



Higher Socioeconomic Status is Associated with Improved Outcomes After Obesity Surgery Among Women in Germany

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Abstract

Background Low socioeconomic status (SES) is associated with an increased prevalence of obesity. It is unknown whether SES influences the outcome after bariatric surgery in Germany. Therefore, the aim of our study was to investigate whether the SES is linked with an inferior outcome after bariatric surgery.

Methods We included all patients who underwent bariatric surgery in our university hospital from 2012–2014. Net income was estimated by matching the zip codes of patient residency with the region-specific purchasing power index. We analyzed the relationship between SES, weight loss and remission of comorbidities.

Results We included 559 patients in this study and detected a mean 5-year percentage excess weight loss (%EWL) of 52.3%. We detected a significantly lower initial body mass index (BMI) and weight in patients with a higher income. One year after surgery, we did not find a significant difference. Further analysis revealed that only women with a higher income had a significantly lower BMI and weight 3 and 5 years after surgery.

Conclusions Bariatric surgery is beneficial for all patients regardless of income. Furthermore, we demonstrated that women with high SES have a better outcome after bariatric surgery.

Introduction

The prevalence of obesity has doubled worldwide in recent years, making obesity one of the most important global challenges [1]. This also applies to Germany [2]. Obesity increases the risk of chronic diseases, including cardiovascular disease, diabetes mellitus, kidney diseases [3], musculoskeletal diseases [4] and cancer [5].

Bariatric surgery is important as the most successful treatment option for obesity [6]. Successful bariatric surgery is viewed as %EWL above 50% [7]. All current procedures are associated with sustained long-term weight

loss [8]. Some factors are known to influence weight loss following surgery. The procedure type seems to affect the expected %EWL [8], while behavioral factors such as physical activity, dietary habits and health responsibilities do not affect the outcome [9].

Risk factors for developing obesity include the genetic predisposition, low physical activity, unhealthy eating behavior, sex and socioeconomic factors [10]. Socioeconomic factors are summarized as socioeconomic status, which is defined by the education, occupation and income of an individual or a group [11]. Obesity is distributed along a socioeconomic gradient, meaning that the prevalence of obesity is higher in people with low socioeconomic status [2]. Income alone influences the risk for obesity. This factor seems to be especially important for women [10].

A low SES is associated with a greater risk of chronic diseases and poorer outcome after therapy. Kucharska-

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Table 1 Patient characteristics

| <i>n</i> | 559 |
|-----------------------------|---------------|
| Age [years] | 44.2 ± 11.5 |
| Weight [kg] | 149.8 ± 33.5 |
| Height [cm] | 172.2 ± 9.6 |
| BMI [kg/m ²] | 50.4 ± 9.9 |
| Women [n/%] | 388/69.4 |
| Men [n/%] | 171/30.6 |
| Procedure: | |
| Sleeve gastrectomy [n] | 270 |
| Gastric bypass [n] | 260 |
| Other ^a [n] | 29 |
| Diabetes[n/%] | 188/33.6 |
| Hypertension[n/%] | 343/61.4 |
| OSAS[n/%] | 75/13.4 |
| Hypertriglyceridemia[n/%] | 241/43.1 |
| Hypercholesterolemia[n/%] | 188/33.6 |
| Average income [€/year] | 24,128 ± 3469 |
| Income < €24,000/year [n/%] | 303/54.2 |

^aOther procedures included gastric banding, single anastomosis duodeno-ileal bypass and conversion of sleeve gastrectomy to gastric bypass

Newton et al. showed that a low SES increases the risk of acute coronary heart disease events [12]. Additionally, Yong et al. reported that low SES leads to higher mortality after ST elevation myocardial infarction [13]. Regarding bariatric surgery, Carden et al. reported that in the USA, a lower SES is associated with reduced weight loss after bariatric surgery [14]. These aforementioned differences could partially be explained by accessibility of health care. In Germany, health insurance is mandatory, and healthcare access poses no problem [15]. Therefore, studying SES effects in Germany is a good choice, because the results should reflect true differences in SES, not in accessibility of health care.

However, the influence of SES on bariatric surgery in Germany has not been studied. It is relevant to explore whether SES, which influences the risk for obesity, also affects the outcome after bariatric surgery. Hence, we hypothesized that SES is in fact an influencing factor and is associated with an inferior outcome after bariatric surgery. Our study focused on the progression of weight, BMI, %TWL and %EWL after bariatric surgery with regard to SES. As a secondary outcome, remission of other weight-associated medical conditions was detected.

