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Correlation between serum vitamin D levels and lipid profile in patients with obesity undergoing metabolic bariatric surgery

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ABSTRACT

Introduction: Roux-en-Y gastric bypass demonstrates high efficacy in reversing vitamin D deficiency and improving the lipid profile in obese patients, thereby reducing cardiovascular risks. The high prevalence of dyslipidemia and cardiovascular risk associated with obesity constitute a serious public health problem, a scenario significantly exacerbated by vitamin D deficiency. **Objective:** To evaluate the correlation between serum vitamin D levels and the lipid profile in patients with obesity undergoing Roux-en-Y gastric bypass. **Methods:** A retrospective study in which data were collected at baseline (0) and at 6 and 12 months postoperatively during the periods 2018–2019 and 2021–2022. All patients underwent Roux-en-Y gastric bypass. Patients were divided into Group 1 (pre-pandemic) and Group 2 (post-pandemic). Preoperatively, participants were classified according to vitamin D status as sufficient, deficient, or insufficient. Data was organized in Excel 2010, with variables described using frequencies. Longitudinal variability was assessed using Generalized Estimating Equations (GEE), and Pearson's correlation was used, with a significance level of $p<0.05$. **Results:** The study evaluated 246 patients who underwent gastric bypass (100 in Group 1 and 146 in Group 2). Preoperative vitamin D deficiency affected approximately 48% to 50% of the patients. At 6 and 12 months post-surgery, most patients showed improvement in vitamin D levels. **Conclusion:** Roux-en-Y gastric bypass is highly effective in reversing vitamin D deficiency and optimizing the lipid profile. Both conditions improve in parallel due to weight loss and overall metabolic improvement, reinforcing the importance of continuous monitoring.

Keywords: Obesity; Bariatric Surgery; Metabolic Syndrome; Vitamin D; Lipid Metabolism Disorders; COVID-19.

INTRODUCTION

Obesity is a serious public health challenge affecting more than 650 million adults worldwide[1]. In addition, it is the main risk factor for the development of type 2 diabetes mellitus (DM2) and contributes to the progression of cardiovascular disease (CVD) and certain types of cancer[2]. Although diet, physical exercise, medication, and behavioral therapy can help mitigate early weight gain, the development of severe and class 3 obesity (body mass index [BMI] ≥35 kg/m^2 and BMI >40 kg/m^2, respectively)[3] presents additional challenges that are difficult to overcome through these measures. Dyslipidemia is an independent risk factor for morbidity and mortality. This disorder also appears to be related to low vitamin D levels, which is why the beneficial effects of this vitamin have been suggested in literature as an ally in reducing comorbidities associated with obesity[4].

Metabolic bariatric surgery (MBS) has become a valuable resource in cases of severe obesity with unsuccessful clinical treatment, reducing mortality and improving clinical comorbidities, especially cardiometabolic diseases and cancer[3]. On the other hand, bariatric surgery is associated with a number of vitamin, mineral, and metabolic deficiencies in both the short and long term, and these occurrences are concerning not only in the preoperative period but also in the postoperative period[4].

Among these deficiencies, hypovitaminosis D is common in individuals with obesity and can be aggravated after bariatric surgery. Often, serum levels of 25-hydroxyvitamin D (25(OH)D) do not rise after surgery, even with supplementation. Thus, vitamin D insufficiency can place individuals with obesity at significant risk, potentially leading to osteoporosis, osteopenia, and fractures, as well as other diseases, and may affect up to 90% of individuals with obesity[5].

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Despite the importance of vitamin D, few studies[6,7] have investigated the direct effect of serum concentrations of this vitamin on body weight reduction in obese individuals[8] and vitamin D deficiency remains a common complication identified during preoperative evaluation. However, studies[8,9] have demonstrated the effectiveness of MBS, which is an effective treatment for severe obesity.

Recently, retrospective studies have sought to correlate the impact of these deficiencies with the success of metabolic procedures. Baad et al.[10] demonstrated, through medical record analysis, that hypovitaminosis D remains critically prevalent following various surgical techniques, raising questions about the efficacy of standard supplementation protocols.

Furthermore, the relationship between these vitamin levels and weight-loss success remains a subject of debate: while some long-term retrospective analyses—such as that by Pereira et al.[11] suggest that chronic vitamin D deficiency does not appear to hinder gross weight loss or immediate glycemic improvement, there is a scarcity of robust data evaluating the direct impact of these fluctuations on the rate of remission for other metabolic comorbidities, such as dyslipidemia.

