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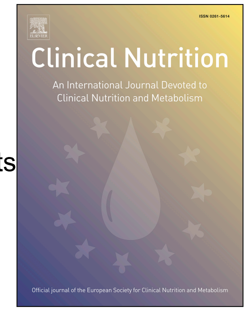

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Timing of food intake is associated with weight loss evolution in severe obese patients after bariatric surgery

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Running title: Food timing and weight loss effectiveness

ABSTRACT

Background: Recent research has demonstrated a relationship between the timing of food intake and weight loss in humans. However, whether the meal timing can be associated with weight loss in patients treated with bariatric surgery is unknown.

Objective: To evaluate the role of food-timing in the evolution of weight loss in a sample of 270 patients that underwent bariatric surgery with a follow-up of 6 years.

Methods: Participants (79% women; age [mean+/−SD]: 52±11 years; BMI: 46.5±6.0 kg/m^2) were classified according their weight loss response patterns after bariatric surgery: good weight-loss-responders (67.8%), primarily poor weight-loss-responders (10.8%) or secondarily poor weight-loss-responders (21.4%). Then, they were grouped in early-eaters and late-eaters, according to the timing of the main meal (before or after 15:00 hours). Obesity and biochemical parameters, energy and macronutrients intake, energy expenditure, sleep duration, and chronotype were studied.

Results: The percentage of late eaters (after 15:00h) was significantly higher in the primarily poor weight-loss-responders (~70%) than in both secondarily poor weight-loss-responders (~42%) and good weight-loss-responders (~37%) (p=0.011). Consistently, primarily poor weight-loss-responders had lunch later as compared to good and secondarily poor weight-loss-responders (p=0.034). Age, gender and type of surgery were not determining. Surprisingly, obesity-related variables, biochemical parameters, pre-surgical total energy expenditure, sleep duration, chronotype, calorie intake and macronutrients distribution, were similar among groups.

Conclusions: Weight loss effectiveness after bariatric surgery is related to the timing of the main meal. Our preliminary results suggest that the timing of food intake is

important for weight regulation and that eating at the right time may be a relevant factor to consider in weight loss therapy even after bariatric surgery.

Introduction

Treatment for severe obesity includes life style changes, such as dietary interventions and exercise, and bariatric surgery.[1] From those approaches, bariatric surgery is the most successful weight loss strategy for severe obesity and its health benefits are beyond weight loss.[2] In terms of weight outcomes in bariatric surgery, “success” is described as loss of >50% excess weight (% EWL), loss of > 20–30% of initial weight, and achieving a BMI < 35 kg/m^2, with the maximum weight loss being observed typically during the postoperatively period between 18 and 24 months.[3] Nonetheless, weight loss after bariatric surgery varies widely and a significant proportion of patients responds poorly.[4-6] Description of patterns of weight change within this variability has seldom been attempted.[5] Recently, de Hollanda *et al*.[5] have reported the high inter-individual variability of the weight loss response following surgery in a Mediterranean population. Interestingly, poor weight loss after bariatric surgery could be illustrated by two different patterns: primarily poor weight-loss-response (approximately 5% of the patients) characterized by sustained limited weight loss, and secondarily poor weight-loss-response (approximately 20% of the subjects) characterized by a successful initial weight loss but subsequent weight regain leading to a final EWL <50%.