Materials and methods

Patient selection

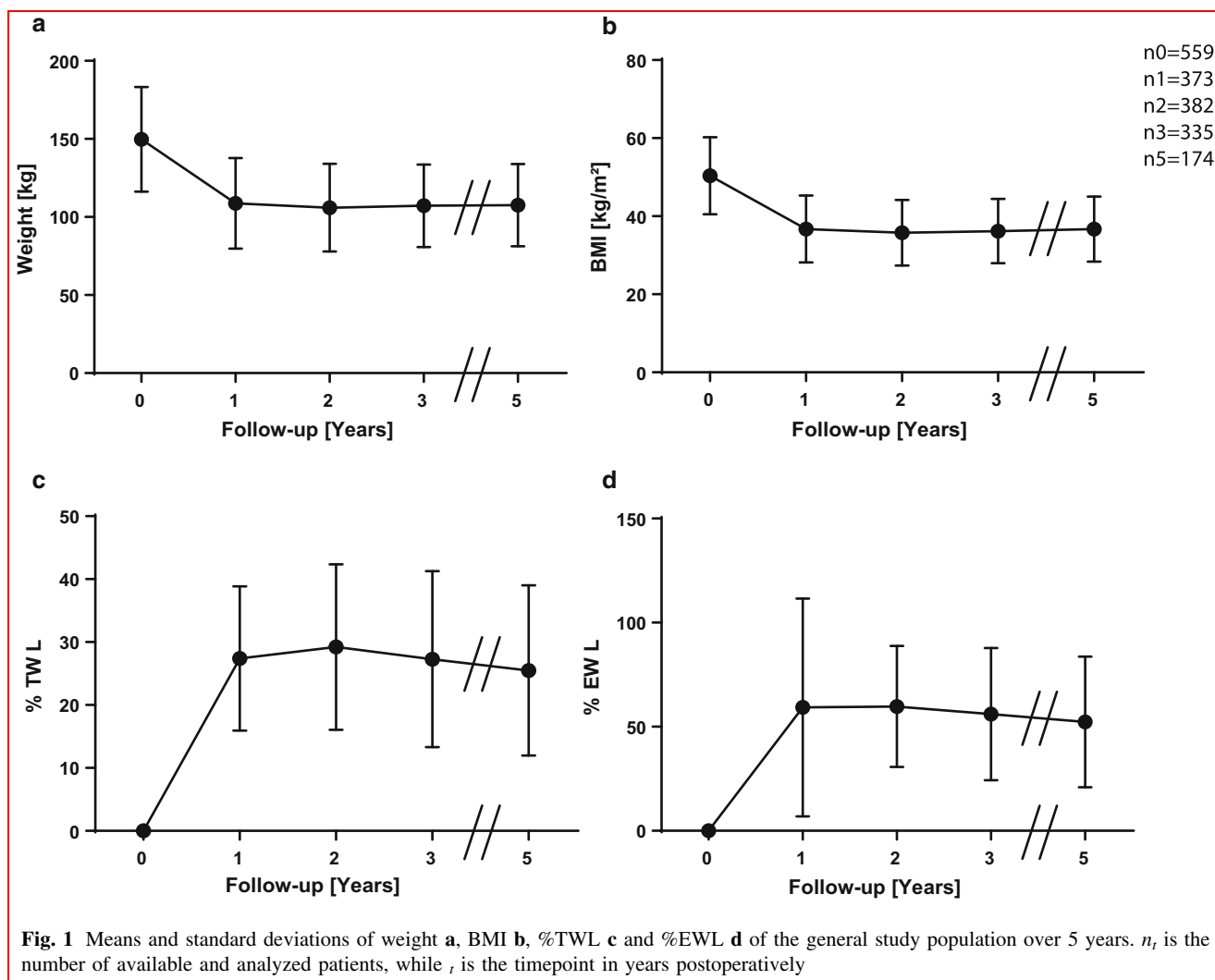
We conducted a retrospective analysis of our database of patients, who underwent bariatric surgery between 2012 and 2014. Perioperative and follow-up data were available for 559 patients. Certified bariatric surgeons in a German bariatric Center of Excellence performed all surgical procedures. All patients were screened before surgery by a multidisciplinary team consisting of an endocrinologist, psychologist, nutritionist, physical therapist and surgeon. Patients were selected for surgery with a BMI > 40 kg/m² or BMI > 35 kg/m² and related comorbidities in accordance with the German Guidelines of Surgical Treatment of Obesity after discussion at our interdisciplinary obesity board. The operating surgeon decided which procedure to perform depending on BMI, comorbidities, medication and patient request [16]. Data regarding demographics, initial height, weight, BMI, comorbidities, procedure, HbA1c and length of follow-up, as well as the follow-up data after 1, 2, 3 and 5 years, including percent total weight loss (%TWL) and percent excess weight loss (%EWL), were collected. SES was indicated by net income per capita/month, which is an approved substitute marker. Income has previously been certified to correctly indicate SES [14, 17–20]. We used the purchasing power index (PPI) as a surrogate parameter to gain income information. The patient's zip code was matched with the according PPI of the specific region, as has been used before [14, 21]. The PPI data were purchased from Michael Bauer Research GmbH. We used €2000 per capita/month as a cutoff based on the GEDA study [22].

The primary outcome was the total weight, BMI, %TWL and %EWL over time. Changes in other weight-associated medical conditions were examined as a secondary outcome. Patients under treatment regarding these conditions were defined as positive for weight-related diseases, according to the IDF consensus statement [23]. The American Society for Metabolic and bariatric Surgery criteria were used to define (partial) remission of weight-related diseases [24].

The local ethics committee approved the clinical database. All patients gave informed consent.

Statistics

Statistical analysis was performed with the Statistical Package for Social Sciences software (SPSS; IBM, version 24). Patient characteristics are presented overall using the mean ± SD for continuous variables. For comparisons between continuous variables, independent Student's *t* test



was performed. Linear regression was performed to validate income/head/year as an independent variable. Multiple linear regression was computed to predict weight and BMI with sex, age, procedure, income/head and comorbidities as independent variables. To determine differences between nominal data, a Chi-square test was used and, if numbers of events were smaller than 5, Fisher's exact test was performed. p -values < 0.05 were considered to be statistically significant.