To address this gap in the literature, the aim of this retrospective study is to evaluate the correlation between serum vitamin D levels and the lipid profile in patients with obesity undergoing Roux-en-Y gastric bypass.

METHODS

This retrospective, descriptive study with a quantitative approach was conducted at an Obesity and Digestive System Surgery Clinic located in central Rio Grande do Sul. Data were collected from the clinic's database for the periods 2018–2019 and 2021–2022, during which

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all patients included in the study underwent MBS. The sample consisted of adults of both sexes aged 18 years or older who underwent the procedure.

Patients were divided into two groups based on the date of the surgical procedure, with March 1, 2020[12], considered the start of the SARS-CoV-2 pandemic. The pandemic period was excluded from the analysis. Group 1 (Pre-pandemic): Patients who underwent surgery and completed follow-up prior to the pandemic period. Group 2 (Post-pandemic): Patients who underwent surgery and follow-up after the critical phase of the pandemic. Clinical assessments took place at three fixed time points: preoperatively (baseline/time 0), and at 6 and 12 months postoperatively.

The study included patients of both sexes (male and female), aged 18 to 80 years, who underwent metabolic bariatric surgery using the Roux-en-Y gastric bypass technique between January 2018 and January 2019 (Group 1) and between January 2021 and January 2022 (Group 2). Exclusion criteria included pregnant patients, individuals under 18 years of age, and patients with incomplete medical records. Participants were selected through an active search of the database at the Dr. Glauco Alvarez Bariatric and Digestive Surgery Clinic, constituting a convenience sample. Patient follow-up adhered to the service's standard routine, with data collection occurring at three specific time points: the preoperative period (baseline) and follow-up visits at 6 and 12 months post-surgery.

The following data were collected from patient medical records: (a) weight and height, for subsequent nutritional status classification using BMI according to WHO criteria[13]; (b) patient characteristics (age, sex and marital status); (c) comorbidities (systemic arterial hypertension, type 2 diabetes mellitus, dyslipidemia, hepatic steatosis, total cholesterol, high-density lipoprotein cholesterol [HDL-c], low-density lipoprotein cholesterol [LDL-c], and triglycerides); and (d) vitamin D levels before and after metabolic bariatric surgery (at 6 and 12

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months). Additionally, participants were categorized preoperatively based on serum vitamin D concentrations as having sufficient, deficient, or insufficient levels. Vitamin D was analyzed as 25(OH)D, and serum values were compared against the normal reference cut-off points proposed by Holick[14]. Thus, serum vitamin D concentrations were classified as deficient (≤20 ng/mL), insufficient (21–29 ng/mL), or sufficient (30–100 ng/mL). All data were collected during patient consultations, following the clinic's protocol, at the preoperative assessment (baseline) and at 6 and 12 months after bariatric metabolic surgery (BMS). The percentage of excess weight loss was calculated using the formula: (preoperative weight [kg] − current weight [kg]) / (preoperative weight [kg] − ideal weight corresponding to a BMI of 20.8 kg/m² for men and 22 kg/m² for women) × 100, according to Deitel and Shikora[15].

Statistical Analysis

The data were entered into Microsoft Excel 2010® and, after verification, transferred to IBM SPSS® (Statistical Package for Social Sciences), version 20.0. Quantitative data were described using mean and standard deviation, and longitudinal variability was evaluated using Generalized Estimating Equation models GEE) and p interaction time*group was presented. When distributional assumptions were not met, data were expressed as median and interquartile range. Categorical data were described as counts and percentages. Longitudinal variability of vitamin D, BMI, and percentage of excess weight loss was assessed using generalized estimating equations. The correlation between vitamin D (25(OH)D) and lipid profile variables was evaluated using Pearson's correlation coefficient. For all analyses, results were considered statistically significant at $p<0.05$.

The study was conducted in accordance with established ethical principles and was approved by the Research Ethics Committee of the Pontifical Catholic University of Rio Grande

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do Sul (PUCRS), in accordance with Resolution 466/12 of the National Health Council (CNS), under protocol number 4.843.016. Ethical aspects related to the legitimacy of information, privacy, and confidentiality were respected throughout the research process. The data obtained were used exclusively for the purposes of this study and not for any other purpose.

RESULTS

A total of 246 participants were included in the study, divided into two groups: Group 1 (n=100) and Group 2 (n=146).

