

# Association Between Weight Gain, Psychological, Sociodemographic Factors, and Physical Activity in Bariatric Patients: A Network Perspective

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## Research Article

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# Abstract

**Background** Weight gain affects about 10-20% of patients after bariatric surgery (BS). It's a phenomenon that's difficult to understand and to intervene due to its complexity and etiological heterogeneity. In the present study, we investigated, from a network analysis perspective, the associations between weight regain, psychological, sociodemographic factors and physical activity in patients undergoing BS.

**Methods** The sample consisted of 124 patients, of both sexes, aged  $39 \pm 9.1$  years, who had undergone surgical intervention for more than 18 months. After voluntary consent, respondents answered questionnaires and instruments directly on the Google Forms platform.

**Results** The weight gain was negatively associated with the items of depression, anxiety and stress, binge eating and with the dimensions of the personality questionnaire (negative affectivity -0.182; detachment -0.078; antagonism -0.107; disinterest - 0.198 and psychoticism -0.158).

**Conclusion** Characteristics of disinterest and negative affectivity and most of the items on the depression, anxiety and stress scale had a greater expected influence, indicating that these are the most sensitive variables to intervention and who need more attention from health professionals.

**Level of evidence:** Level III, evidence obtained from well-designed case-control analytic studies.

## Introduction

Obesity is a worldwide epidemic. In 2016, more than 1.9 billion adults were overweight and of these, more than 650 million were obese [1]. Morbid obesity is the most severe form of this disease, reducing life expectancy between 10 and 15 years [2]. This pathology is defined as a metabolic disease of genetic etiology and aggravated by exposure to environmental, psychological, cultural, economic, social phenomena. Still being associated with factors such as age, race, gender, and sedentary lifestyle, proving its multifactoriality and complexity [3–4].

Clinical treatment for obesity includes nutritional therapy, medication and physical activity. When there is failure in this treatment and obesity becomes morbid, BS is indicated [5]. Unfortunately, in an average period of 18 months after surgery, 10–20% of operated patients gain weight [6–8]. Eating behavior, sedentary lifestyle, and psychological factors such as depression, anxiety, stress, binge eating, personality, body self-image, and how the individual faces external stress factors, may be listed as the several factors that influence weight gain. Indeed, patients with anxious behaviors tend to eat more after BS, and those with greater capacity for concentration, organization and systematic control would likely avoid weight gain [9]. These characteristics may be linked to the evaluation that individuals have about eating behavior. Studies have even indicated that this failure of evaluative capacity is one of the best predictors of weight gain, once the patient does not perceive what he eats, how much he eats, what habits are healthy, including physical activity, and which are not [10–12]. Though all these factors seem to be intrinsically related in the same individual, the relationship among them is still unclear [6].

Failure to maintain weight loss after BS has been the subject of study in different clinical trials, in order to predict possible influencing factors in outcomes in people with obesity before and after surgical intervention [16]. Studies have shown that among the different factors involved in weight regain, preoperative and postoperative psychological distress are related to eating behaviors and weight maintenance after BS, [13–15]. However, systematic review research [14] and meta-analysis [15] claim that the evidence on the association between emotional conditions and preoperative eating disorders and postoperative weight loss is inconsistent. Therefore, in order to investigate the interaction between personality traits, anxiety and eating symptoms in obese candidates for BS, Monteleone et al. [17] demonstrated, for the first time in a network analysis perspective, the influences between personality traits and anxiety symptoms on eating behaviors in this group of patients; however, the authors state that the main limitation of that study was the failure to include depressive symptoms and social measures in their analyzes.

Therefore, considering the aforementioned attributes, the problem of obesity and weight gain can be characterized as a complex system (SCA). Complex systems have heterogeneous agents that interact in a non-linear way and are sensitive to small changes. In this sense, the perspective of networks can be proposed as an excellent tool to evaluate complex systems, as in the health area [18] and specifically in obesity [19]. Thus, the present study aimed to evaluate possible associations between weight regain, psychological (anxiety, stress, depression and personality), sociodemographic factors and physical activity from a network perspective in patients undergoing BS.