A substantial amount of research has addressed the association of poor weight loss response after bariatric surgery with a complete set of factors, potentially involved in the variation of postsurgical responses, such as: clinical,[6] genetic,[7] hormonal,[8] and nutritional[9]. However, the role and relative importance of all these factors in the variability of weight loss outcomes after bariatric surgery is not well understood. Current studies suggest that not only “what” we eat, but also “when” we eat may have a significant role in obesity treatment.[10-14] Moreover, recent research links energy metabolism to the circadian clock at different levels: behavioral, physiological and molecular, concluding that the timing of food intake itself have a major role in obesity.[10,13] Our group, in a longitudinal study with an overweight and obese Mediterranean population, recently found that those who ate their main meal later in the day (lunch for this population) lost significantly less weight than those who ate lunch early, although early eaters and late eaters showed similar intake and physical activity, dietary consumption, macronutrient distribution, sleep duration and hormone levels.[13] These results suggest that eating late may weaken the achievement of weight loss therapies.[12,13] Furthermore, we have demonstrated in a randomized, crossover trial that eating late lunch is associated with a decreased of a) resting-energy expenditure, b) fasting carbohydrate oxidation and c) glucose tolerance.[12] Moreover, eating late lunch flattened daily profile in levels of free cortisol and decreased thermal effect of food on wrist temperature. [12] Also, a recent human study has shown that the time of food intake affects both the energy expenditure and the metabolic responses to meals.[14] Nevertheless, there is currently no evidence that food timing can predict weight loss in severe obese patients submitted to bariatric surgery. Therefore, the aim of our observational prospective study (6 years of follow up) was to evaluate if food timing is associated with the weight loss effectiveness following bariatric surgery in a cohort of severe obese.

Subjects and methods

Participants and procedures

Participants in our observational prospective study were selected from the 1135 subjects that underwent bariatric surgery at the Hospital Clinic of Barcelona (Spain) between 2006 and 2011. Inclusion criteria included age ≥18 years, first-time bariatric surgery, and 60 months of available follow up. From those who fulfilled the eligibility criteria, a total of 320 patients agreed to participate. Fifteen % of the initial volunteer subjects dropped out of the trial. Finally, a total of 270 patients (79% women) participated in this study. Patients were considered for bariatric surgery based on the current guidelines, which include to have a body mass index (BMI) ≥ 40 kg/m^2 or to have a BMI ≥ 35 kg/m^2 with 2 or more health risk factors, such as high blood pressure or diabetes.[15] Two commonly performed surgery techniques were performed, namely Roux-en-Y gastric bypass (RYGB; n=203) and sleeve gastrectomy (SG; n=67). The technical aspects of those surgery techniques and the criteria for selection of RYGB or SG at the Hospital Clinic Barcelona have previously been reported.[16] Data were prospectively collected prior to the surgery and at 12, 18, 24, 36, 48, 60 and 72 months (6 years) in the postsurgical period. All procedures were in accordance with good clinical practice. Patient data were codified to guarantee anonymity.

All subjects attended both group and individual sessions, which included nutritional counseling according to the current guidelines for the bariatric patient prior the surgery[15]. Dietary advice was given to the patients after surgery: at 2 and 6 weeks, and then at 4, 8, and 12 months, emphasizing to sustain a hypocaloric and proteinrich diet, rather than a recommendation of specific timetable. During the first year after the surgery, the patients were advised to eat 5-6 meals per day and after this first year, to eat 3-4 meals per day. No different nutritional education was given according to the type of surgery.

Ethics

The study followed the ethical guidelines of the Declaration of Helsinki 1961 (revised Edinburgh 2000) and the current legislation concerning clinical research in humans.

Ethics Committee of the Hospital Clinic Barcelona approved the protocol and the written informed consent was obtained from all the participants of the study.

Obesity and biochemical parameters

Participants were weighed wearing light clothes and without shoes to the nearest 0.1 kg (Seca 703 scale, Hamburg, Germany). Height was determined using a fixed wall stadiometer (Seca 217, Hamburg, Germany) to the nearest 0.1 cm. Waist circumference was measured to the nearest 0.5cm, at the level of the iliac crest, and hip circumference was measured to the nearest 0.1cm to the maximum extension at the buttocks level. All measurements were made with a standard flexible and inelastic measuring tape. Body mass index (BMI) was calculated as weight (kg) divided by squared height (meters). Postoperative weight loss (WL) was expressed as a percentage excess of weight loss (%EWL) following the formula: EWL= [100× (weight prior to surgery − weight at the time of evaluation)/ (weight prior to surgery − weight corresponding to body mass index (BMI) =25 kg/m^2)]. Plasma cholesterol, triglycerides, lipoproteins' concentrations were determined by automated chemical analysis at the Hospital Clinic of Barcelona.

