Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Predictive Value of Blood Parameters for Bariatric Surgery Success: A Comparison with Anthropometric Parameters

Robin Lavreysen
Sam van Hout

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

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Prof. dr. Kenneth VERBOVEN

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Situating

This research master's thesis falls within the domain of Health Promotion and Movement, which is part of the Faculty of Rehabilitation Sciences at Hasselt University. It aims to explore the factors that influence the outcomes of treatments for people living with obesity, including bariatric surgery, in an attempt to optimize more personalized interventions and enhance patient care.

In this study, the aim is to investigate cardiometabolic blood variables as potential predicting factors for the success of bariatric surgery and to compare their efficacy with other predictors such as anthropometric parameters. These outcomes may potentially give us more insight into the prognostic factors that can be measured and adjusted, prior to the bariatric surgery, to increase postoperative success. Moreover, alternative interventions (GLP-1 receptor agonists) may prove to be more effective for a patient than bariatric surgery, particularly when a suboptimal outcome is anticipated based on these prognostic factors.

This master thesis was situated within a recent research project conducted by Verboven in collaboration with the Obesity Clinic of Hospital East-Limburg (Dr. Bouckaert), titled "*Prevalentie van sarcopenie bij morbiede obesitas: een retrospectieve studie*". Medical records were consulted in a retrospective manner (ethical committee ZOL Genk: Z-2023013).

This master thesis was conducted by Robin Lavreysen and Sam van Hout. The corresponding research question was formulated in consultation with the supervisor, Prof. dr. Kenneth Verboven. The majority of the work was carried out simultaneously by both master students.

Abstract

Background: Obesity affects 16% of the global adult population and is associated with other chronic illnesses. Bariatric surgery is an effective treatment for obesity, in which surgical success is defined as significant weight loss, comorbidity reduction and/or the enhancement of the patient's quality of life. Excessive weight loss (%EWL) is currently used as a metric to define weight loss success following bariatric surgery. Although various preoperative predictors have been identified, limited evidence exists regarding the predictive value of cardiometabolic blood variables. These may offer additional prognostic information.

Objectives: To investigate blood variables as potential predicting factors for the success of bariatric surgery-induced weight loss.

Methods: In this retrospective study, 174 patients (41±13 years; BMI 41.0±4.1 kg/m²; female 73%) who underwent bariatric surgery were selected according to age (18-70 years), preoperative Body Mass Index (BMI) (>30kg/m²), availability of preoperative body composition and blood profile assessments, derived from medical files. The primary outcome measure used was %EWL 1-year after surgery.

Results: The combined model, including anthropometric and blood parameters, explained 41.1% of the variance in %EWL 1-year after bariatric surgery, independent of age, sex and smoking status. BMI was negatively associated with %EWL ($p < .001$), while Low-Density Lipoprotein (LDL) was positively associated with %EWL ($p = .001$). In the blood parameter model, fasting glycemia was negatively associated with %EWL ($p = .020$).

Conclusion: LDL and BMI could serve as preoperative predictors of %EWL 1-year after bariatric surgery, although their predictive value is limited and other variables are likely to contribute as well.