## Materials And Methods

This is a quantitative and cross-sectional study. The STROBE protocol [20] and CHERRIES [21] were used. The sample was composed of convenience. Inclusion criteria were: patients aged at least 18 years old, of both sexes, operated by the same surgeon, by Gastric Bypass or Sleeve techniques and who accepted to voluntarily participate in the study. Patients with post-surgical time less than 18 months were excluded from the sample. Invitations were sent to bariatric patients Brazilians over 18 months old, of which only 124 voluntarily agreed to participate in the research, and it is emphasized that of this total 14.5% of the patients were operated by the Sleeve technique and 85.5% by the Bypass technique. The individuals in the sample had a mean age of  $39 \pm 9.1$  years, of both sexes, with a minimum post-surgical time of 18 months and a maximum of 144 months, followed by the multidisciplinary health team of the Nucleus – Health Services located in the municipality of Ceará, Brazil. An online invitation to participate in this study was directed individually to each participant, where they were informed about the objectives, protocols and procedures of the research. After voluntary consent, the interviewees answered the instruments directly on the Google Forms online platform. The Helsinki Declarations' ethical aspects were followed. This study was approved by the Brazil National Board of Research Ethics under the requirement of proper informed consent.

## Measures

A questionnaire was used to obtain information on the clinical and socioeconomic variables. Two instruments were applied: Bulimic Investigatory Test of Edinburgh (BITE) [22], in its version in Portuguese [23], and the Periodic Binge Eating Scale (ECAP) [24] also in its Brazilian version [25]. The BITE is a self-administered questionnaire, composed of two scales: one of symptoms (composed of 30 items) and one of severity (3 dimensional items). [22–23]. ECAP is an appropriate instrument to distinguish individuals who are candidates for BS according to the severity of 'periodic binge eating' (CAP) [26]. BMI (body mass index) was calculated by dividing body mass by square of height in meters ( $\text{Kg}/\text{m}^2$ ). To evaluate weight loss and regained weight after surgery, the equation of %TWL (Percent total weight loss) was used, considered one of the best methods to evaluate post-bariatric weight loss. Values higher than 15% of NADIR weight (lower body weight achieved after bariatric powders) [27–28] is considered weight regain [27]. The level of physical activity (PA) was assessed using the summarized version of the International Physical Activity Questionnaire (IPAQ) validated in Brazil by Matsudo et al. [29–30]. Symptoms of stress, anxiety and depression were measured and differentiated using the Depression, Anxiety and Stress Scale - Short Form (DASS-21) instrument [31]. In this study, the DASS-21 version was used for Brazilian adults translated and valid by Machado and Bandeira [32]. [33]. Pathological personality traits were evaluated using the Personality Inventory for DSM-5 Short Form (PID-5-SF) [34]. It is a self-applicable instrument composed of 100 items extracted from the Personality Inventory for DSM-5 (PID-5) [35], which was reduced and validated by Timm et al. [32]. The scores of the PID-5-SF domains are calculated by adding scores from the three scales that contribute to the evaluation of the pathological personality traits of the hybrid model proposed by the DSM-5 [35–36].

## Statistical analysis

Means and standard deviations were used for continuous variables and frequency distributions (absolute and relative values) for categorical variables. To compare age between the group with weight regain and without weight regimen, the t test for independent samples was used. The other categorical variables were compared between patients with and without weight regain and between sex using the chi-square test. P-value < 0.05 was considered significant. A network analysis was used to evaluate the association between biological and psychosocial variables. Indicators of closeness and expected influence were reported. Variables with higher expected influence values are more sensitive to change and can act as a hub by connecting other pairs of variables on the network. A variable with a high closeness value will be quickly affected by changes anywhere in the network and can also affect other parts. To improve network accuracy, we use the "Markov random fields in pairs" model. The algorithm adds a penalty "L1" (regularized neighborhood regression). The adjustment is estimated by a less complete selection and contraction operator (Lasso) that controls the sparse network. The extended Bayesian information criterion (EBIC) was observed to select the Lambda from the regularization parameter. Network analysis uses regularized algorithms of lower absolute reduction and selection operator (LASSO) to obtain the precision matrix. This matrix, when standardized, represents the associations between the variables present in the network. The blue color represents positive associations, and the red color represents negative associations. The thickness and intensity of colors represent the magnitude of the associations. The analyses were performed through the RStudio and package qgraph.