Energy and dietary intake before and after bariatric surgery

The dietary intake was analyzed through 4-days food records (one of which was a non-working day) that were collected at every follow up prior and after surgery. For the purpose of our study we have included: a) prior to surgery (initial values), b) at nadir weight, and c) at the last follow up. Instructions about how to fill the 4-days record were explained by a registered dietitian during the clinical evaluations. Patients were instructed to complete the dietary records the week prior to the nutritional interview. Total energy intake and macronutrient composition were analyzed using the software Dietsource 2.0® (Novartis). During the follow-up period of each subject, patients also registered the time (hour) when each meal began (for example, breakfast, lunch and dinner) with the questionnaire developed by Bertéus-Forslund *et al*.[17] The cohort was divided in early and late Spanish lunch eaters (before or after 15:00h) following Garaulet *et al.* [13]

Energy expenditure

The total expenditure was calculated by multiplying each individual's basal metabolic rate with the individual physical activity level (PAL). Basal metabolic rate was estimated by the Harris-Benedict equation and physical activity level was self-reported as either "sedentary or light activity" (PAL=1.53) or "moderate activity" (PAL=1.76).[18]

Weight loss classification criteria.

The criterion of weight loss response following bariatric surgery proposed by de Hollanda *et al*.[5], which establishes three different patterns of weight loss, was used to classify the patients. Those three patterns were: 1) Patients with EWL ≥50 % at nadir and throughout subsequent follow-up were considered as good weight-loss-responders; 2) Patients with EWL <50% at nadir weight and up to the end of follow up were considered as primarily poor weight-loss- responders; and 3) Patients with EWL ≥ 50% at nadir weight but EWL <50% at last follow up were considered as secondarily poor-weight-loss responders.

Morningness/ Eveningness questionnaire

Subjects completed the 19-item morningness/eveningness questionnaire (MEQ) of Horne and Ostberg[19] at the follow-up period. According to this score, individuals were categorized as neutral (53-64 of score), morning (above 64 of score) or evening types (under 53 of score).[20] Morningness-eveningness typology is a procedure to characterize individuals depending on individual differences of wake/sleep patterns and the time of the day people report to better performance. Some people are night ‘owls’ and like to stay up late in the night and sleep late in the morning (evening type), whereas others are ‘early birds’ and prefer to go to bed early and arise with the break of dawn (morning types).

Sleep duration

Habitual sleep duration was evaluate by questionnaire, including the questions ‘During week days: How many hours (and minutes) do you usually sleep?’, and ‘During weekend days: How many hours (and minutes) do you usually sleep?’. A total weekly sleep duration was calculated as ((min weekdays * 5) + (min weekend days*2))/7.[21]

Statistics

All data are expressed as mean ± standard deviation (SD) unless stated otherwise. Differences in the general characteristics of the population, in daily energy and macronutrient intake and in meal times between the subjects grouped by the three different weight loss patterns were analyzed by analysis of variance (ANOVA). Levene’s test to assess variance homogeneity and Tukey’s post hoc tests were performed. Then, subjects were grouped in early and late eaters for Spanish lunch using the median values of the population as the cutoff point, as previously reported[13]. Chi-square tests were used to test differences in percentages between early or late lunch eaters. Statistical analyses were performed using SPSS 21.0 software (SPSS). A two-tailed p-value of < 0.05 was considered statistically significant.

RESULTS

In the population studied, 67.8% of participants were considered good weight-loss-responders (presented EWL ≥ 50% at nadir and last follow up) according to the criteria proposed by de Hollanda *et al*.[5] On the other hand, 10.8% of subjects were classified as primarily poor weight-loss-responders (showing EWL < 50% at nadir) and 21.4% of the participants as secondarily poor weight-loss-responders. The EWL trajectories of our whole cohort according to de Hollanda *et al*.[5] patterns of weight loss response following bariatric surgery are shown in **Figure 1**.