Keywords: Obesity; Bariatric surgery; Weight loss

Introduction

In 2022, 2.5 billion adults aged 18 and older were overweight, including more than 890 million living with obesity worldwide, an alarming rising rate (World Health Organization, 2024). The World Health Organization (WHO) defines obesity as a "chronic complex disease defined by excessive fat deposits that can impair health" (World Health Organization, 2024). According to the National Heart, Lung and Blood Institute (NIH) overweight and obesity status can arise from a variety of factors, including dietary behaviors, certain medications, insufficient sleep or physical activity, genetic predisposition and family history (National Heart, Lung and Blood Institute, 2022). Moreover, the WHO identifies the fundamental cause of obesity and overweight as an energy imbalance between calories consumed and calories expended (World Health Organization, 2024). To assess this condition in clinical settings, obesity is typically evaluated using the Body Mass Index (BMI), calculated as the ratio of an individual's weight in kilograms to their height in square meters (kg/m^2) (González-Muniesa et al., 2017). BMI is classified into distinct categories based on specific ranges. A BMI of 18.5 to 24.9 kg/m^2 is considered normal weight. Overweight is defined as a BMI of 25 to 29.9 kg/m^2. Obesity is indicated by a BMI of 30 kg/m^2 or higher, which is further stratified into three classes. Class I obesity corresponds to a BMI of 30 to 34.9 kg/m^2, Class II obesity to a BMI of 35 to 39.9 kg/m^2 and Class III obesity, also known as morbid obesity, corresponds to a BMI of 40 kg/m^2 or higher (Weir & Jan, 2025). An elevated BMI serves as a risk factor for chronic illness, potentially including cardiovascular disease, metabolic diseases like type two diabetes mellitus, chronic kidney disease, cancer and many musculoskeletal disorders (Afshin et al., 2017). The rising global impact of this chronic and complex condition presents a serious health concern, highlighting the importance of effective prevention and management strategies. A multicomponent intervention is essential to reduce its growing burden (Afshin et al., 2017). For patients with morbid obesity, surgical intervention may be considered, which was proven to be a more effective weight loss strategy than nonsurgical treatment (Maggard et al., 2005). However, the use of pharmacological treatments is rapidly increasing. Between the second half of 2022 and the second half of 2023, the use of GLP-1 receptor agonists (GLP-1RAs) increased by 106%, whereas the number of bariatric surgeries performed declined by 9% over the same period (Lin et al., 2024). A recent study offers robust evidence supporting the weight-reducing effects of GLP-1RAs in individuals with obesity who do not have diabetes, demonstrating a nonlinear dose-response relationship. Consistent and substantial effects on body weight, BMI and waist circumference further confirm the efficacy of GLP-1RAs in promoting weight loss in this population (Liu et al., 2023). However, the maintenance of weight loss typically necessitates long-term treatment combined with sustained support for lifestyle modifications (Berning et al., 2025). Bariatric surgery constitutes a highly effective intervention for the treatment of severe obesity and its associated health conditions. Various surgical techniques have been shown to result in significant and durable weight loss, improvements in obesity-related comorbidities and enhanced quality of life. Nevertheless, the durability of these outcomes is contingent upon multiple factors, including the surgical method employed, the patient's adherence to recommended lifestyle modifications, and the quality of long-term postoperative care (Ram Sohan et al., 2024).

The success of bariatric surgery is defined by three main goals: to achieve significant weight loss, to reduce comorbidities associated with obesity and to enhance the patient's quality of life. The percentage of excess weight loss (%EWL) is currently the most widely used metric in the bariatric surgery literature to report surgical therapy success (Masnyj et al., 2020). The %EWL is the percentage of weight that is lost above (or even beyond) the ideal body weight (Masnyj et al., 2020). Achieving more than 50% EWL sustained for over two years post-surgery has traditionally been regarded as indicative of successful bariatric surgery (Masnyj et al., 2020). These outcomes are consistent with those of a more recent study, which reported a high rate of success (50%EWL) one year postoperatively, with 92.6% of patients with morbid obesity meeting this criterion (Azhri et al., 2023). Multiple variables have been investigated as potential predictors of bariatric surgery success (van Hout et al., 2005) (Crozet et al., 2023), this retrospective study aims to investigate blood variables related to cardiometabolic health as potential predicting factors for the success of bariatric surgery and to compare their predictability with other predictors such as anthropometric parameters from a DEXA based detailed body composition assessment. These outcomes may potentially give more insights into the prognostic factors that can be measured and potentially be treated in a non-surgical, conservative manner before the bariatric surgery to increase the postoperative success. It can therefore provide paramedics with preoperative information on these factors to enhance their understanding of the potential outcomes for their patient.

Methods

Participant recruitment and selection

Patients who underwent bariatric surgery at the Obesity Clinic of the Hospital of East Limburg were selected for the retrospective study (ethical committee ZOL Genk: Z-2023013). Given the retrospective nature of the study, the requirement to obtain individual patient consent is not applicable. Data were extracted from electronic patient records and compiled into a pseudonymized Masterfile, which was utilized to identify participants meeting the current study's inclusion criteria. The following inclusion criteria were used: aged 18-70 years old; initial BMI > 30kg/m^2; available preoperative body composition analysis and blood profile assessment.

Patients were excluded when the following information was missing from the masterfile: age; sex; smoking status; preoperative length; preoperative weight; weight 12 months postoperative; preoperative BMI; BMI 12 months postoperative; preoperative waist circumference; preoperative fat percentage (fat%); preoperative fat mass (kg); preoperative lean mass (kg); preoperative android fat mass (kg); preoperative gynoid fat mass (kg); preoperative a/g ratio; preoperative Z-score (bone density compared to that of a healthy peer); preoperative C-reactive protein (CRP) (mg/l); preoperative total cholesterol (mg/dl); preoperative high-density lipoprotein (HDL) (mg/dl); preoperative LDL (mg/dl); preoperative triglyceride (mg/dl); preoperative fasting glycemia; preoperative Thyroid-stimulating hormone (TSH) (mU/l); preoperative 25-hydroxyvitamin D (25-OH vitamin D).