## Results

Sociodemographic characteristics and reported PA levels of participants with and without weight gain by sex are presented in Table 1. In the weight gain group ( $N = 42$ ), most of the participants were female ( $N = 97$ ), satisfied with the current weight (71.4%). Only in the income variable was found a statistically significant difference between the group with and without weight gain ( $\chi^2 = 13.58$ ;  $p = 0.009$ ).

Table 1  
Characteristics of the participants.

Variable	M(SD) ou N (%)		M(SD) or N (%)		t ou $\chi^2$	p-value
	Regain (N = 42)				Without regain (N = 82)	
	Men (N = 10)		Woman(N = 32)		Men (N = 17)	
<b>Age (years old)</b>	35.2(6.05)	38.93(9.96)	40.7(7.93)	39.96(10.46)	-1.13	0.26
<b>Satisfaction with current weight N (%)</b>						
Dissatisfied	2(20)	10(31)	8(47)	30(46)	3.64	0.056
Satisfied	8(80)	22(69)	9(53)	35(54)		
<b>People in the house N (%)</b>						
1	1(10)	11(34)	1(5.9)	14(22)	3.37	0.49
2	3(30)	4(12.5)	2(11.76)	15(23)		
3	4(40)	8(25)	11(64.70)	21(32)		
4	2(20)	5(16)	3(17.64)	11(17)		
5	0 (0)	4(12.5)	0 (0)	4(6)		
<b>Income N (%)</b>						
Up to 380 USD	0 (0)	3(9)	1(6)	1(1)	13.58	0.009
380USD to 760USD	1(10)	5(16)	1(6)	18(28)		
760USD to 1900USD	6(60)	19(59)	3(18)	22(34)		
1900USD to 3800USD	2(20)	5(16)	10(59)	24(37)		
Over 3800USD	1(10)	0 (0)	2(11)	0 (0)		
<b>Schooling (in years) N (%)</b>						
9	4(40)	14(44)	10(59)	16(25)	1.80	0.40
12	6(60)	18(56)	7(41)	47(72)		
$\geq 16$	0 (0)	0 (0)	0 (0)	2(3)		
<b>Physical activity</b>						
Inactive	3(30)	13(41)	4(24)	17(26)	2.06	0.15

Variable	M(SD) ou N (%)	M(SD) or N (%)	t ou $\chi^2$	p- value
Active	7(70)	19(59)	13(76)	48(74)

## Network Analysis

The main results of the network indicated that weight regain was negatively associated with all items of depression, anxiety and stress, with the items of binge eating, and with the dimensions of the personality questionnaire (negative affectivity – 0.182; distancing – 0.078; Antagonism – 0.107; Disinhibition – 0.198 and Psychoticism – 0.158). The regain is also associated with having a lower income (-0.292) and having a better schooling (0.255).

## Centrality measures

Table 2 shows the network centrality measures. The personality characteristics: disinterest and negative affectivity and most items of the depression, anxiety and stress scale (D3 "I could not have positive feelings", D5 "I found it difficult to have initiative to do things", D8 "I felt i was quite nervous", D9 "I was worried about situations where I could panic and make a fool of myself", D10 "I felt I had no positive expectations about anything", D11 "I noticed i was getting agitated", D12 "I found it difficult to relax", D13 "I felt downcast and sad", D14 " I didn't have patience with anything that interrupted what I was doing", D15 " I felt I was about to panic", D16 " I couldn't get carried away with anything", D17 " I felt i didn't have much value as a person", D18 "I felt that I was very angry", D20 "I felt scared without any reason" and D21 " I felt that life had no meaning".) had greater expected influence, ranging from 1,043 to 1,502.

