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ORIGINAL ARTICLE

Metabolic profile and psychological variables after bariatric surgery: association with weight outcomes

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Abstract
Purpose This study aims to examine associations between metabolic profile and psychological variables in post-bariatric patients and to investigate if metabolic and psychological variables, namely high-density lipoprotein cholesterol (HDL-C), triglycerides (TG), glycated hemoglobin (HbA 1c), impulsivity, psychological distress, depressive and eating disorder symptoms are independently associated with percentage of excess weight loss (%EWL) after bariatric surgery.
Methods One hundred and fifty bariatric patients (BMI = 33.04 ± 5.8 kg/m^2) who underwent to bariatric surgery for more than 28.63 ± 4.9 months were assessed through a clinical interview, a set of self-report measures and venous blood samples. Pearson's correlations were used to assess correlations between %EWL, metabolic and psychological variables. Multiple linear regression was conducted to investigate which metabolic and psychological variables were independently associated with %EWL, while controlling for type of surgery.
Results Higher TG blood levels were associated with higher disordered eating, psychological distress and depression scores. HDL-C was associated with higher depression scores. Both metabolic and psychological variables were associated with %EWL. Regression analyses showed that, controlling for type of surgery, higher %EWL is significantly and independently associated with less disordered eating symptoms and lower TG and *HbA_1c* blood concentrations (R^2 aj = 0.383, F (4, 82) = 14.34, $p < 0.000$).
Conclusion An association between metabolic and psychological variables, particularly concerning TG blood levels, disordered eating and psychological distress/depression was found. Only higher levels of disordered eating, TG and HbA_1c showed and independent correlation with less weight loss. Targeting maladaptive eating behaviors may be a reasonable strategy to avoid weight regain and optimize health status post-operatively.

Keywords Bariatric surgery · Eating behavior · Depression · Metabolic profile · Type 2 diabetes mellitus

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Introduction

Obesity and its associated medical comorbidities remain a major public health problem [1]. In spite of the possibility of unsatisfactory weight loss or weight regain [2, 3], bariatric surgery remains as the most effective treatment for severe obesity [4], with patients usually achieving their total weight loss in the first and second year of surgery [5]. Weight loss subsequent to bariatric surgeries frequently results in several medical benefits and in the resolution or improvement in obesity-related comorbidities [6], as well as in significant improvement in psychosocial functioning [7–9].

Besides its impact on weight loss, bariatric surgery has also been suggested as a metabolic surgery for its effect on the resolution of type 2 diabetes mellitus [10, 11] and metabolic syndrome [12], a constellation of metabolic risk factors for insulin resistance, cardiovascular disease and mortality [13]. Metabolic syndrome refers to a series of metabolic indicators that tend to co-occur together than apart, including high levels of triglycerides (TG) and serum glucose [ex: glycated hemoglobin (HbA_1c)], low level of high-density lipoprotein cholesterol (HDL-C), high blood pressure and abdominal obesity [13]. Research indicates that bariatric surgery has a beneficial effect on metabolic and lipid profile [14] and that individuals with a higher percentage of excess weight loss (%EWL) present lower TG, HbA_1c and HDL-C following surgery [14–17]. Successful weight loss has also been associated with improvements in depression, anxiety [9], personality traits (e.g., impulsiveness) [18, 19] and eating behavior [8, 18, 20, 21].

Nonetheless, difficulties in weight loss maintenance have been associated with variation in metabolic and behavioral variables, particularly in the long term. Post-operative weight regain has been associated with the reemergence of obesity-related medical comorbidities, and particularly with deleterious metabolic profile [10, 11]. Further, poorer weight outcomes have been related with disordered or maladaptive eating behaviors such as grazing [22, 23], binge eating [20] and loss of control eating [21, 24], due to the increased caloric intake that ultimately leads to weight regain [25].

Despite the consistent findings in the literature regarding the impact of bariatric surgery on both metabolic and psychological variables [4, 26], the relation between these variables is poorly understood and research is yet to determine which variables (metabolic or psychological) are more strongly correlated with weight outcomes.

This study aim was twofold: (1) to investigate correlation between psychological variables with metabolic profile, namely impulsiveness, depressive and eating disorder symptoms, psychological distress, HDL-C, TG and HbA_1c blood concentrations in post-bariatric patients; and (2) to investigate if psychological and metabolic variables are independently associated with weight loss.

Materials and methods

Subjects and procedures

This study was approved by institutional ethics review board of Hospital de São João, (CHSJ), and University of Minho, Portugal. All participants signed the informed consent form. Patients were bariatric surgery individuals who underwent bariatric surgery for 24 months (±2 months). Pregnant women and revisional surgery patients were not included in this sample. Data were collected between January of 2009 and June of 2013 during regular multidisciplinary post-operative medical appointments. Subjects were recruited based on the list of scheduled medical appointments and contacted by phone to be invited for participation in the study. A clinical interview and a set of self-report questionnaires were applied at the end of medical appointments. One week prior the scheduled multidisciplinary medical appointments, venous blood samples were collected as part of their post-operative treatment protocol.