Table 1 includes the initial characteristics of the patients according to the pattern of weight loss response following bariatric surgery. No significant differences were found in obesity-related variables neither in biochemical parameters such as pre-surgical blood lipids values, pre-surgical total energy expenditure, sleep duration and individual chronotype (morning-evening score) as assessed by the morningness-eveningness questionnaire, among the three weight loss groups. Moreover, no significant differences were found for energy intake and the macronutrients distribution at the periods of time studied (**Table 2**). No significant differences were observed also after adjusting for gender, age and type of surgery ($p > 0.05$).

Our results indicate that weight loss effectiveness was related to the timing of the meals. The percentage of late eaters (after 15:00 h) was significantly higher in the primarily poor weight-loss-responders (~70%) than in both the secondarily poor weight-loss-responders (~42%) and the good weight-loss-responders (~37%) ($p=0.011$), after adjusting for gender, age and type of surgery (**Figure 2**). Consistently, primarily poor weight-loss-responders had lunch later (by approximately 22 min) compared to the other two groups, while no differences were found in the timing of the other two main meals of the day (breakfast and dinner) among the three weight loss groups **(Table 3).**

DISCUSSION

As far as we are aware, this is the first observational prospective study to show a relationship between meal timing and weight loss response in a cohort of severe obese after bariatric surgery. We found that the percentage of late lunch eaters was significantly higher in the primarily poor weight-loss-responders and their lunch was an average of 22 min later than the secondarily poor and the good weight-loss-responders. Interestingly, the difference of the evolution of weight loss among the three groups: good, secondary poor, and primary poor weight-loss-responders was not explained by differences in caloric intake, macronutrient distribution, sleep characteristics, chronotype or estimated energy expenditure during the time period studied.

Previously, our research group proved **that eating late was predictive of decreased weight loss success** in overweight and moderately obese subjects following a dietary weight loss therapy.[13] Also, in an interventional study, we have also shown that delaying the timing of the main meal of the day may create metabolic disturbances such as decreased resting-energy expenditure, decreased glucose tolerance and carbohydrate oxidation, among others.[12] Recently, it has been shown that time-restricted feeding (TRF), with food access limited to daytime 12 hours every day and on a high fat diet, prevented body weight gain in *Drosophila.*[22] Authors concluded that the daily rhythm of feeding and fasting *per se* (without any change in caloric intake and activity) could improve sleep, prevent body weight gain, and deceleration of cardiac aging under TRF, benefits that appear to be mediated by the circadian clock.[22] Moreover, Bo et al., in a recent study conducted on healthy subjects, have shown that the time of the food intake itself affects both the thermogenic and the metabolic responses to meals.[14]

It is important to consider that in our severe obese population, weight loss effectiveness after bariatric surgery was associated with the timing of th**e main meal (**lunch for the Spanish population), with no significant association with breakfast and dinner. Moreover, no significant differences in the percentage of breakfast skipping (~10%) among the three groups were found. Thus, it is hypothesized that this relative important intake of energy (lunch comprises ~40% of daily energy intake in Spanish populations[20]) could be resetting peripheral clocks by itself or indirectly through changes in timing of the other meals.[10,13]

In our study, the caloric intake of the severe obese subjects followed was similar to that described in other severe obese populations for both pre- and post-surgery.[23,24] However, interestingly, there were no significant differences in energy intake and macronutrient distribution among the three weight loss groups at any of the points studied (baseline, nadir and last follow up), suggesting that the time "**when**" food is eaten is an influential factor in weight loss effectiveness beyond "**what**" is eaten (in terms of energy intake and macronutrient distribution) in our population. Several previous studies done in mice and rats had similar outcomes concluding that the time of food intake is crucial in weight evolution regardless of energy intake.[11]

Furthermore, we investigated different **clinical factors at baseline** that could potentially affect the weight loss response to bariatric surgery such as anthropometric and metabolic parameters. Unexpectedly, obesity degree or metabolic parameters did not predict the weight loss outcome among the different weight loss patterns. Several studies have reported that baseline BMI[25,26] could be considered predictor of success in terms of weight loss after bariatric surgery. A possible explanation for the differences found between the current study and previous ones could be that most of these studies were performed in a short-term follow up while our study presents a **mean of 6 years of follow-up**.