Among the participants studied, 72.0% and 81.5% were female in the two groups evaluated. The mean age was 41.3±9.7 years in Group 1 and 38.6±10.2 years in Group 2, and most patients were married. The prevalence of preoperative comorbidities was high in both groups, particularly systemic arterial hypertension, dyslipidemia, and type 2 diabetes mellitus (Table 1).

Regarding weight and BMI, there was no significant difference in the evolution of patients' weight and BMI between the 2018–2019 and 2021–2022 groups (P=0.700 and P=0.881, respectively), as described in Table 2.

Preoperative vitamin D deficiency was identified in 48.4% of patients in Group 1 and 50.1% in Group 2. After 6 months, vitamin D levels increased in 82.3% and 80.5% of patients in Groups 1 and 2, respectively. At 12 months, increases in vitamin D levels were observed in 79.5% and 77.2% of participants, respectively. There was a significant difference in the rates of vitamin D deficiency and subsequent increase in vitamin D levels (p=0.044) (Table 3).

A significant, inverse, and weak correlation was observed between vitamin D and HDL-c in Group 1 preoperatively. In the same group and period, a weak inverse correlation was

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observed between vitamin D and LDL-c. At 6 months, a weak inverse correlation was found between triglycerides and vitamin D in Group 2 (Table 4).

Table 5 presents the comparison of mean HDL-c, LDL-c, total cholesterol, and triglyceride levels between Groups 1 and 2 preoperatively and at 6 and 12 months of follow-up. Regarding the lipid profile, HDL-c ($p<0.001$), LDL-c ($p=0.006$), and triglyceride ($p<0.001$) showed similar behavior over time (6 and 12 months) in both groups. Total cholesterol also changed significantly during the study period ($p=0.010$). Regarding vitamin D, there was a significant difference in the rates of deficiency and increase over time ($p=0.044$). Significant differences in vitamin D levels were observed between the preoperative and 6-month assessments ($p<0.001$), as well as between the preoperative and 12-month assessments ($p<0.001$) in both groups. However, when vitamin D levels at 6 and 12 months were compared, similar behavior over time was observed between the groups ($p=0.721$). No association was found between sex and vitamin D levels preoperatively or at 6 and 12 months of follow-up.

DISCUSSION

The prevalence of severe obesity has increased exponentially in recent decades, affecting both sexes and all social and cultural groups. Studies have shown that up to 80% of patients undergoing bariatric surgery are women of reproductive age[16]. These findings are consistent with our results, in which 72.0% of patients in Group 1 and 81.5% in Group 2 were female. This higher proportion may be explained by the greater prevalence of severe obesity among women and by women's greater concern with health and body image[17]. Previous studies[17,18] have reported a median age of 38.9 years among patients undergoing bariatric surgery, which is similar to that observed in our study, where the mean age was 41.3±9.7 years in Group 1 and 38.6±10.2 years in Group 2, with most patients being married.

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MBS is an effective procedure for the treatment of severe obesity, regardless of the presence of associated comorbidities[19]. According to Bays et al.[20], approximately 60% of individuals with severe obesity have dyslipidemia and are candidates for surgical treatment. These findings are consistent with our study, in which the prevalence of preoperative comorbidities was high in both groups, with dyslipidemia present in 76.0% and 66.4% of patients, respectively.

In addition, Roux-en-Y gastric bypass promotes greater weight loss through a combination of mechanisms, including gastric restriction, delayed gastric emptying, altered peptide release in the duodenum, and reduced fat absorption[19]. A retrospective study of patients undergoing MBS reported a weight loss of 22.7% within 6 months after surgery[20]. Similarly, in the present study, weight and BMI decreased at both assessment points (6 and 12 months) in both groups, demonstrating a consistent reduction in these anthropometric parameters throughout the follow-up period; however, this was not statistically significant (p=0.700 and p=0.881, respectively). These findings are in agreement with those reported by Ben-Porat et al.[21] and Peligrini et al.[22] over comparable follow-up periods. Weight loss tends to be more rapid during the first months after surgery and gradually attenuates over time. Even a reduction of 5% to 10% in body weight is sufficient to provide metabolic benefits and reduce cardiovascular risk factors[23].

