




# Weight Change After Roux-en Y Gastric Bypass, Physical Activity and Eating Style: Is There a Relationship?

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## Abstract

**Background** Insufficient weight loss and weight regain is seen in 20–30% of the post-bariatric population. More knowledge about the effect of physical activity and eating style on weight change after Roux-en-Y gastric bypass is essential since behaviour can be modified and thereby results improved. The goal of this study is to determine the relationship between weight change, self-reported physical activity and eating style.

**Methods** Weight, physical activity (PA) and eating style (ES) were assessed before surgery and 15, 24, 36 and 48 months after surgery. A linear mixed model was performed to assess the association between the change in PA and ES and percentage total weight loss (% TWL).

**Results** There were 4569 patients included. Preoperative PA and ES were not related to weight change. Change in PA was positively associated with % TWL at 15, 36 and 48 months follow-up. Change in emotional eating was negatively related to % TWL at all follow-up moments. Change in external eating was only negatively related to weight loss at 24 months follow-up. Change in restrained eating was negatively associated with weight loss up to 36 months follow-up. More restrained eating at 36 months follow-up was related to higher weight regain, and more emotional eating at 48 months to 48-month weight regain.

**Conclusion** Preoperative self-reported PA and ES did not predict weight change after RYGB. Being more physically active and showing less emotional and restrained eating was related to a higher weight loss. Emotional and restrained eating were related to higher weight regain.

**Keywords** Roux-and-Y gastric bypass · Weight loss · Weight regain · Physical activity · Eating style

## Introduction

Bariatric surgery has proven to effectively treat morbid obesity and its comorbidities [1, 2]. However, in 20–30% of the bariatric population insufficient weight loss (<50% excess

weight loss) or substantial weight regain is observed; both can lead to re-emerging of comorbidities and secondary and/or tertiary bariatric procedures [3–4]. Behavioural factors can be modified and thereby reoperations could be avoided. A recent review focussed on the association between behaviour, mainly physical activity and eating, and weight change after bariatric surgery [5]. This review showed that these factors have only been studied sparsely.

Physical activity is considered an important way to achieve weight loss and maintain a healthy weight [6–8]. Therefore, bariatric patients are advised to engage in regular physical activity [8–11]. Previous studies indicate that low physical activity after bariatric surgery is related to less weight loss and more weight regain [12–14], though more recent studies question whether weight loss is positively influenced by adherence to a healthy lifestyle with regular physical activity [15, 16].

Self-reported eating styles, like emotional, restrained or external eating, have not been studied frequently in the

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bariatric population. Emotional eating, in which patients report to eat more in response to emotions, has been linked to less weight loss in two studies [17, 18]. However, others did not support this association [12, 13]. Studies on self-reported external and restrained eating show the same conflicting results; some suggest a negative effect on weight change, while other studies show no effect [12, 13, 17, 19].

In addition to these conflicting results, most of the previous studies, assessing the physical activity and eating style, include small populations and relatively short follow-ups [12, 13, 17, 18]. A longer follow-up is of interest since weight loss plateaus around 18 months after surgery [20].

In the present study, the relationship between weight change and self-reported physical activity and eating style was examined in a large bariatric population (primary RYGB) with a longer follow-up (15, 24, 36 and 48 months). It was hypothesised that patients with better physical activity and better eating styles have higher weight loss and less weight regain.

## Methods

### Standard Treatment

This is a retrospective analysis of prospectively collected data of patients who were treated at the Nederlandse Obesitas Kliniek (NOK, Dutch Obesity Clinic). Data were collected until 22nd February 2017. The NOK is the largest outpatient clinic for bariatric surgery in the Netherlands, with eight locations throughout the country. In addition to the bariatric procedure, the treatment program entails group counselling by a multidisciplinary team. Group counselling starts before surgery and is focussed on behavioural change. After 15-month follow-up, patients are invited yearly for consultation with the whole multidisciplinary team.