Results

Patient's characteristics

The characteristics of the patients are displayed in Table 1. A total of 559 patients were included in this study. Follow-up data were available for 66.7% of patients after 1 year, for 68.3% after 2 years, for 59.9% after 3 years and for

30.9% after 5 years. The initial mean weight was 149.8 ± 33.5 kg, with a BMI of 50.4 ± 9.9 kg/m². The majority of the patients were female (69.4%). The average income/per capita/year was $\text{€}24,128 \pm 3469$, while 54.2% had an estimated income of less than $\text{€}24,000$ annually. The most common comorbidity was hypertension (61.4%), followed by diabetes (33.6%) and OSA (13.4%) (Table 1).

Overall time course of weight, BMI, %TWL and %EWL

We measured an average weight of 108.7 ± 29 kg of the cohort after 1 year. After 2 years, the weight reached its nadir with 106 ± 28 kg, then went slightly up after 3 years and remained stable after 5 years (Fig. 1a). The initial BMI dropped to 36.8 ± 8.5 kg/m² after 1 year, resulting in a change of -13.6 kg/m². The nadir was reached after 2 years, and the mean slightly increased after 3 years and stabilized after 5 years (Fig. 1b). After 1 year, we detected

Table 2 Patient characteristics in terms of socioeconomic status

| | Low SES (Income ≤ €24,000/year) | High SES (Income > €24,000/year) | <i>p</i> value |
|---------------------------|---------------------------------|----------------------------------|----------------|
| <i>n</i> | 303 | 256 | |
| Age [years] | 43.7 ± 11.6 | 44.9 ± 11.4 | 0.22 |
| Weight [kg] | 152 ± 35 | 146 ± 30 | 0.023 |
| Height [cm] | 172.3 ± 9.6 | 172.1 ± 9.6 | 0.84 |
| BMI [kg/m ²] | 51.3 ± 10.3 | 49.2 ± 9.2 | 0.016 |
| Women [n/%] | 209/69 | 179/70 | 0.8 |
| Men [n/%] | 94/31 | 77/30 | 0.8 |
| Procedure: | | | 0.17 |
| Sleeve gastrectomy [n] | 159 | 111 | |
| Gastric bypass [n] | 131 | 129 | |
| Other ^a [n] | 13 | 16 | |
| Diabetes[n/%] | 109/36 | 79/31 | 0.2 |
| Hypertension[n/%] | 190/63 | 151/59 | 0.32 |
| OSAS[n/%] | 47/16 | 28/11 | 0.14 |
| Hypertriglyceridemia[n/%] | 123/41 | 118/46 | 0.12 |
| Hypercholesterolemia[n/%] | 105/35 | 82/32 | 0.64 |
| Average income [€/year] | 21,804 ± 1582 | 26,881 ± 3055 | < 0.001 |

^aOther procedures included gastric banding, single anastomosis duodeno-ileal bypass and conversion of sleeve gastrectomy to gastric bypass

a %TWL of $27.4 \pm 11.5\%$, which increased to $29.2 \pm 13.1\%$ after 2 years. In the following years, we observed a slight drop (Fig. 1c). The progression of %EWL was similar; after 1 year, it was $59.3 \pm 52.3\%$, and then it reached its maximum 2 years postoperatively. It also dropped after 3 and 5 years postoperatively (Fig. 1d).

Patients with higher income present themselves with lower weight and BMI

We divided the cohort into a low SES ($n = 303$) and a high SES group ($n = 254$). The low SES group was defined as an estimated income lower than €2000/month/per capita [22]. We observed an initial significantly lower weight and BMI in the high SES group (152.7 ± 35.4 kg vs. 146.2 ± 30.8 kg and 51.3 ± 10.3 kg/m² vs. 49.2 ± 9.2 kg/m²) ($p < 0.05$). Additionally, the two groups only showed a significant difference in their average income ($p < 0.05$). Importantly, the groups were similar in procedure makeup (Table 2).

Over the course of the study period, the initial advantage vanished, although the high SES group had a significantly lower BMI after 3 years; after 5 years, no significant difference was detected (Fig. 2a, b). The course of the %TWL and %EWL showed no significant difference between the groups (Fig. 2c, d). We did not observe a difference in terms of remission of other weight-associated medical conditions (data not shown). We wondered whether we

needed to reject our hypothesis that SES influences weight loss outcomes. Therefore, we performed linear regression analysis using income/head as an independent variable and BMI and weight as dependent variables. Although the proportion of explained variance was low, we observed that income was indeed an independent variable for BMI up to three years postoperatively and 1 year postoperatively for weight (Tables 3, 4).

Women benefit from a higher income regarding total weight and BMI

We were looking for an explanation of why income was an independent variable for weight loss, but we did not see an effect in our data. Among females in highly developed countries such as Germany, low income is associated with higher weight [10, 25, 26]. Therefore, we analyzed the data in terms of sex differences. We did not find any significant differences in men with high SES ($n = 77$) compared to men with lower SES ($n = 94$) (Fig. 3a–d). The female groups presented themselves with no significant difference in weight or BMI prior to operation. After 3 years, women with high SES ($n = 179$) established a significantly lower weight (98 ± 23.3 kg vs. 104.9 ± 23.3 kg, $p < 0.05$) and BMI (34.5 ± 7.8 kg/m² vs. 37 ± 8.4 kg/m², $p < 0.05$) than females with low SES ($n = 209$). They also maintained a significant advantage in weight (97 ± 20.2 kg vs. 107 ± 27.3 kg) and BMI (34.7 ± 7.7 kg/m² vs.