However, vitamin D deficiency is commonly diagnosed during preoperative clinical evaluation for MBS in patients with severe obesity[21,23]. An inverse relationship between BMI and vitamin D levels has been reported and is thought to result from altered dietary habits, avoidance of sun exposure, reduced bioavailability of vitamin D due to its sequestration in adipose tissue and decreased hepatic 25-hydroxylase activity in obese patients with nonalcoholic fatty liver disease[19]. In the study by Pellegrini et al.[22], vitamin D deficiency was

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observed in 74.5% of patients. Similarly, in a prospective cross-sectional study conducted in Singapore[23], 75.7% of patients presented with vitamin D deficiency and 20.7% with vitamin D insufficiency. In our study, patients with severe obesity presented preoperatively with vitamin D deficiency in 48.4% of cases in Group 1 and 50.1% in Group 2, while vitamin D insufficiency was observed in 33.1% and 30.6%, respectively. These patients also had elevated BMI values (44.0±10.3 kg/m^2 in Group 1 and 42.8±6.2 kg/m^2 in Group 2). These findings support the inverse relationship between BMI and vitamin D levels, with higher BMI values associated with lower vitamin D concentrations. It is worth highlighting preliminary evidence suggesting that vitamin D supplementation may be associated with a significant reduction in fat mass[24].

Although severe obesity is strongly associated with vitamin D deficiency, several other factors can influence vitamin D status, including geographic region, ethnicity, and sun exposure. MBS has also been associated with postoperative malnutrition resulting from poor adherence to dietary recommendations and prescribed supplementation[22]. Despite this, several reports have shown that MBS leads to a gradual improvement in vitamin D levels, as observed in this study[25,26].

Arias et al.[27] reported that vitamin D deficiency rates decreased over time (6 and 12 months) compared with preoperative values, findings that were also observed by Krzizek et al.[28] and Araújo et al.[29]. Similarly, in our study, the prevalence of vitamin D deficiency decreased from 48.4% preoperatively to 4.0% in Group 1 and from 50.1% to 2.8% in Group 2. In parallel, vitamin D adequacy increased, reaching 82.3% in Group 1 and 80.5% in Group 2 at 6 months after surgery, with a similar pattern maintained at 12 months (79.5% and 77.2%, respectively). The significant difference observed in vitamin D deficiency rates and the increase in vitamin D levels ($p=0.044$) can be explained by the clinic nutritionist's routine

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recommendation for vitamin supplementation; this likely contributed to improved vitamin D status over time, consistent with previously published studies[30,31].

The prevalence of dyslipidemia among patients with severe obesity is highly variable, ranging from 19.0% to 82.9%[21]. In the present study, dyslipidemia was observed in 76.0% of patients in Group 1 and 66.4% of patients in Group 2. Ben-Port et al.[21] reported resolution of dyslipidemia in 92.3% of cases 1 year after surgery, which is consistent with our findings.

However, improvements in the lipid profile may be secondary to substantial dietary changes after surgery. In addition, weight reduction often enables patients to adopt a more active lifestyle, which may further contribute to these improvements[25]. Several studies have demonstrated an association between weight loss and improved lipid profile parameters in the medium and long term[27,29]. In the present study, lipid profile parameters changed significantly over time, with HDL-c ($p<0.001$), LDL-c ($p=0.006$), and triglycerides ($p<0.001$) showing similar behavior at 6 and 12 months in both groups. Total cholesterol also changed significantly during the study period ($p=0.010$). These findings suggest that weight loss is associated with a reduction in visceral fat and improvement in related metabolic abnormalities.

In addition to bariatric surgery, other approaches may contribute to improvement of the lipid profile, including optimization of vitamin D status. Vitamin D deficiency is a common condition in the general population, affecting approximately 30% to 50% of individuals across all age groups. Patients undergoing bariatric surgery frequently present with hypovitaminosis D both before and after surgery. Several studies have reported a high prevalence of vitamin D deficiency among candidates for bariatric surgery[32,33]. In our study, 48.4% of patients in Group 1 and 50.1% of patients in Group 2 presented preoperative 25(OH)D levels below 30 ng/mL.

Similar findings have been reported by de Luis et al.[34], Aridi et al.[35] and Santos[36], all of whom observed preoperative hypovitaminosis D. In our study, the reduction in hypovitaminosis

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D prevalence and the increase in vitamin D levels during the postoperative period were statistically significant (p=0.044). Significant differences in vitamin D levels were observed between the preoperative assessment and 6 months after surgery (p<0.001), as well as between the preoperative assessment and 12 months after surgery (p<0.001) in both groups. However, when vitamin D levels at 6 and 12 months were compared, a similar pattern over time was observed between the two groups (p=0.721).