Another factor to considerer for weight loss **is sleep duration** because several studies have associated short sleep duration as an increased risk for obesity and impaired weight loss.[27,28] However, in the current work the self-reported data on sleep duration indicate similar sleep duration (~7 h) among the different weight loss patterns. Our results agree with the data of Garaulet *et al.*[13], which indicated no overall differences in sleep duration between late and early eaters who showed different patterns of weight loss. Moreover, in a previous study with human subjects Baron *et al.* found that the caloric consumption in the evening (after 8:00 PM) was associated with a higher BMI independently of sleep timing and duration.[29]

Our study supports the efficacy of bariatric surgery on severe obesity treatment since the current population showed a high proportion of good weight loss responders (67.8%). Our results are comparable to other studies carried out in Dutch[30] and in American population.[4] We further provide novel data on the effect of the timing of food intake in bariatric surgery effectiveness. It is worth pointing out the use of the weight loss patterns proposed by de Hollanda *et al.*[5] since they define two distinct poor weight loss trajectories that can be clinically meaningful. As a result, Hollanda's patterns can help to discriminate among subjects who did not achieve adequate postsurgical weight loss throughout follow up (primarily poor-weight-loss response) from those in whom long-term outcome was determined mainly by a pronounced weight regain (secondarily poor-weight-loss response). In the current work the timing of food intake was particularly useful to discriminate between "good" and "primarily poor-weight-loss responders" but not secondarily poor-weight-loss responders. It has been hypothesized that factors linked with resistance to weight loss would potentially underlie the primarily poor-weight-loss responders. On the contrary, factors facilitating weight regain would largely lie beneath secondarily poor-weight- loss response.[5]

Our study explores the important subject of the food timing in weight-loss therapies. An important strength is that includes a long-term data (6 y) with a relatively large sample considering clinical and anthropometrical factors and unique information on meal timing, chronotype and sleep duration. However, our study has several limitations. First, we want to highlight the fact that is an observational prospective study. Therefore, although the association between timing of the main meal and weight loss response to bariatric surgery is an important observation, further research is needed to demonstrate the causality of and potential mechanisms underlying this relationship in bariatric surgery patients. Several potent mechanisms could be implicated in this association such as changes in energy expenditure and metabolic disturbances as have been demonstrated by our group[12, 31]. Second, we cannot rule out the possibility that the energy expenditure differed between the three weight loss groups after surgery, even though we found no significant differences in energy expenditure at baseline among the three groups. Moreover, energy expenditure was estimated using Harris and Benedict equation during the pre-operative phase. Therefore, more research is needed to measure the effect of meal timing on energy expenditure through calorimetry, as it has been previously done in normal weight subjects[12]. Furthermore, another limitation is the fact that dietary intake, physical activity and sleep data were self-reported by the patients using validated questionnaires. Self-report data has many important uses but caution must be accepted when interpreting it. Hence further investigation in food timing is needed using a reference method such a biomarkers, accelorometers and sleep polysomnograpy to corroborate the accuracy of the data and avoid bias. Finally, the dietary intake assessment only includes global total energy and macronutrient distribution *per* day but not by each meal. Nonetheless, as mentioned before, lunch is the most important meal of the day in this Spanish population and did not differ in size between early and late eaters in our previous study.[13] In addition, Spanish lunchtime intake could be considered late when compared to other cultures. However, it should bear in mind that lunch is the main meal in Spain; therefore our results open a door to investigate the influence of the time of the main meal on weight evolution in other cultures.