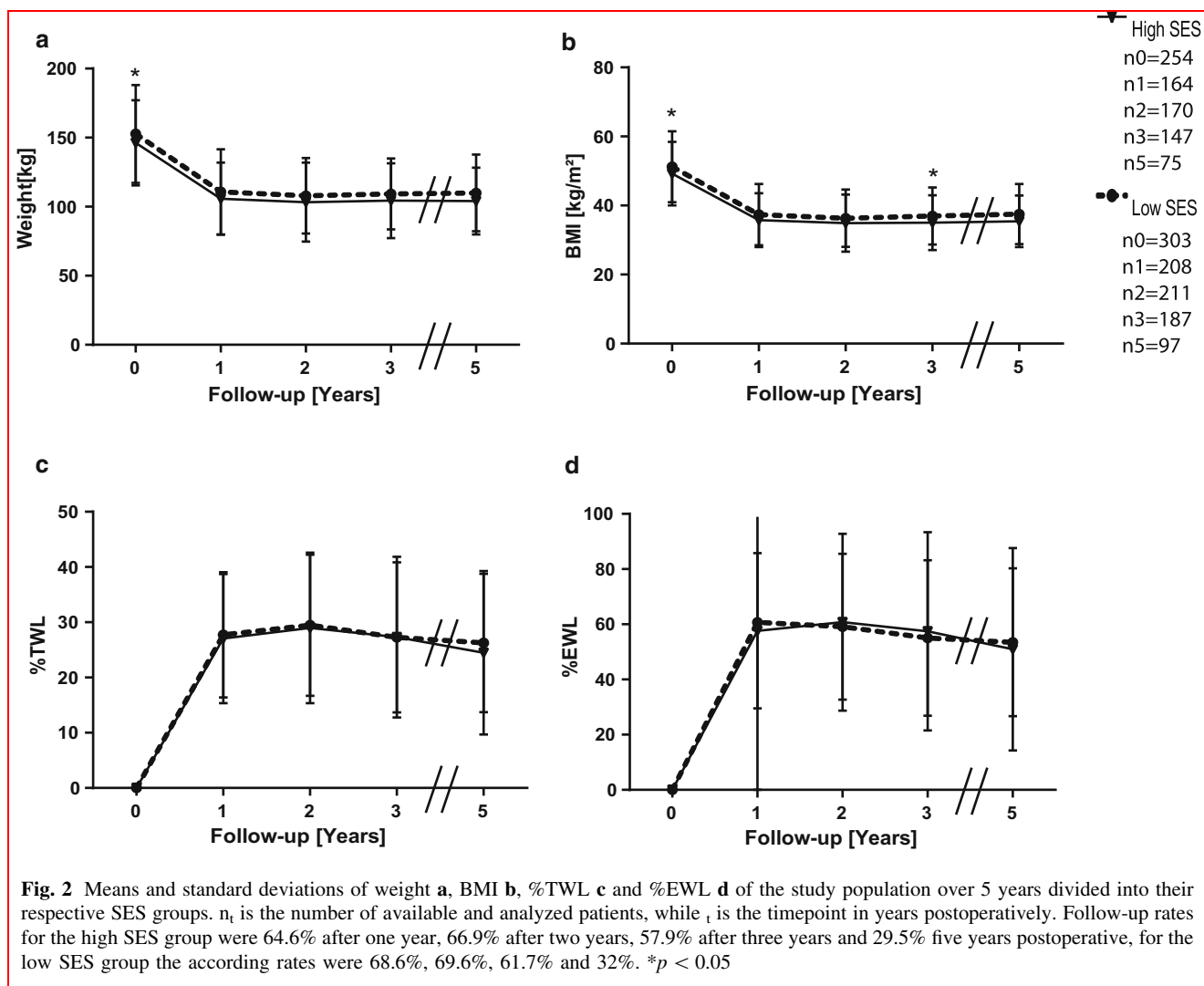


Table 3 Linear regression of income/head on BMI.

| BMI | 1 year postoperative | 2 years postoperative | 3 years postoperative | 5 years postoperative |
|---------|----------------------|-----------------------|-----------------------|-----------------------|
| Overall | 0.024* | 0.01* | 0.013* | 0.003 |
| Male | 0.025 | 0.001 | 0 | 0.012 |
| Female | 0.028* | 0.02* | 0.024* | 0.005 |

Coefficient of determination (R^2) as numerical value and significance (*)

* denotes statistical significance ($p < 0.05$)

$37.8 \pm 9.1 \text{ kg/m}^2$ 5 years postoperatively (Fig. 4a, b). The procedure makeup of both female groups was similar (Table 5), indicating that the observed effect was caused by differences in SES. Furthermore, no difference in %TWL, %EWL (Fig. 4c, d) or remission of other weight-associated medical conditions was observed (data not shown). We

also performed linear regression and observed that income could only be regarded as an independent variable in females for BMI and weight up to three years postsurgery (Tables 3 and 4), further providing evidence that income affects only the weight loss of females postbariatric surgery.