The variables with the highest values of closeness were, Ec3, Ec7, Ec9, Ec10, Ec11, D14, Bite\_8 "Does your eating pattern severely harm your life?", Bite\_10 "Do you eat non-stop until you are forced to stop feeling physically unwell?", Bite\_11 "Are there times when you can only think about food?", Bite\_14 "Have you ever felt an uncontrollable urge to eat and eat non-stop?", Bite\_15 "When do you feel anxious), tend to eat too much?", Bite\_18 "Are you ashamed of your eating habits?", Bite\_31 "Your eating habits are what you might consider normal?" and Bite\_32 "Do you consider yourself someone who eats compulsively?", ranging from 1,004 to 1,968.

Table 2  
Network centrality measures.

	Closeness	Expected Influence
Gender	-1.730	-0.315
Regain	-0.490	-1.646
AGE	-1.736	-0.424
Negative Affectivity	<b>1.389</b>	<b>1.267</b>
Distancing	0.087	0.878
Antagonism	-0.773	0.347
Disinterest	0.790	<b>1.071</b>
Psychoticism	-0.303	0.910
Ec1	0.775	0.328
Ec2	-1.554	-0.481
Ec3	<b>1.968</b>	0.730
Ec4	0.964	0.369
Ec5	0.699	0.650
Ec6	0.965	0.119
Ec7	<b>1.186</b>	0.828
Ec8	0.340	0.285
Ec9	<b>1.297</b>	0.393
Ec10	<b>1.812</b>	0.990
Ec11	<b>1.013</b>	0.636
Ec12	-0.515	-0.609
Ec13	-1.120	-0.519
Ec14	-0.179	-0.008
Ec15	0.451	0.244
Ec16	0.282	0.555
D1	-0.392	0.747
D2	-1.609	-0.098

	Closeness	Expected Influence
D3	0.810	<b>1.190</b>
D4	-0.615	0.497
D5	0.292	<b>1.043</b>
D6	-0.479	0.786
D7	-0.814	0.726
D8	-0.168	<b>1.301</b>
D9	-0.073	<b>1.126</b>
D10	0.833	<b>1.370</b>
D11	-0.077	<b>1.248</b>
D12	0.459	<b>1.357</b>
D13	0.340	<b>1.296</b>
D14	<b>1.117</b>	<b>1.290</b>
D15	0.254	<b>1.502</b>
D16	0.733	<b>1.374</b>
D17	0.707	<b>1.291</b>
D18	0.635	<b>1.281</b>
D19	-0.609	0.894
D20	0.003	<b>1.383</b>
D21	0.276	<b>1.564</b>
Bite1	-0.848	0.251
Bite2	-0.877	0.538
Bite3	0.246	-0.987
Bite4	-0.544	0.189
Bite5	-1.316	-1.025
Bite7_1	-1.256	-0.412
Bite7_2	-1.136	-0.572
Bite7_3	-1.228	-0.352
Bite7_4	-1.156	-0.208

	Closeness	Expected Influence
Bite_8	<b>1.269</b>	-1.672
Bite_9	0.527	-1.071
Bite_10	<b>1.004</b>	-1.743
Bite_11	<b>1.376</b>	-1.762
Bite_12	0.511	-1.159
Bite_13	0.853	0.387
Bite_14	<b>1.224</b>	-1.706
Bite_15	<b>1.069</b>	-1.488
Bite_16	-0.192	-1.337
Bite_17	-0.818	-0.770
Bite_18	<b>1.211</b>	-1.581
Bite_19	0.444	-0.857
Bite_20	0.638	-1.229
Bite_21	0.733	0.749
Bite_22	0.490	-1.248
Bite_23	-1.940	-0.060
Bite_24	-0.304	-0.975
Bite_25	-0.652	-0.777
Bite_26	-1.759	-0.356
Bite_27	0.465	0.386
Bite_28	-0.443	-1.314
Bite_29	-0.399	-0.470
Bite_30	0.603	-1.230
Bite_31	<b>1.731</b>	0.683
Bite_32	<b>1.041</b>	-1.605
Bite_33	-0.656	-1.035
Income	-1.881	-1.261
People in the house	-2.372	-0.389