Routine assessment (as part of the treatment program) of self-reported physical activity and eating style was enrolled over the different locations at several time points during 2012 and 2013.

### Patients

There were 4829 patients who had undergone a primary RYGB between 2012 and 2015 and had a follow-up of 24 months or more were selected from the prospective database. A total of 260 patients (5.6%) patients were excluded because they were lost to follow-up before 12 months post-surgery and/or no results were available for the questionnaires (see below).

## Assessments

### Physical Activity

Physical activity was evaluated preoperatively (baseline) and at 15, 24, 36 and 48 months after surgery with the Baecke questionnaire [21]. This questionnaire has shown good test-retest reliability and validity, and was used in the bariatric population before [14, 21, 22]. The Baecke consists of 22 questions assessing physical activity at work, during sports and during leisure time. A total score can be calculated, which ranges from 3 to 15, with higher scores indicating increasing self-reported activity. For this analysis, the scores at baseline and follow-up were used. Based on weight loss plateau around 18 months, the maximum change in physical activity ( $\Delta$ PA) from baseline to 15 or 24 months follow-up was calculated.

### Eating Style

Eating style was evaluated at the same time points as the physical activity measurements, using the Dutch Eating Behaviour Questionnaire (DEBQ) [23]. The DEBQ is a widely used questionnaire to measure eating style [23]. It consists of 33 questions assessing three styles of eating: emotional eating, external eating and restrained eating. Emotional eating means eating in response to negative emotions. External eating refers to eating in response to external cues (like seeing food). Restrained eating refers to the intention to eat less. For all subscales, a total score can be calculated. These scores range from 1 to 5; a higher score means the patient indicates being a more emotional, external and/or restrained eater. For the DEBQ score, a maximum change score was also calculated using baseline and 15 or 24 months follow-up scores:  $\Delta$ EME for change in emotional eating;  $\Delta$ EXE for change in external eating and  $\Delta$ REE for change in restrained eating.

### Weight Change

Body weight was assessed preoperatively (baseline) and at 12, 15, 24, 36 and 48 months after surgery; height was assessed during preoperative screening. Weight loss was calculated and reported as stated in the most recent guidelines: body mass index (BMI in  $\text{kg}/\text{m}^2$ ) and percent total weight loss (% TWL) [24]. New variables were created for maximum weight loss and weight regain, since up to date, there are no uniform definitions to report this [3, 25]. First, nadir body weight was defined as the lowest weight up to 24 months post-surgery. Based on that, maximum postoperative weight loss (TWLmax) was calculated using the following formula:

$$\text{TWL}_{\text{max}} = \frac{\text{baseline body weight} - \text{nadir body weight}}{\text{baseline body weight}} \times 100\%$$

Since weight regain usually develops after the weight plateau, weight regain (WR) was calculated for 36 and 48 months follow-up with the following formulas:

$$36\text{mWR} = \frac{36\text{-month body weight} - \text{nadir body weight}}{\text{nadir body weight}} \times 100\%$$

$$48\text{mWR} = \frac{48\text{-month body weight} - \text{nadir body weight}}{\text{nadir body weight}} \times 100\%$$

### Statistical Analyses

Descriptive statistics were used to summarise patients' baseline and follow-up characteristics. Changes in body weight and scores of Baecke and DEBQ were analysed using repeated measures ANOVA. Quartiles for preoperative physical activity and eating style were calculated and a MANCOVA analysis was conducted to assess the different weight loss trajectories. Creating weight loss trajectories in four groups ranging from low preoperative physical activity to high preoperative physical activity and four groups ranging from low preoperative emotional, external and restrained eating to high preoperative emotional, external and restrained eating. Plots were created to visualise the differences between these groups. All above analyses were performed using SPSS software, version 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.).

Regression analyses were used to investigate the relationship between baseline self-reported physical activity/eating style and weight change (TWL<sub>max</sub>, 36mWR and 48mWR), and between physical activity and eating style at follow-up and weight regain at 36 and 48 months.