Table 4 Linear regression of income/head on weight.

| Weight | 1 year postoperative | 2 years postoperative | 3 years postoperative | 5 years postoperative |
|---------|----------------------|-----------------------|-----------------------|-----------------------|
| Overall | 0.016* | 0.005 | 0.01 | 0.006 |
| Male | 0.022 | 0 | 0 | 0.005 |
| Female | 0.023* | 0.022* | 0.024* | 0.012 |

Coefficient of determination (R^2) as numerical value and significance (*)

* denotes statistical significance ($p < 0.05$)

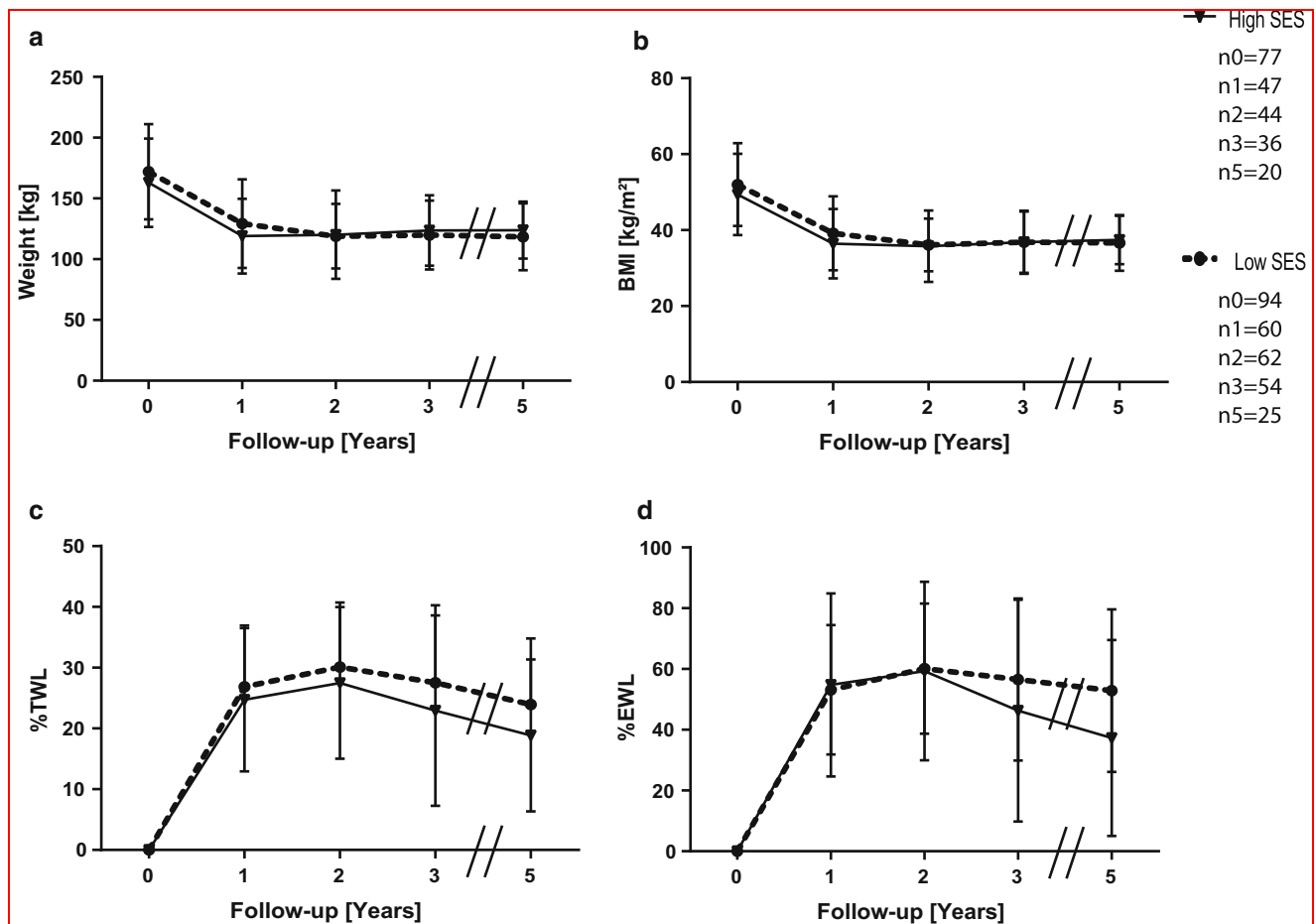
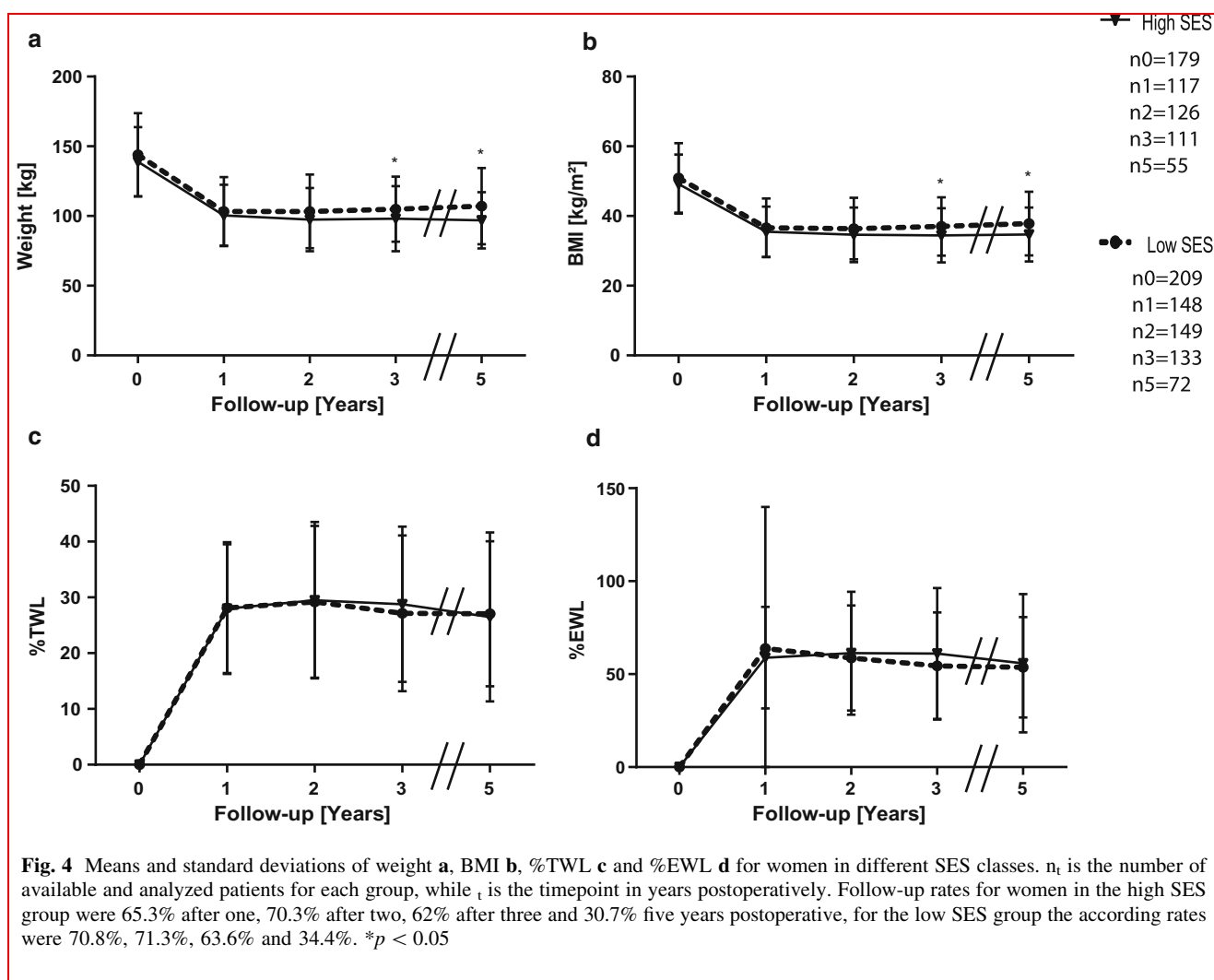