One study indicated that in patients with obesity, there is a direct, although often weak, correlation between serum vitamin D and HDL levels[37]. This suggests that increases in vitamin D levels tend to be accompanied by modest increases in HDL. Another study reported that patients with lower 25(OH)D concentrations tend to have higher LDL levels, particularly in the preoperative period[38]. In the present study, a significant, inverse, and weak correlation was observed between vitamin D and HDL-c in Group 1 preoperatively. In the same group and period, a weak inverse correlation was observed between vitamin D and LDL-c. At 6 months, a weak inverse correlation was found between triglycerides and vitamin D in Group 2. This finding is consistent with observational studies that reported a similar inverse relationship between vitamin D and triglyceride levels in patients undergoing MBS 6 months after surgery[38].

No association was found between sex and vitamin D levels preoperatively or at 6 and 12 months of follow-up. Goldner et al.[39] evaluated vitamin D levels below 30 ng/mL and reported findings consistent with those of the present study, in which vitamin D levels increased at 6 and 12 months after surgery, with most patients achieving concentrations above the deficiency threshold. Similar results at 12 months after surgery were reported by Carlin et al.[40].

The study's main limitations include the lack of standardized supplementation dosages, attrition bias regarding long-term patient follow-up, variability among the surgical techniques studied, and the difficulty of isolating the effect of vitamin storage in adipose tissue; however,

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a positive aspect is the long-term clinical impact regarding the patients' comprehensive metabolic improvement. Therefore, multidisciplinary follow-up—including nutritional assessments and monitoring for vitamin and mineral deficiencies—is essential, as demonstrated by the analyzed studies. Furthermore, research in this field is crucial to ensuring that post-bariatric patients receive appropriate care and achieve better short- and long-term outcomes.

Conclusion

The study shows that clinical interventions yielded significant and lasting improvements over a 12-month period. Outcomes included weight loss and a reduction in BMI, as well as the reversal of vitamin D deficiency, evidenced by a greater than 77% increase in blood levels. This improvement in vitamin D status coincided with an optimized lipid profile, resulting in positive and statistically significant changes in HDL-C, LDL-C, total cholesterol, and triglyceride levels. Thus, the intervention proved highly successful in weight management and metabolic improvement for patients with a significant history of pre-existing comorbidities. Bariatric surgery remains an essential intervention for severe obesity, offering substantial clinical benefits. However, routine monitoring of vitamin D levels and lipid profile parameters—both before and after surgery—is crucial to minimizing complications associated with vitamin D deficiency.

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Table 1: Demographic data and comorbidities of patients with obesity Bariatric Metabolic Surgey in (2018-2019 e 2021-2022).

Characteristics	2018-2019 Group 1 (n=100)	2021-2022 Group 2 (n=146)	p
Age, mean±SD	41.3±9.7	42.3±9.2	0.399
Sex, n (%)			0.109
Female	72 (72.0)	119 (81.5)	
Male	28 (28.0)	27 (18.5)	
Marital Status, n (%)			0.513
Married	57 (57.0)	87 (59.6)	
Divorced	4 (4.0)	8 (5.5)	
Separated	1 (1.0)	1 (0.7)	
Single	37 (37.0)	44 (30.1)	
Widowed	1 (1.0)	6 (4.1)	
SAH, n(%)	50 (50.0)	68 (46.6)	0.690
Dyslipidemia, n(%)	76 (76.0)	97 (66.4)	0.141
NAFLD, n(%)			0.218
Baseline (0)	22 (22.0)	43 (29.5)	
6 months (1)	77 (77.0)	103 (70.5)	
12 months (2)	1 (1.0)	-	
T2DM, n(%)			0.428
Baseline (0)	60 (60.0)	84 (57.5)	
6 months (1)	39 (39.0)	62 (42.5)	
12 months (2)	1 (1.0)	-	

SD: Standart Deviation; SAH (Systemic Arterial Hypertension); NAFLD (Non-Alcoholic Fatt Liver Disease); T2DM (Type 2 Diabetes Mellitus); Quantitative variables compared by Student's t-test for independent samples and categorical variables by Chi-Square and Fisher's exact test.

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Table 2: Evolution of weight and BMI for patients with obesity undergoing Bariatric Metabolic Surgey (2018-2019 e 2021-2022).