A linear mixed model was conducted to assess the association between physical activity and % TWL over all the follow-up moments. This model compared Baecke scoring at the specific follow-up moment with the baseline score, thus focussing on how Baecke scores changed. The relationship between Baecke scores and % TWL over all follow-up moments was assessed using a random intercept, thereby the model takes into account different intercepts for each patient. Then, baseline score, gender and age were added to the model as fixed effects. In the last part of the model, effect modification of time on Baecke was assessed. First calculating if the interaction of Baecke and time had a significant impact on the model and then assessing on which follow-up moments this was. The same model was performed for each of the eating styles (separately). All assumptions for regression analysis were met. These analyses were performed using STATA,

version 13 (StataCorp. 2013. Stata 13 Base Reference Manual. College Station, TX: Stata Press.).

Findings were considered statistically significant if the *p* value was < 0.05.

## Results

### Study Population

The patients included in the analysis (*n* = 4569) had a mean age of 47.1 years (± 10.7), which was higher compared to those who were excluded from the analysis (mean age 44.3 (± 11.2), *p* < 0.001). More females (81.7%) were observed in the included population compared to the excluded population (69.2%, *p* < 0.001). Mean follow-up (FU) since surgery was 38.7 months (range 24–59 months), which was shorter compared to the excluded population (42.3 months, *p* < 0.001).

### Weight Change

Mean baseline BMI was 44.4 kg/m<sup>2</sup> (range 30.3–75.7 kg/m<sup>2</sup>, Table 1). Mean TWL at 12 months after surgery was 30.8%, at 15 months this was 31.6% and at 24 months 31.4%. Mean TWL<sub>max</sub> was 32.7% (± 7.9).

Mean TWL was 29.2% at 36-month FU and 27.3% at 48-month FU (*p* < 0.001). Mean 36 mWR was 5.3% ± 6.7 and the mean 48 mWR was 7.2% ± 9.2 (*p* < 0.001).

### Physical Activity

Mean Baecke scores were lowest before surgery (8.12 ± 1.39) and highest 15 months after surgery, mean score 8.66 ± 1.29 (*p* < 0.001, Table 2). At 24 months, the mean score was 8.54 ± 1.31, which was significantly lower than the score at 15-month FU (*p* = 0.042). And at 36-month FU, the mean score was 8.38 ± 1.34, which was lower than the score at 24 months (*p* = 0.006). Mean maximum change in Baecke score, ΔPA, was 0.76 (range – 6.25 to 7.62).

### Eating Style

For emotional eating, the lowest score was observed 15 months after surgery (mean score 1.94 ± 0.77, Table 2). This score was significantly lower compared to the mean score before surgery (2.43 ± 0.82, *p* < 0.001) and compared to the score at 24 months (2.09 ± 0.78, *p* < 0.001).

For external eating, the mean score was highest before surgery, 2.84 ± 0.58, and lowest at 15-month FU (2.23 ± 0.56, *p* < 0.001). There was also a significant difference when comparing scores at 15 and 24-month FU (2.35 ± 0.54, *p* < 0.001).

**Table 1** Weight change of the included population ( $n = 4569$ ) and availability of data per follow-up moment, data presented as mean  $\pm$  standard deviation

Follow-up	Available data	BMI, kg/m <sup>2</sup>	% TWL	% WR
Baseline	4569	44.4 $\pm$ 5.7***		
12-month	4079/4569 (90%)	30.7 $\pm$ 4.9***	30.8 $\pm$ 7.2***	
15-month	4359/4569 (95%)	30.4 $\pm$ 5.0***	31.6 $\pm$ 7.7***	
24-month	3786/4569 (83%)	30.3 $\pm$ 5.1***	31.4 $\pm$ 8.6***	
36-month	1620/2636 (61%)	31.4 $\pm$ 5.3***	29.2 $\pm$ 8.9***	5.3 $\pm$ 6.7***
48-month	479/1020 (47%)	32.4 $\pm$ 5.6	27.3 $\pm$ 9.6	7.2 $\pm$ 9.2

\*\*\*Significant difference compared to next follow-up,  $p \leq 0.001$

For restrained eating, there was only a significant difference when comparing baseline score ( $3.01 \pm 0.60$ ) and score 15 months after surgery ( $2.49 \pm 0.75$ ,  $p < 0.001$ ). Mean score at 24 months was  $2.56 \pm 0.75$ .