Procedure

After applying the aforementioned criteria to the participants from the masterfile of the retrospective study by Verboven (2023), the number of selected participants decreased from 336 to 174.

Given the aim of this study, %EWL $\left(\frac{initial\ weight - 12\ months\ postoperative\ weight}{initial\ weight - 25*(height^2)} * 100\right)$ was selected as the primary outcome measure, to evaluate the predictive value of different anthropometric and blood parameters in determining the success of bariatric surgery.

Data-analysis

Data analysis was conducted using JMP® Pro (Version 17; SAS Institute Inc., 2022). Statistical conclusions were drawn at a significance level of 5%. First, assumptions were checked, including normality of the residuals (Shapiro-Wilk test), homoscedasticity and linearity based on the residuals-by-predicted plot. If normality of the residuals was not met, a square root transformation was conducted. If homoscedasticity was not clearly met based on the residuals-by-predicted plot, the Breusch-Pagan test was used to further assess this assumption. If linearity was not clearly met based on the residuals-by-predicted plot, the lack-of-fit test was applied.

For the statistical analysis, several fixed covariates (age; sex; smoking status) were chosen and used consistently throughout the analysis. Initially, ten anthropometric and eight blood parameters were used to conduct various simple linear regression analyses, using continuous %EWL as the dependent variable, to identify associated blood and anthropometric parameters. Depending on whether the assumptions were satisfied, either a parametric or non-parametric simple linear regression analysis was chosen, as seen in Figure 1. A two-sample t-test and rank-sum test was conducted to evaluate the significance of the contribution of the fixed covariates, depending on whether the assumptions are met as seen in Figure 2.

Subsequently, to examine whether the various predictor variables are independent of one another, a simple Pearson or Spearman correlation was conducted depending on whether the assumptions were met. If the predictor variables exhibit an intercorrelation greater than 0.7, indicating a strong correlation (National Library of Medicine, n.d.), a selection was made regarding which variables to retain in the final model, prioritizing the variable with the strongest association with the dependent variable (Y), in order to minimize multicollinearity.

With the remaining independent variables as well as the fixed covariates (age; sex; smoking status), two separate multivariate models were established: one including blood variables and the other including anthropometric values. Based on these two models as well as a final model combining the variables from the previous two models, the most significant predictors of %EWL were identified using the backwards procedure, based on the adjusted R-square, AICc and Variance Inflation Factor (VIF).

Results

Subject characteristics

The patient cohort had a mean age of 41 ± 13 years old, and a preoperative mean BMI of 41.0 ± 4.1 kg/m². Of the 174 participants, 127 were female and 47 were male. The mean %EWL of the total cohort was 86.17 ± 24.46%. (Table 1). Based on the aforementioned criteria of the success of bariatric surgery, the participants can be divided into two groups; a success (EWL > 50%) and non-successful group (EWL < 50%). Several parameters differed significantly ($p < 0.05$) between the two groups. The success group showed a significantly lower weight; lower waist circumference; lower BMI; lower total lean mass; lower android fat mass; lower triglycerides; lower fasting glycaemia compared to the non-successful group (Table 1).

Table 1

Summary of Preoperative Demographic and Clinical Characteristics of the Participants

Parameter	Total group (*N* = 174)	Success group (*N* = 161)	Non-success group (*N* = 13)	p-value
Age (years)	42 ± 13	41 ± 13	47 ± 13	.199[b]
Sex (M/V)	47 / 127	42 / 119	5 / 8	
Smoke status (Y/N)	38 / 136	36 / 125	2 / 11	
Weight (kg)	117.4 ± 17.6	116.4 ± 17.0	130 ± 19.7	**.016**[b*]
Waist circumference (cm)	128.7 ± 11.6	127.8 ± 11.0	139.5 ± 14.4	**.004**[a*]; **.004**[b*]
BMI (kg/m²)	41 ± 4	41 ± 4	46 ± 5	**.001**[b*]
Total fat mass (%)	49.6 ± 5.8	49.6 ± 5.7	50.3 ± 6.3	.496[b]
Total fat mass (kg)	56.3 ± 9.7	55.8 ± 9.1	62.4 ± 13.8	.116[c]
Total lean mass (kg)	56.6 ± 12.4	56.1 ± 12.4	62.8 ± 11.4	**.030**[b*]
Z-score	0.08 ± 1.09	0.04 ± 1.05	0.53 ± 1.49	.286[b]
Android fat mass (kg)	5.7 ± 1.2	5.6 ± 1.1	6.5 ± 1.1	**.019**[b*]
Gynoid fat mass (kg)	9.0 ± 3.6	8.9 ± 3.7	9.2 ± 3.0	.941[b]
A/G ratio	0.68 ± 0.20	0.67 ± 0.19	0.75 ± 0.24	.212[b]
Cholesterol (mg/dL)	193.61 ± 38.59	194.41 ± 37.35	183.69 ± 52.43	.337[a]; .290[bd]
HDL (mg/dL)	54.26 ± 12.95	54.11 ± 12.63	56.15 ± 16.87	.418[b]
LDL (mg/dL)	115.08 ± 38.78	116.99 ± 36.84	91.46 ± 54.12	**.092**[c]
Triglycerides (mg/dL)	118.80 ± 66.98	113.81 ± 60.38	180.54 ± 107.68	**.010**[b*]