To summarize, we have found for the first time an association between the timing of food intake and weight-loss response after a bariatric surgery treatment. Indeed, weight loss effectiveness was better in early eaters as compared to late eaters. Age, gender and type of surgery were not determining in our results. Moreover, differences in weight loss evolution could not be explained by differences in energy intake, dietary composition and sleep duration. These preliminary results stress the importance of not just what we eat, but also when we eat. Our data furthermore suggest that eating at the right time may be a relevant factor to consider in weight loss therapy even in bariatric surgery.

CONFLICT OF INTEREST

The authors declare no conflict of interest

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AUTHOR CONTRIBUTIONS

MIP, MG designed the research; TRL, MIP, JV, AdH conducted the research; TRL, MIP, MG analyzed data; TRL, MG, MIP, FAJLS wrote the paper. All authors read and approved the final manuscript.

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Figure legends

Figure 1. Excess weight loss over 6 years according to the three different weight loss patterns following bariatric surgery.

Figure 2. Percentages of early eaters (before 15:00) and late eaters (after 15:00) in the population grouped according to the three different weight loss patterns following bariatric surgery. WL: weight loss. *Differences among percentages were statistically significant (p=0.011) after adjusting by sex, age and type of surgery*

Table legends

Table 1. Characteristics[1] of the population grouped according to the three different weight loss patterns following bariatric surgery.

Table 2. Daily energy and macronutrient intake[1] of the population grouped according to the three different weight loss patterns following bariatric surgery.

Table 3. Meal times (hours: minutes) [1] of the population grouped according to the three different weight loss patterns following bariatric surgery.

Table 1. Characteristics[1] of the population grouped according to the three different weight loss patterns following bariatric surgery.

	Good WL[2] response	Primarily poor WL response	Secondarily poor WL response	P-value
n	183	29	58	---
Age (y)	50.4 (11.0)	57.3 (8.7)	54.1 (11.5)	0.002
Gender (% female)	81.9	86.2	65.5	0.014
Type of surgery (% GBP[3])	76.9	86.2	63.8	0.045
Initial weight (kg)	123.1 (18.8)	123.3 (37.4)	123.9 (16.5)	0.995
Initial BMI (kg/m^2)	46.3 (5.3)	47.6 (8.9)	46.5 (6.3)	0.549
Initial waist (cm)	130.8 (12.3)	128.6 (17.9)	131.2 (10.8)	0.658
Initial waist hip ratio	0.94 (0.08)	0.89 (0.08)	0.96 (0.12)	0.078
Initial triglycerides (mg/dl^{-1})	138.0 (57.5)	124.8 (54.8)	159.0 (91.8)	0.362
Initial cholesterol (mg/dl^{-1}	200.3 (40.9)	192.3 (32.5)	200.3 (31.4)	0.799
Initial LDL (mg/dl^{-1})	125.8 (30.9)	122.0 (23.1)	124.8 (30.3)	0.942
Initial HDL (mg/dl^{-1})	47.5 (10.1)	46.8 (8.6)	41.5 (8.4)	0.153
Initial total energy expenditure (kcal/day)	2082.9 (268.8)	2053.5 (424.2)	2013.4 (265.5)	0.274
Morning-evening score[4]	56.2 (8.2)	53.6 (10.1)	57.5 (8.4)	0.127
Sleep duration (hrs)	6.9 (1.2)	7.0 (1.5)	7.1 (1.8)	0.737

[1]Data are shown as percentage or mean (SD); [2] WL: weight loss; [3] GBP: gastric bypass; [4]Morningness - eveningness typology: evening types<53, neutral types 53-64, morning types >64.

Table 2. Daily energy and macronutrient intake[1] of the population grouped according to the three different weight loss patterns following bariatric surgery.