Patients reported less emotional eating after surgery, mean maximum change,  $\Delta$ EME, was  $-0.32$  (range  $-3.54$  to  $2.39$ ). External eating also decreased after surgery, mean maximum change,  $\Delta$ EXE, was  $-0.61$  (range  $-3.00$  to  $1.80$ ). For restrained eating the maximum change,  $\Delta$ REE, was  $-0.53$  (range  $-3.60$  to  $3.30$ ).

### Preoperative Physical Activity and Eating Style

Preoperative Baecke and DEBQ scores were not related to TWLmax or WR at 36 and 48 months. Figure 1a shows the weight loss trajectories for the four groups of patients based on the quartiles of preoperative Baecke scores, ranging from the group with the lowest physical activity (1st quartile) to the group with the highest physical activity (4th quartile). Weight loss was not significantly different between these groups ( $p = 0.238$ ). Weight loss trajectories for the four group, based quartiles of preoperative DEBQ scores, are shown in Fig. 1b–d. A lower quartile means a patient has less emotional, restrained or external eating. Weight loss was not significantly different between the four groups for emotional eating ( $p =$

$0.699$ ). There was also no significant difference for restrained eating ( $p = 0.586$ ) and for external eating ( $p = 0.526$ ).

### Weight Regain

Restrained eating at 36 months was significantly, positively related to 36mWR ( $\beta = 1.10$ ,  $p = 0.025$ ). Thus, more restrained eating at 36-month FU was related to higher weight regain. Emotional eating at 48-month FU was significantly, positively related to 48mWR ( $\beta = 3.89$ ,  $p = 0.002$ ); patients who reported more emotional eating 48 months after RYGB, regained more weight. None of the other Baecke and DEBQ scores at 15, 24, 36 and 48 months were related to 36 or 48 months weight regain.

