family undergoes bariatric surgery. After conducting the four studies included in the thesis, we may draw some tentative conclusions:

Restrictive bariatric surgery seems to offer no protective effects when it comes to offspring's risk of overweight or obesity. The effects of more extensive surgical techniques such as RYGB is less clear.

Partners of female RYGB patients seem to experience some weight loss following their partner's surgery, at least short-term. However, this weight loss does not seem to be associated with reduced intake of sugar-sweetened beverages or sweets. Furthermore, the partners do not seem to experience any changes in body dissatisfaction, sleep quality, eating behaviour, anxiety or depressive symptomatology, even though the women experience improvements in all of these variables.

Seven-to-14-year old children of female RYGB patients, especially daughters, appear to experience a reduction in age-adjusted relative risk of overweight following maternal RYGB. Sons of RYGB patients seem to benefit from slightly improved weight-related body esteem and eating behaviour, whilst the same cannot be said for daughters. Sons also seem to reduce their intake of sugar-sweetened soft drinks following maternal RYGB.

When comparing overweight children of RYGB patients with children who are normal weight, the overweight children seem to increase their consumption frequency of fruit and vegetables, whilst the normal weight children's intake of both fruit and vegetables and sugar-sweetened soft drinks decrease.

As the number of individuals who have undergone bariatric surgery continues to rise, both in Sweden and worldwide, the implications for the patients' families will become increasingly important. Research in this field is still relatively sparse, and the present thesis, despite its somewhat inconclusive results, adds some knowledge in this important area.

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