	Good WL[2] response	Primarily poor WL response	Secondarily poor WL response	P-value
n	183	29	58	---
Dietary initial values				
Energy intake (kcal)	2507.9 (1108.6)	2152.1 (746.4)	2448.5 (850.9)	0.332
Protein intake (g)	96.8 (34.2)	96.3 (25.6)	99.4 (30.6)	0.906
Carbohydrate intake (g)	242.3 (105.7)	200.0 (78.5)	230.1 (81.5)	0.183
Fat intake (g)	125.5 (67.9)	106.2 (48.1)	120.9 (54.5)	0.429
Protein intake (%)	16.5 (3.8)	18.8 (4.8)	17.3 (4.8)	0.062
Carbohydrate intake (%)	39.7 (8.8)	36.6 (7.3)	38.9 (10.4)	0.377
Fat intake (%)	43.8 (9.2)	43.6 (9.7)	43.7 (9.8)	0.995
Dietary values at nadir weight[3]				
Energy intake (kcal)	1492.6 (301.5)	1570.8 (361.9)	1593.5 (355.2)	0.282
Protein intake (g)	74.5 (20.4)	79.4 (18.8)	72.7 (22.7)	0.552
Carbohydrate intake (g)	142.3 (46.9)	148.8 (40.1)	154.9 (57.3)	0.464
Fat intake (g)	69.5 (21.5)	73.1 (31.4)	74.7 (22.0)	0.544
Protein intake (%)	21.4 (11.5)	20.4 (4.1)	18.6 (5.1)	0.375
Carbohydrate intake (%)	38.1 (9.2)	38.8 (10.7)	39.8 (9.5)	0.699
Fat intake (%)	41.5 (8.3)	40.7 (10.2)	41.7 (7.4)	0.909
Dietary values at last follow-up[4]				
Energy intake (kcal)	1614.0 (498.1)	1519.6 (330.1)	1616.7 (418.1)	0.708
Protein intake (g)	80.1 (22.9)	68.2 (16.4)	71.6 (21.4)	0.580
Carbohydrate intake (g)	164.0 (62.3)	160.6 (54.7)	169.1 (66.4)	0.888
Fat intake (g)	74.3 (28.9)	67.2 (18.3)	71.4 (25.6)	0.557
Protein intake (%)	18.6 (4.9)	18.4 (4.2)	18.6 (5.3)	0.983
Carbohydrate intake (%)	40.4 (9.7)	41.9 (7.9)	41.8 (11.5)	0.695
Fat intake (%)	41.3 (8.8)	40.1 (8.0)	39.7 (9.5)	0.667

[1]Data are shown as percentage or mean (SD); [2]WL: weight loss; [3]Nadir weight was achieved at 18-24 months after surgery; [4]Last follow-up was at 60 months after surgery.

Table 3. Meal times (hours: minutes) [1] of the population grouped according to the three different weight loss patterns following bariatric surgery.

	Good WL[2] response	Primarily poor WL response	Secondarily poor WL response	P-value*
Breakfast	08:52[a] (01:16) (n=165)	08:45[a] (01:07) (n=26)	09:01[a] (01:07) (n=52)	0.496
Lunch	14:09[b] (00:46) (n=183)	14:31[c] (00:43) (n=29)	14:10[b] (00:50) (n=58)	**0.034**
Dinner	21:22[d] (00:52) (n=183)	21:09[d] (00:49) (n=29)	21:07[d] (00:46) (n=58)	0.090

[1]Data are expressed as mean (SD); [2]WL: weight loss; *Adjusted by sex, age and type of surgery. Bold face representing statistical differences with *P*<0.05. Different letters indicate significant differences between groups after post hoc analysis (Tukey's post hoc test).

Figure 1. Excess weight loss over 6 years according to the three different weight loss patterns following bariatric surgery.