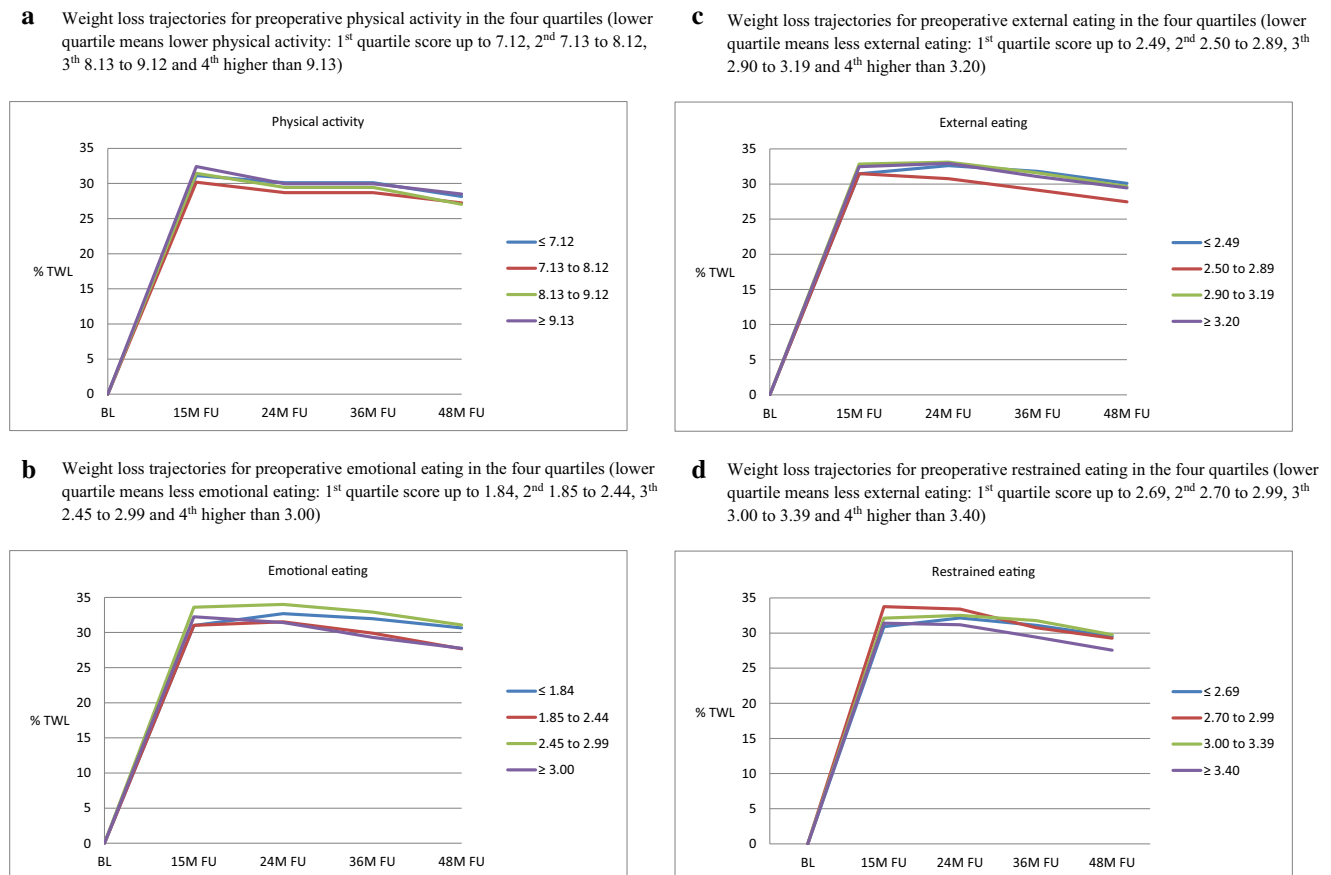
### Mixed Model for Physical Activity

There was a significant, positive relationship between change in physical activity and % TWL. Looking at the specific follow-up moments, there was a significant, positive association between physical activity and % TWL at 15 months follow-up ( $\beta = 0.22$ ,  $p = 0.012$ , Table 3). Patients who engaged in more physical activity at 15-months follow-up had higher weight loss compared to baseline. There was also a significant association at 36 months ( $\beta = 0.39$ ,  $p = 0.002$ ) and 48 months ( $\beta = 0.62$ ,  $p = 0.005$ ). Gender and age did

**Table 2** Mean scores and maximum change in scores from baseline to 15 or 24 months follow-up in Baecke and DEBQ scores and availability of data per follow-up moment

Follow-up	Baecke		N	Emotional eating	External eating	Restrained eating
	N	Mean $\pm$ sd				
Baseline	4384	8.12 $\pm$ 1.39***	2028	2.43 $\pm$ 0.82***	2.84 $\pm$ 0.58***	3.01 $\pm$ 0.60***
15-month	4162	8.66 $\pm$ 1.29*	1939	1.94 $\pm$ 0.77***	2.23 $\pm$ 0.56***	2.49 $\pm$ 0.75
24-month	3525	8.54 $\pm$ 1.31**	1401	2.09 $\pm$ 0.78	2.35 $\pm$ 0.54	2.56 $\pm$ 0.75
36-month	1470	8.38 $\pm$ 1.34	388	2.27 $\pm$ 0.82	2.43 $\pm$ 0.57	2.59 $\pm$ 0.70
48-month	416	8.29 $\pm$ 1.28	112	2.35 $\pm$ 0.86	2.54 $\pm$ 0.59	2.58 $\pm$ 0.67
Change	4199	0.76 $\pm$ 1.22	1946	$-0.32 \pm 0.73$	$-0.46 \pm 0.57$	$-0.36 \pm 0.82$