Fasting glycemia (mg/dL)	111.32 ± 29.49	109.76 ± 28.38	130.62 ± 36.88	**.004**^{b*}
CRP (mg/L)	7.64 ± 8.48	7.15 ± 7.16	13.75 ± 17.62	.073^{b}
TSH (mU/L)	2.13 ± 9.43	2.20 ± 9.80	1.34 ± 1.09	.342^{b}
25 OH vit D (µg/L)	20.06 ± 7.75	20.29 ± 7.68	17.09 ± 8.38	.153^{a}; .126^{bd}

Note. Means ± Standard Deviations and Significant Group (success/non-success) Differences. BMI = Body Mass Index; LDL = Low density lipoproteins; HDL = High density lipoproteins; CRP = C-reactive protein; TSH = thyroid stimulating hormone; 25 OH vit D = 25-hydroxy vitamin D; Z-score: bone density compared to that of a healthy peer

^{a}p-value derived from two-sample t-test ^{b}p-value derived from rank-sum test ^{c}p-value derived from Welch test ^{d} Assumption violation led to two tests and p-values (Figure 2)

*Statistical significance was set at significance level of α = 0.05 ($p < 0.05$)

Linear regression analysis of blood and anthropometric variables on %EWL

Eight anthropometric parameters showed a significant association with %EWL and were therefore retained for further analysis. Weight was negatively associated with %EWL and significantly predicted %EWL (β = [-0.505], p = [< .001]). Waist circumference was negatively associated with %EWL and significantly predicted %EWL (β = [-0.683], p = [< .001]). BMI was negatively associated with %EWL and significantly predicted %EWL (β = [-3,072], p = [< .001]). Total fat mass was negatively associated with %EWL and significantly predicted %EWL (β = [-0.001], p = [.003]). Total lean mass was negatively associated with %EWL and significantly predicted %EWL (β = [-0.001], p = [.004]). Z-score was negatively associated with %EWL and significantly predicted %EWL (β = [-4.202], p = [.013]). Android fat mass was negatively associated with %EWL and significantly predicted %EWL (β = [-0.006], p = [.003]). A/G ratio was negatively associated with %EWL and significantly predicted %EWL (β = [-20.231], p = [.030]). Two anthropometric parameters showed no significant association with %EWL and were therefore excluded from further analysis. Total Fat mass showed a positive association with %EWL but was not a significant predictor (β = [0.067], p = [.838]). Gynoid fat mass showed a positive association with %EWL but was not a significant predictor (β = [0.003], p = [.537]). Four blood variables showed a significant association with %EWL and were therefore retained for further analysis. Total cholesterol was positively associated with %EWL and significantly predicted %EWL (β = [0.157], p = [.001]). LDL was positively associated with %EWL and significantly predicted %EWL (β = [0.181], p = [.001]). Triglycerides were negatively associated with %EWL and significantly predicted %EWL (β = [-0.069], p = [.013]). Fasting glycemia was negatively associated with %EWL and significantly predicted %EWL (β = [-0.187], p = [.003]). Four blood variables showed no significant association with %EWL and were therefore excluded from further analysis. HDL showed a positive association with %EWL but was not a significant predictor (β = [0.138], p = [.339]). TSH showed a positive association with %EWL but was not a significant predictor (β = [0.174], p = [.380]). 25 OH vit D showed a positive association with %EWL but was not a significant predictor (β = [0.414], p = [.085]). CRP showed a negative association with %EWL but was not a significant predictor (β = [-0.418], p = [.057]). The results for each parameter are summarized in Table 2.