Fig. 3 Means and standard deviations of weight **a**, BMI **b**, %TWL **c** and %EWL **d** for men in different SES classes. n_i is the number of available and analyzed patients for each group, while t_i is the timepoint in years postoperatively. Follow-up rates for men in the high SES group were 61% after one, 57.1% after two, 46.8% after three and 25.9% five years postoperative, for the low SES group the according rates were 63.8%, 66%, 57.4% and 26.6%

Multiple linear regression analysis

Additionally, we performed multiple linear regression to see how income would perform compared to other variables. We used the type of procedure, income/head, comorbidities (diabetes, OSA, hypertension, dyslipidemia), sex and age as independent variables. This model showed a significant influence of the procedure type, income/head

and diabetes on BMI one year after surgery. After two and three years, only the procedure was predictive. After 5 years, the procedure and OSA were predictive. We used the same variables to predict weight and observed a similar picture. One year after surgery, the type of procedure, income/head, sex and age significantly influenced the weight. After two and three years, only procedure and sex were predictive. After 5 years, we discovered the type of



procedure, sex, OSA and dyslipidemia as influencing factors. We wondered whether these models would again perform better for female patients. The model for the female cohort showed a similar picture as the total cohort. The model could not predict BMI or weight for the male cohort (Tables 6, 7). This justified our sex-specific considerations further.

Type of procedure

However, the cohorts were homogenous regarding their type of procedures. We still wondered whether there was a procedure-specific effect. We compared the patients undergoing sleeve gastrectomy and patients undergoing gastric bypass surgery. Patients who received gastric bypass surgery had significantly ($p < 0.05$) lower BMI and weight (Fig. 5). Then, we split the cohorts based on income and procedure type. We observed significantly lower weight after 5 years in the high SES bypass group (Fig. 6a) but no difference in BMI (Fig. 6b). The sleeve groups only

initially showed a significant difference ($p < 0.05$) in weight and BMI (Fig. 6c, d).

Discussion

In this study, we assessed whether socioeconomic status impacts the outcome after bariatric surgery in Germany. First, we detected a good outcome after bariatric surgery, indicated by a %EWL above 50 through 5 years postoperatively, regardless of the SES. We observed that people with high SES present themselves with lower weight and BMI compared to patients with low SES. This difference could not be detected after 5 years. We used linear regression to show that income was indeed an independent variable for weight loss outcomes. In females, an inverse correlation exists between income and weight [10, 25, 26]. Therefore, we evaluated whether a sex-specific effect might be present. We observed that females with high SES had a lower weight and BMI up to 5 years postoperatively.

Table 5 Female patient characteristics

| | Low SES (Income ≤ €24,000/year) | High SES (Income > €24,000/year) | p value |
|---------------------------|---------------------------------|----------------------------------|---------|
| n | 209 | 179 | |
| Age [years] | 42.4 ± 10.7 | 43.5 ± 11.2 | 0.32 |
| Weight [kg] | 144 ± 29 | 139 ± 25 | 0.09 |
| Height [cm] | 168.1 ± 6.7 | 167.8 ± 6.8 | 0.74 |
| BMI [kg/m ²] | 50.9 ± 10 | 49.3 ± 8.6 | 0.1 |
| Procedure: | | | 0.17 |
| Sleeve gastrectomy [n] | 95 | 65 | |
| Gastric bypass [n] | 105 | 107 | |
| Other ^a [n] | 9 | 7 | |
| Diabetes[n/%] | 71/35 | 52/30 | 0.32 |
| Hypertension[n/%] | 125/60 | 96/54 | 0.2 |
| OSAS[n/%] | 24/14 | 21/13 | 0.91 |
| Hypertriglyceridemia[n/%] | 74/38 | 71/43 | 0.29 |
| Hypercholesterolemia[n/%] | 77/39.5 | 61/37.2 | 0.66 |
| Average income [€/year] | 21,830 ± 1526 | 26,656 ± 2631 | < 0.001 |