\*Significant difference compared to next follow-up,  $p < 0.05$ ; \*\*significant difference compared to next follow-up,  $p < 0.01$ ; \*\*\*significant difference compared to next follow-up,  $p \leq 0.001$



**Fig. 1** Weight loss trajectories for preoperative Baecke and DEBQ scores. BL: baseline, 15 M FU: 15 month follow-up, 24 M FU: 24 months follow-up, 36 M FU: 36 months follow-up; 48 M FU: 48 months follow-up

not significantly influence the model; baseline Baecke score did and thus, the aforementioned models were adjusted for the baseline Baecke score.

### Mixed Model for Eating Styles

For emotional eating, there was a significant, negative association with % TWL at all follow-up moments, with the most prominent association at 48 months FU ( $\beta = -1.66, p = 0.014$ , Table 3). Patients who experienced more emotional eating compared to baseline had less weight loss.

There was a negative association between external eating and % TWL. Patients who experienced more external eating had less weight loss; this association was only significant at 24 months FU ( $\beta = -1.06, p = 0.003$ ). For restrained eating, there was also a negative association with % TWL; more restrained eating was associated with less weight loss. This association was significant at 15, 24 and 36-month follow-up, while it was not significant at 48 months after surgery. In all eating style models, baseline score of the specific eating style influenced the model, so models were adjusted for baseline score.

### Discussion

The goal of this study was to evaluate the effect of physical activity and self-reported eating style on weight change up to 48 months after primary RYGB. The results suggest that patients' activity and eating style before RYGB are not related to weight loss or weight regain after surgery. In general, patients became more active after surgery and had less emotional, external and restrained eating. Physical activity at 15, 36 and 48 months follow-up was positively associated with weight loss; patients who became more active compared to baseline had higher weight loss. Emotional eating was related to weight loss at all follow-up moments; patients with more emotional eating showed less weight loss. The reporting of more emotional eating at 48 months follow-up was also related to higher weight regain at 48 months. External eating was only related to weight loss at 24 months follow-up; patients who reported more external eating had less weight loss. Restrained eating was negatively associated with weight loss up to 36 months follow-up; patients who reported more restrained eating at follow-up had less weight loss. Patients who experienced more restrained eating at 36 months follow-up also had higher weight regain at this FU moment. Since the mixed



**Table 3** Linear mixed model was used to assess the relationship between change in physical activity/eating style (from baseline to the specific follow-up) and percentage total weight loss

	Follow-up	Coefficient	<i>P</i> value*	95% confidence intervals	
Physical activity	15-month	0.22	0.012	0.05	0.39
	24-month	0.13	0.163	−0.05	0.31
	36-month	0.39	0.002	0.15	0.63
	48-month	0.62	0.005	0.19	1.05
Emotional eating	15-month	−0.76	0.000	−1.18	−0.34
	24-month	−0.95	0.000	−1.41	−0.48
	36-month	−0.91	0.015	−1.65	−0.18
	48-month	−1.66	0.014	−2.98	−0.33
External eating	15-month	−0.60	0.058	−1.22	0.02
	24-month	−1.06	0.003	−1.76	−0.36
	36-month	−0.89	0.110	−1.99	0.20
	48-month	−1.42	0.136	−3.29	0.45
Restrained eating	15-month	−0.81	0.006	−1.39	−0.23
	24-month	−1.80	0.000	−2.42	−1.19
	36-month	−1.51	0.002	−2.45	−0.56
	48-month	−0.94	0.238	−2.50	0.62

\*Adjusted for baseline score, as gender/age were no significant confounders

model compared scores on the questionnaire with baselines scoring, the model in fact shows that the post-surgery change in physical activity and self-reported eating style was related to weight loss.