Measures

Clinical interview

Socio-demographic and clinical variables such as age, gender, type of surgery, time elapsed since surgery, medical history, comorbidities and medication were recorded during face-to-face interview. Anthropometric measurements such as height and weight variables (pre-surgery and post- surgery weight) were obtained from hospital charts.

Psychological variables

Depressive symptomatology—the Beck Depression Inventory-II (BDI-II) [27] validated for Portuguese population was used to evaluate depressive symptoms in the previous week. Higher scores indicate more depressive symptoms.

Eating disorder examination questionnaire (EDE-Q) [28]—this is a self-report questionnaire with 28 items used to access eating disorder symptoms and associated psychological characteristics. This questionnaire generates four subscale scores (restraint, eating concern, shape concern and weight concern) and a global score. Higher scores indicate more eating disorder symptoms.

Barratt impulsiveness scale-version 11 (BIS-11) [29] is a 30-item self-report instrument designed to assess the multidimensional personality construct of impulsiveness. BIS-11 is composed of three subscales: attentional impulsiveness, motor impulsiveness and non-planning impulsiveness and a total score.

Outcome questionnaire-45 (OQ45.2) [30]—a 45 item self-report questionnaire that assesses general psychological distress and social impairment. Items generate three subscales (interpersonal relationships, social roles, symptom distress) and a total score.

Metabolic variables

High-density lipoprotein cholesterol (HDL-C), Triglycerides (TG), Glycated hemoglobin (HbA_1c): peripheral

Table 1 Correlations between metabolic and psychological variables

	M (SD)	Pearson's correlation coefficients							
		PEWL	EDE-Q	BDI-II	BIS-11	OQ-45.2	HDL-C	TG	HbA 1c
PEWL	53.07 (24.40)	–	−0.35***	−0.32**	0.02	−0.18	0.19*	−0.32***	−0.43***
EDE-Q	1.82 (1.13)		–	0.53***	0.15	0.49***	−0.09	0.22*	0.15
BDI-II	6.96 (7.87)			–	0.33**	0.80***	−0.28**	0.37***	0.08
BIS-11	56.75 (8.54)				–	0.50***	−0.04	0.05	−0.10
OQ-45.2	44.88 (21.93)					–	−0.10	0.31**	−0.30
HDL-C	60.15 (12.28)						–	−0.14	−0.12
TG	100.49 (53.27)							–	0.13
HbA 1c	5.53 (0.53)								–

PEWL percentage excessive weight loss, *EDE-Q* eating disorder examination questionnaire, *BDI-II* beck depression inventory-II, *BIS-11* barratt impulsiveness scale-version 11, *OQ-45.2* outcome questionnaire-45.2, *HDL-C* high-density lipoprotein cholesterol, *TG* triglycerides, *HbA 1c* glycated hemoglobin

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

venous blood samples were collected after a 12-h fast during the early hours of the morning to assess HDL-C, TG and HbA_1c levels. All analytical parameters were measured at the Department of Clinical Pathology of Hospital of St. John. HDL-C and TG were measured with an Olympus AU5400 automated analyzer (Beckman-Coulter, Portugal), using conventional methods. HbA_1c was determined by an ion-exchange HPLC system with a D-10 Bio-Rad analyzer (Bio-Rad, Portugal).

Statistics analysis

IBM® SPSS® Statistics 22.0 (SPSS Inc., Chicago, IL) was used for data analyses. To characterize demographic and clinical characteristics of the sample, descriptive statistics were conducted. %EWL was computed by % EWL = (weight_presurg − weight_current)/(excessweight) × 100. Excess weight was calculated based on the metropolitan guidelines [31]. Pearson's correlations were used to test associations between psychological and metabolic variables and their correlation with post-operative weight loss. For variables significantly associated with post-operative weight loss, multiple linear regression was conducted to investigate which variables (metabolic or psychological) were independently associated with weight loss, while controlling for type of surgery. For this analysis, %EWL was considered the outcome variable (dependent variable), and the independent variables were metabolic and psychological variables previously found to be individually correlated with weight loss. Values with $p < 0.05$ were considered significant. Differences in the sample size across different statistical analyses are due to missing data on questionnaires.

Results

A total of 150 Caucasian participants, 137 females and 13 males, aged between 21 and 64 years were enrolled in the study. Mean body mass index (BMI) were 33.04 kg/m^2 (SD = 5.8), 93 (62.0 %) underwent a RYGB and 57 (38.0 %) a LAGB. Most participants were married (74.0 %), employed (51.3 %) with elementary education (26.7 %) or preparatory education (19.3 %).

Means and standard deviations of all continuous variables assessed in this study are presented in Table 1. Table 1 also presents the individual correlations between metabolic and psychological variables, and their correlation with %EWL. Impulsiveness (BIS) and psychological distress (OQ45) were the only variables not significantly associated with %EWL. Significant positive correlations were found between TG and disordered eating (EDE), depression (BDI) and psychological distress (OQ45). Depression (BDI) was further significantly and negatively associated with HDL-C. No significant correlations were found between *HbA_1c* and any of the psychological measures.