^aOther procedures included gastric banding, single anastomosis duodeno-ileal bypass and conversion of sleeve gastrectomy to gastric bypass

Table 6 Multiple linear regression for BMI. Adjusted coefficient of determination (R²) as numerical value, significance (*) and independent variables

| Weight | 1 year postoperative | 2 years postoperative | 3 years postoperative | 5 years postoperative |
|---------|---------------------------|------------------------|------------------------|------------------------|
| Overall | 0.126* ^{1, 2, 3} | 0.12* ¹ | 0.105* ¹ | 0.123* ^{1, 6} |
| Male | NS | 0.306* ^{1, 9} | NS | 0.366* (constant) |
| Female | 0.149* ^{1, 2} | 0.114* ¹ | 0.158* ^{1, 6} | 0.149* ^{6, 9} |

* denotes statistical significance ($p < 0.05$), NS = not significant

Numbers denote significant variables (1 = procedure, 2 = income/head, 3 = diabetes, 4 = hypercholesterolemia, 5 = hyperglyceridemia, 6 = OSA, 7 = hypertension, 8 = sex, 9 = age)

Table 7 Multiple linear regression for weight. Adjusted coefficient of determination (R²) as numerical value, significance (*) and independent variables

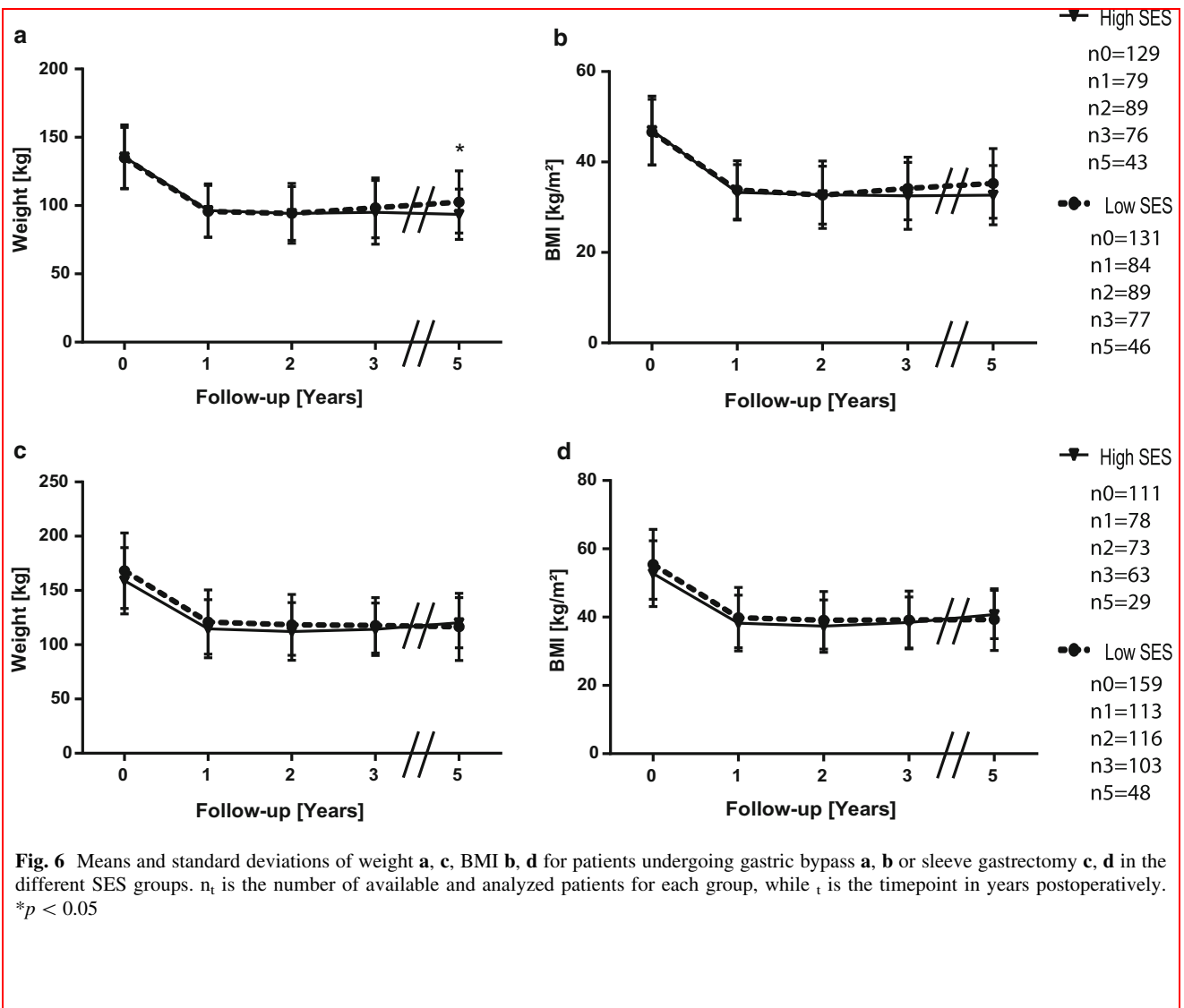
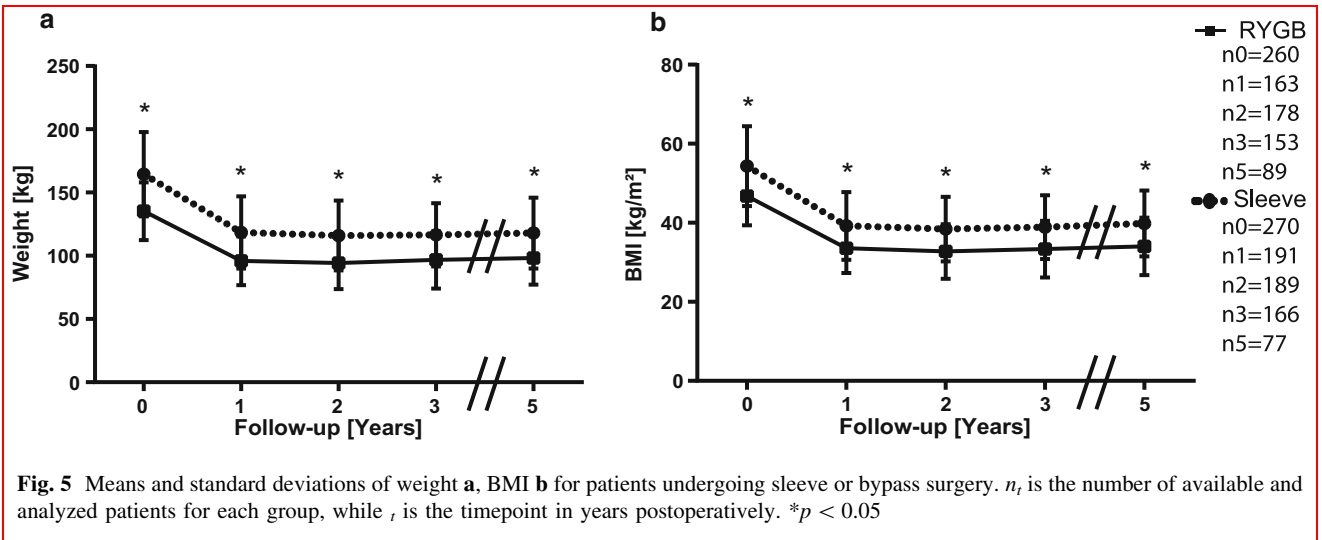
| Weight | 1 year postoperative | 2 years postoperative | 3 years postoperative | 5 years postoperative |
|---------|------------------------------|------------------------|------------------------|-----------------------------|
| Overall | 0.234* ^{1, 2, 8, 9} | 0.244* ^{1, 8} | 0.211* ^{1, 8} | 0.29* ^{1, 5, 6, 8} |
| Male | NS | 0.284* ^{1, 5} | NS | NS |
| Female | 0.183* ^{1, 2} | 0.136* ^{1, 2} | 0.169* ¹ | 0.149* ^{1, 6} |