Preoperative screening of eligible patients is standard part of bariatric treatment. According to the IFSO criteria, motivation of the patient to follow-up and adherence to, non-specified, behavioural changes is part of the pre-operative assessment [26]. Thus, preoperative behaviour of the patients is, at least partly, used to decide whether a patient is suitable for bariatric surgery. Thereby, it is assumed that current (preoperative) behaviours influence behaviour and weight change after surgery. This has been questioned before [27]. The results of the current study show that preoperative self-reported physical activity and eating style are not related to weight loss or weight regain at any of the follow-up moments. This indicates that questionnaires evaluating physical activity and eating style do not provide information that should be used to decide whether a patient is suitable for bariatric surgery. Preoperative scores did influence the association between changes in physical activity/eating styles and weight loss after surgery and changing of physical activity and eating style should thus be focus of post-operative care.

Like in the non-bariatric population, regular physical activity is advised to all bariatric patients [8–11]. In previous publications, higher physical activity after surgery was related to better weight loss [28–34]. In our population, patients who became increasingly active showed higher weight loss at almost all follow-up moments. This has been shown before, even when looking at preoperative change in physical activity [22, 35].

Emotional eating is thought to negatively influence weight loss results, after non-surgical and surgical weight loss treatments [18, 36, 37]. There was a decrease in emotional eating after surgery, this decrease was mostly observed between baseline and 15 months; after that, emotional eating scores gradually increased. The mixed model showed that patients who experienced more emotional eating after surgery had lower weight loss. In addition, at 48-month follow-up, reporting more emotional eating was related to more weight regain. These data do not permit conclusions about causality: self-reported emotional eating might be a factor that contributes to weight regain, though it is also possible that weight regain leads to an increase in emotional eating.

For external and restrained eating, studies assessing the effect on weight loss in bariatric patients are sparse and show conflicting results [12, 13, 17, 19]. In the large population of the current study, higher self-reported restrained eating at 15, 24 and 36 months after RYGB was related with a lower weight loss. Higher restrained eating was also related to more weight regain 36 months after surgery. It was interesting that, like emotional and external eating, restrained eating scores decreased after surgery and that higher restrained had a negative relationship with weight loss. These results again show that self-reported restrained eating seems to reflect intentions to restrain intake instead of actual restrained eating [38]. For external eating, there was only a significant relationship with 24 months weight loss; patients had a higher decrease in external eating lost more weight. Contrary to previous research, in our study, external eating was not related to weight regain [12].

A surprising result was that the mean changes in self-reported physical activity (0.76) and eating styles (−0.32 to −0.61) were quite small. Other studies have also shown a small change in physical activity [39]. For eating style, results are hard to compare since this was the first large study using the DEBQ. Other studies, using other questionnaires, show variable results in changes of eating style [12, 19, 40]. We did see a large range in the changes in physical activity and eating style. An explanation for the small changes can be that in our treatment program patients are educated on physical activity and eating styles, patients might overestimate physical activity and underestimate eating style before surgery and, with the education of the program, their own estimations change.

Although we included more than four thousand post-bariatric patients in this longitudinal study, our data cannot be interpreted in a causal way. It could be that an increase in physical activity is causal to an increase in weight loss, but the association might as well be the other way around; a decrease in weight loss facilitating physical activity. Another limitation is the lost to follow-up of 39% and 53% of the patients at respectively 36 and 48-month follow-up. Nonetheless, this is the first study assessing the effect of self-reported physical activity, emotional, external and restrained eating in such a large population with a follow-up until 48 months.

## Conclusion

Based on our results, we could argue that success after RYGB is not related to self-reported preoperative physical activity or eating behaviour. Therefore, the decision whether a patient is suitable for surgery should not be made on these self-reports of physical activity and eating style. In addition, professionals working in the bariatric field should be aware that these specific preoperative behaviours are not predictive of results.

Changes in self-reported physical activity, emotional eating and restrained eating and were related to increased weight loss. Future research should study whether changes in self-reported physical activity and/or eating style are causal to weight change after surgery. Lastly, efforts should be made in order to predict which patients will experience weight regain in an earlier stage.

## Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Ethical Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

For this type of study formal consent is not required.

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