Given that %EWL was individually correlated with both psychological and metabolic variables, we further investigated which of these variables were independently correlated with weight loss. The regression analyses showed that, controlling for type of surgery, disordered eating (EDE; $B = -0.238$, $t = -2.68$, $p < 0.05$), TG ($B = -0.19$, $t = -2.16$, $p < 0.05$) and *HbA_1c* ($B = -0.2$, $t = 2.3$, $p < 0.05$) were significantly and independently associated with %EWL. The model was significant [F (4, 82) = 14.34, $p < 0.000$] and explained 41.2 % of the %EWL variance (R^2 aj = 0.383). These data

show that higher %EWL is significantly and independently associated with less disordered eating symptoms and lower TG and *HbA_1c* blood concentrations. Other variables that were individually correlated with %EWL [depression (BDI) and HDL-C] did not improve the model or showed significant associations and thus were withdrawn.

Discussion

To the best of our knowledge, this is the first study to investigate the correlations between psychological variables, including disordered eating, depression, impulsiveness and psychological distress; and medical variables concerning the patients' metabolic profile in post-operative bariatric patients.

TG was the metabolic variable most associated with psychological status, suggesting that higher levels of blood TG are significantly correlated with higher scores of disordered eating, depression and psychological distress. A link between metabolic profiles and acute or chronic stress in healthy subjects has been proposed by previous research, but the mechanisms by which psychological status influence lipid indicators are poorly understood [32, 33]. Acute psychological stress is thought not only to increase triglyceride concentrations, but also to significantly reduce triglyceride clearance [32]. Additionally, chronic stress is thought to be associated with excess cortisol release which exerts known effects on lipid metabolism via the augmentation of lipoprotein lipase activity [33]. Depression has also been associated with increased TG and low HDL-C [34]. Behavioral and physiological mechanisms have been suggested to underlie this relation. Unhealthy lifestyle and eating behaviors frequently associated with depression [35], as well as altered autonomic nervous system activity inducing heart rate variations, and dysregulation of hypothalamic-pituitaty-adrenal axis have been suggested as implicated in altered metabolic profile [34]. Unhealthy food choices, including the ingestion of high *trans*-fat foods, are also known to be associated with serum levels of TG [36–39]. Binge eating disorder has been associated with the onset of adverse metabolic profile in other samples [40]. Although disordered eating behaviors such as binge eating episodes, eating rapidly or irregular meal patterns have been associated with increased fasting glucose levels, decreased glucose tolerance and elevated serum lipids [41–43], this relation has not been established for the post-bariatric population thus far.

We hypothesized that impulsiveness was related with disturbed eating patterns and subsequently non-successful weight loss. However, type of bariatric surgery and weight loss variables did not show any association with impulsiveness [44]. One explanation may be that impulsiveness is more associated with weight regain after surgery and not with % of weight loss, which was not tested in this study.

These results show preliminary evidence that this is a research area worth pursuing among bariatric patients, particularly given that eating behaviors are modifiable variables that can be successfully addressed post-operatively with non-invasive life-style modification approaches [45]. Targeting these maladaptive behaviors may be a reasonable strategy to optimize weight loss, psychological and metabolic status post-operatively [8, 46, 47].

Despite most variables studied were individually associated with weight loss, only disordered eating, TG and HbA_1c showed to be independently associated with %EWL, even when controlling for the type of surgery performed, suggesting that higher %EWL is associated with lower scores of disordered eating and a better metabolic profile. These data show the important role of both metabolic and psychological factors in understanding the variations in weight loss frequently observed in post-operative patients, particularly in long-term follow-up. Given that this is a cross-sectional study, we cannot conclude about the direction of the association found. Based on previous studies, we anticipate that disordered eating would lead to poorer weight loss or weight regain [48] which, in turn, would be related to the re-emergence or lack of remission of medical comorbidities of excessive weight such as diabetes and altered metabolic profile [10, 11]. However, future research should investigate if variation in the %EWL is cause or consequence of disordered eating or altered metabolic profile. Further, longitudinal research designed to investigate mediators in the relation between weight regain, metabolic profile and eating behaviors is needed for a better understanding of the nature of the correlations found in this work.

The results of the present study should be understood in the context of its limitations. Besides being a cross-sectional study, our sample included mostly women limiting the generalization of these results to both genders. Notwithstanding, anthropometric measurements were obtained from hospital charts and were assessed during medical appointments removing the recall bias of participants and increasing reliability of data obtained.

In conclusion, we found an association between metabolic and psychological variables, particularly concerning TG blood levels with disordered eating and psychological distress/depression. Further, excepting for impulsiveness and psychological distress, all other metabolic and psychological variables were significantly correlated with the %EWL. Nonetheless, only higher levels of disordered eating, TG and HbA_1c showed and independent correlation with less weight loss.

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Conflict of interest On behalf of all authors, the corresponding author states that there is 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.

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

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