* denotes statistical significance ($p < 0.05$), NS = not significant

Numbers denote significant variables (1 = procedure, 2 = income/head, 3 = diabetes, 4 = hypercholesterolemia, 5 = hyperglyceridemia, 6 = OSA, 7 = hypertension, 8 = sex, 9 = age)

Previous studies that analyzed the impact of SES came to various conclusions. In 2008, Akkary et al. could not detect an advantage for patients with high SES [27]. More recently, Carden et al. reported that in a Veteran population, which consisted of mostly males, low SES led to

significantly lower weight loss [14]. Our data suggest that only females with high SES have a better outcome. A study from Andersen et al. showed that predictors of weight loss following sleeve gastrectomy are sex-specific. Unemployment in women resulted in lower percent excess body mass



index loss (%EBMIL) [28]. Which socioeconomic factors exactly influence the postoperative outcome remains to be examined. Women of lower-income classes have an increased risk for developing obesity [10]. Lower-income households seem to have less access to healthy food [29], and many women are still solely responsible for food purchase and preparation [25]. Access to physical activity or confidence to pursue physical activity can be reduced in women of low-income households [30]. Whether these factors also contribute to inferior weight loss in women with low SES after bariatric surgery remains to be determined. Further studies are needed to elucidate the exact socioeconomic aspects that contribute to a better outcome.

We observed that patients with high SES presented themselves with lower weight and BMI. Five years after surgery, this advantage disappeared. This indicates that bariatric surgery is distinguished regardless of SES. We detected no difference in %TWL and %EWL between the SES groups. The %TWL and %EWL are not the only markers for success after bariatric surgery and are not undisputed [31]. Individual patients are most likely only concerned about their total weight and BMI, since BMI is correlated with higher mortality [32]. This is the reason we focused on the total BMI and not the %TWL or %EWL.

This retrospective study suffers from some limitations. We used an approximation for the patient's income, meaning that it is possible that patients were assigned to the wrong group. Additionally, the relocation of a patient could not be detected. However, this is an established tool [14, 21]. The strength of this study is the large sample size, which can reduce the errors of this tool. Another limitation is the low follow-up rate after 5 years (30.9%). Loss to follow-up is a problem after bariatric surgery, and attrition rates increase year by year [33]. However, through our large sample size, we still analyzed 174 patients and therefore concluded that our findings are valid.

Our results show that bariatric surgery is effective for all socioeconomic classes. Low income is a risk factor in women for an inferior outcome after bariatric surgery. Further studies should focus on elucidating the exact factors that induce these effects to aid all patients.

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

This study was approved by the local ethics committee.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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