	Closeness	Expected Influence
Schooling	-1.660	-0.930
Current Weight Satisfaction	-0.362	0.073
Physical Activity Level	-0.876	-1.440

## Discussion

The aim of this study was to evaluate the possible associations between personality, psychological, sociodemographic factors, physical activity, eating behavior and the influences of these variables on weight regain of patients undergoing BS, considering the interactions between these variables in an adaptive complex system measured in a network analysis, characterizing a novelty in the literature.

Our findings revealed that there is a negative relationship between weight gain and personality traits: disinterest and negative affectivity (PID-5-SF) and these are associated with depressive, anxiety and stress behaviors (DASS 21) reflecting on bulimic and/or compulsive eating behavior (BITE and ECAP). The literature is scarce in the investigation between changes in eating behavior and weight recovery after BS [37–38]. However, some studies have observed that the mental health of the patient is one of the most important factors in the maintenance and weight gain after surgical intervention [39–41]. In this sense, the occurrence of binge eating in obese candidates for BS is frequent [42–44]. In the study by Cella et al. [44], the authors observed that the prevalence of periodic compulsive eating disorders in candidates for BS ranges from 2 to 49% [45].

Although different authors claim that the occurrence of binge eating, depression and anxiety are not predictive factors regarding the magnitude of weight loss and maintenance or recurrence of compulsive disorders after BS [46–48], our findings reveal that there is a negative relationship between weight gain and symptoms that suggest personality traits associated with depressive, anxiety and stress behaviors, which, consequently, correlate with periodic compulsive eating disorders. Similar studies, although with different statistical perspectives, demonstrate that risk factors that compromise physical and psychological well-being, both in the preoperative period and in the postoperative period of BS, are associated with unbalanced diet, lack of physical activity and psychological disorders [48]. For example, the study by Figueiredo et al. [49], who investigated the types of personalities in obese women and post-BS, reported that participants with introverted attitudes showed a higher prevalence of severe binge eating, recent and lifelong suicidal thoughts, when compared to participants extrovert. In this perspective, the study by Freire et al. [38] observed that obese candidates for BS with episodes of binge eating have a high prevalence of depressive and anxious symptoms.

In our study beyond personality, depression, anxiety and stress, we added information about and how these psychological factors act in a network with sociodemographic factors, binge eating, physical activity and weight gain in patients 18 to 144 months after BS. Our findings revealed that bariatric

patients who have a lower income and better education have a greater weight regain. With regard to the association between income and overweight, similar data have been reported in previous studies, which state that a higher socioeconomic level is related to a lower risk of obesity [50–52–53]. In addition, the literature demonstrates a relationship between income and a healthier lifestyle, as people who have a higher income are more likely to practice physical activity and follow a dietary follow-up [54–56].

The factors that predict the susceptibility of patients to weight gain after BS are not fully known [38]. Studies state that weight recovery is a multifactorial process of complex etiology [56–57]. In our study we also investigated through an analysis of weight gain networks, which are the most sensitive factors to interventions from network indicators. We found that the items referring to personality characteristics: disinterest and negative affectivity and most items of the depression, anxiety and stress scale presented high expected influence, these items need to be urgently treated in these patients by professionals from different areas. We also elucidate from the indications of closeness centrality that the items of binge eating will be the most benefited from multidisciplinary interventions, which indicates that the treatment of patients with weight gain in the present study should focus on these psychological aspects, which, consequently, would improve the compulsive eating behavior.

Another point of limitation refers only to patients after BS (18 to 144 months post-surgery), since it is necessary to analyze the different preoperative and postoperative factors that possibly affect the loss process and weight regain, which would allow a more effective perioperative follow-up.