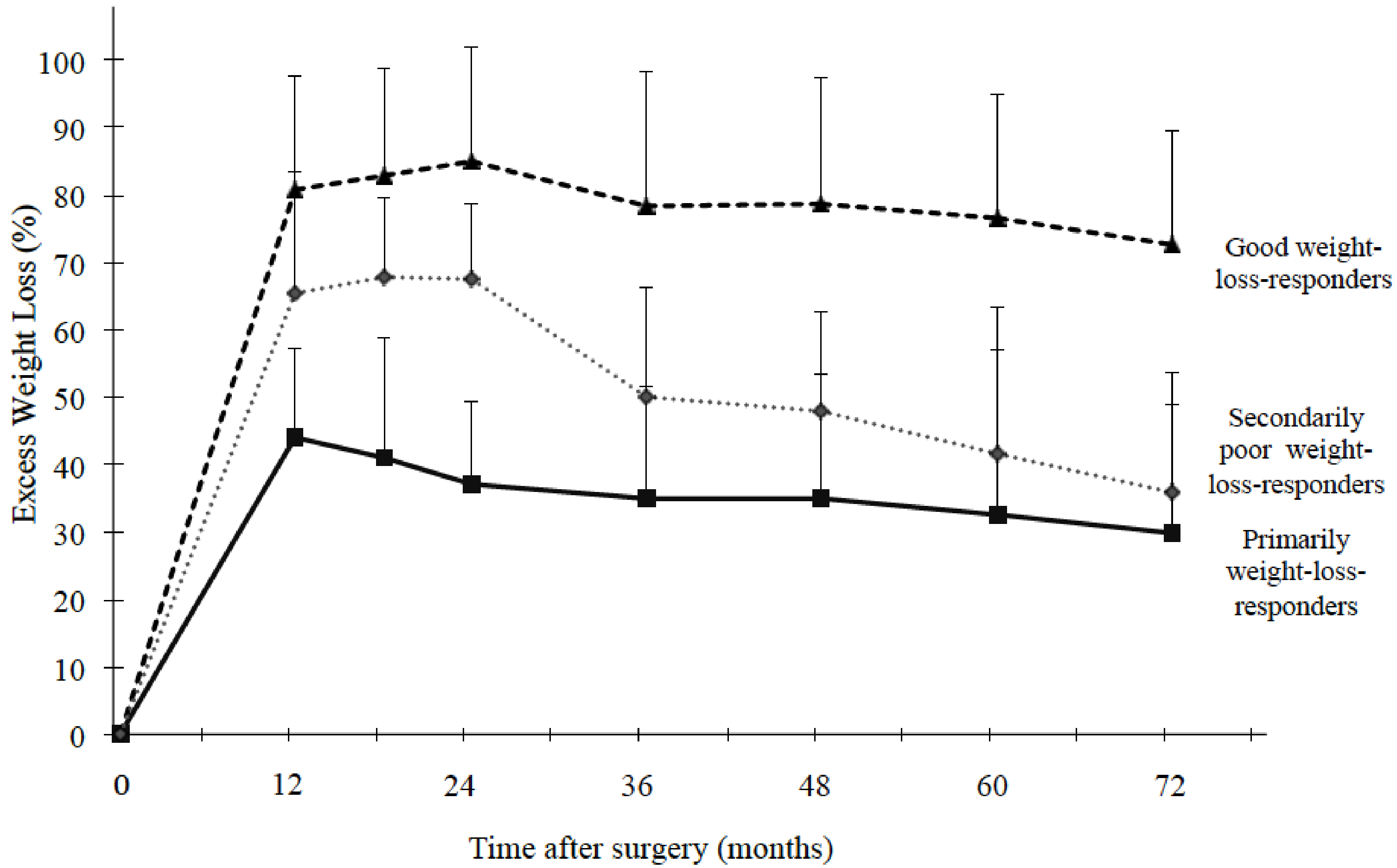

Figure 2. Percentages of early eaters (before 15:00) and late eaters (after 15:00) in the population grouped according to the three different weight loss patterns following bariatric surgery. WL: weight loss. *Differences among percentages were statistically significant (p=0.011) after adjusting by sex, age and type of surgery.*