	2018-2019 (n=100)			2021-2022 (n=146)			
Measures	**Pre**	**6m**	**12m**	**Pre**	**6m**	**12m**	**p***
Weight (kg) mean±SD	117.0±22.6	81.1±16.4	73.3±13.3	114.7±22.0	79.8±13.3	70.9±13.2	0,700
BMI (kg/m^2) mean±SD	44.0±10.3	30.7±4.5	27.3±4.0	42.3±6.2	29.8±4.0	26.5±3.0	0,881

SD: Standart Deviation; GEE; BMI: Body Mass Index; *p interaction time*group.

Table 3: Estimate of low vitamin D levels in obese patients undergoing metabolic bariatric

		(n=246)	
Vitamin D	**Pre % (CI95%)**	**6m % (CI95%)**	**12m % (CI95%)**
Deficient (%)	48.4 (42.0-54.8)	4.0 (2.0-7.3)	4.8 (2.5-8.3)
Insufficient (%)	33.1 (27.2-39.3)	13.7 (9.7-18.6)	15.7 (11.4-20.9)
Sufficient (%)	18.5 (13.9-24.0)	82.3 (73.9-86.8)	79.5 (73.9-84.3)

95%CI: confidence interval for prevalence. BMS: Bariatric/Metabolic Surgery; BMI: Body Mass Index; Group 1: (2018-2019); Group 2: (2021-2022).

Table 4: Correlation between Vitamin D and Lipid Profile of patients undergoing metabolic bariatric surgery in 2018-2019 and 2021-2022.

	2018-2019 (n=100)			2021-2022 (n=146)		
Exams	**Pre**	**6m**	**12m**	**Pre**	**6m**	**12m**
Cholesterol	-0,02	-0,06	-0,06	-0,11	-0,02	-0,04
HDLc	**-0,27***	-0,11	-0,11	-0,06	-0,06	-0,12
LDLc	**-0,20***	-0,06	-0,06	-0,15	-0,12	-0,02
Triglycerides	-0,07	-0,05	-0,04	-0,02	**-0,22***	-0,01

Total cholesterol (mg/dL); HDLc (mg/dL); LDLc (mg/dL); Triglyceride (mg/dL); HDLc (High-Density Lopoprotein Cholesterol); LDLc (Low-Density Lopoprotein Cholesterol); Group 1: (2018-2019); Group 2: 2021-2022); Presented data are Pearson´s correlation coeficients *p<0,05.

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Table 5: Comparative analysis of the evolution of tests for patients undergoing metabolic bariatric surgery in 2018-2019 and 2021-2022.

	2018-2019 (n=100)			2021-2022 (n=146)			
Exams	**Pre**	**6m**	**12m**	**Pre**	**6m**	**12m**	**p**
Vitamin D	23.2±10.4^{Aa}	45.5±16.8^{B}	40.5±16.1^{C}	20.2±10.3^{Ab}	45.6±15.6^{B}	43.3±12.4^{B}	**0,044**
Cholesterol	193.2±35.8^{A}	157.3±30.5^{B}	154.7±32.1^{Ba}	199.1±35.4^{A}	153.5±27.1^{B}	146.3±26.0^{bC}	**0,010**
HDLc	50.8±12.2^{A}	52.0±10.8^{Aa}	60.8±13.4^{Ba}	52.6±16.3^{A}	47.6±10,5^{Bb}	54.9±12.9^{Ab}	**<0,001**
LDLc	92,0±16,3^{Aa}	79.0±12.3^{Ba}	69.2±11.8^{Ca}	112.5±27.6^{Bb}	94.1±23.6^{Bb}	82.4±17.0^{Cb}	**0,006**
Triglycerides	129(104-169)^{Aa}	92(73-113)^{C}	75(56-94)^{Ab}	154(112-206)^{Ab}	87(62-106)^{B}	74(58-91)^{C}	**<0,001**

Vitamin D (ng/ml); Total cholesterol (mg/dL); HDLc (mg/dL); LDLc (mg/dL); Triglyceride (mg/dL).SD: Standart Deviation; HDLc (High-Density Lopoprotein Cholesterol); LDLc (Low-Density Lopoprotein Cholesterol); Group 1: (2018-2019); Group 2: (2021-2022); Data with a normal distribution are presented as mean ± standard deviation, and those with an asymmetrical distribution are presented as median and interquartile range. Data are compared using Generalized Estimating Equations analysis. Superscripted uppercase letters represent statistically significant differences over time within the group, and superscripted lowercase letters represent statistically significant differences over time between groups. Differences over time within the group, and superscripted lowercase letters represent statistically significant differences over time between groups. *p interaction time*group.

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