## Conclusion

The current results indicated that binge eating items could be the most benefited from inventions in psychological aspects to avoid weight gain in the postoperative period of bariatric patients. The present study provides a new approach to evaluate interactions between weight gain and its correlates, as a complex adaptive system. Although complex systems are difficult to intervene, this study highlights important subsides to plan complex interventions in complex systems, based on the centrality indicators.

## Declarations

**Conflicts of Interest:** The authors declare no conflict of interest.

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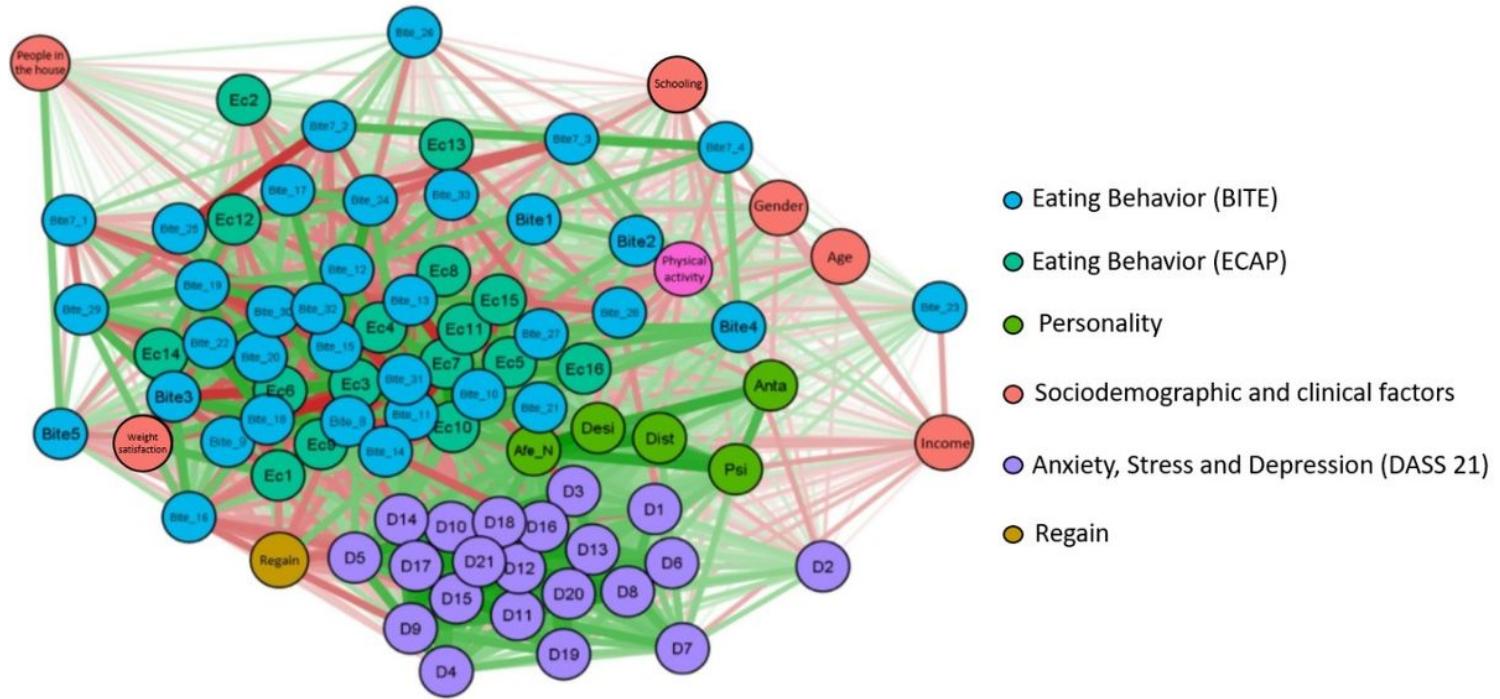
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## Figures



**Figure 1**

Associations between the variables weight gain, psychological factors (anxiety, stress, depression and personality), sociodemographic and physical activity in bariatric patients.

## Supplementary Files

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