Table 2

Simple Regression Analysis of Blood and Anthropometric Parameters on % EWL

Parameter	R^2adjused	β	F-ratio	p-value
Anthropometric Parameters				
Weight (kg)	0.127	-0.505	26.06	**<.001***
Waist circumference (cm)	0.100	-0.683	20.24	**<.001***
BMI (kg/m²)	0.270	-3,072	65.03	**<.001***
Total fat mass (%)	-0.006	0.067	0.04	.838
Total fat mass (g)	0.067	-0.001	13.37	**.003***
Total lean mass (g)	0.065	-0.001	13.11	**.004***
Z-score	0.030	-4.202	6.27	**.013***
Android fat mass (g)	0.069	-0.006	13.81	**.003***
Gynoid fat mass (g)	-0.004	0.0003	0.38	.537
A/G ratio	0.021	-20.231	4.77	**.030***
Blood Parameter				
Total cholesterol (mg/dL)	0.056	0.157	11.18	**.001***
HDL (mg/dL)	-0.001	0.138	0.92	.339
LDL (mg/dL)	0.077	0.181	15.34	**.001***
Triglycerides (mg/dL)	0.030	-0.069	6.31	**.013***
Fasting glycemia (mg/dL)	0.045	-0.187	9.19	**.003***
CRP (mg/L)	0.015	-0.418	3.69	.057

TSH (mU/L)	-0.001	0.174	0.78	.380
25 OH vit D (µg/L)	0.011	0.414	3.01	.085

Note. BMI = Body Mass Index; LDL = Low density lipoproteins; HDL = High density lipoproteins; CRP = C-reactive protein; TSH = thyroid stimulating hormone; 25 OH vit D = 25-hydroxy vitamin D; Z-score: bone density compared to that of a healthy peer
*Statistical significance was set at significance level of $\alpha = 0.05$ ($p < 0.05$)

Correlations between independent variables

Among the anthropometric parameters, weight and waist circumference were strongly correlated (r = .75, p = < .001), as well as weight and lean body mass (r_s = .79, p = < .001). Additionally, for the blood values, LDL and total cholesterol showed a strong correlation (r_s = 0.92, p < .001). Given their strong association with %EWL, weight and LDL were retained for further analysis. Waist circumference; lean body mass and total cholesterol were excluded from further analysis. The remaining parameters had non-significant correlations and were also retained and used in the final multiple model (Table 3).

Table 3

Multicollinearity Anthropometric and Blood Parameters

Parameter 1	Parameter 2	Pearson (r)	Spearman (r_s)
Anthropometric Parameter			
Weight (kg)	Waist circumference (cm)	.75*[a]	.71*[a]
	BMI (kg/m²)	.58*	.57*
	Total fat mass (g)	.68*	.67*
	Total lean mass (g)	.73*[a]	.79*[a]
	Z-score	.35*	.31*
	Android fat mass (g)	.62*	.68*
	A/G ratio	.16*	.16*
Waist circumference (cm)	BMI (kg/m²)	.57*	.49*
	Total fat mass (g)	.61*	.53*
	Total lean mass (g)	.44*	.52*
	Z-score	.21*	.20*
	Android fat mass (g)	.64*	.68*
	A/G ratio	.23*	.30*
BMI (kg/m²)	Total fat mass (g)	.71*[a]	.67*
	Total lean mass (g)	.16*	.22*
	Z-score	.19*	.22*
	Android fat mass (g)	.53*	.55*
	A/G ratio	-.05	-.04
Total fat mass (g)	Total lean mass (g)	.15*	.21*

	Z-score	.18*	.17*
	Android fat mass (g)	.63*	.66*
	A/G ratio	-.27*	-.28*
Total lean mass (g)	Z-score	.35*	.32*
	Android fat mass (g)	.32*	.42*
	A/G ratio	.35*	.40*
Z-score	Android fat mass (g)	.27*	.23*
	A/G ratio	.14	.05
Android fat mass (g)	A/G ratio	.45*	.40*
Blood Parameter			
Cholesterol (mg/dL)	LDL (mg/dL)	.93*[a]	0.92*[a]
	Triglycerides (mg/dL)	.11	.20*
	Fasting glycemia (mg/dL)	-.17*	-.29*
LDL (mg/dL)	Triglycerides (mg/dL)	-.09	.03
	Fasting glycemia (mg/dL)	-.19*	-.28*
Triglycerides (mg/dL)	Fasting glycemia (mg/dL)	.03	.02

Note. BMI = Body Mass Index; LDL = Low density lipoproteins; HDL = High density lipoproteins; CRP = C-reactive protein; TSH = thyroid stimulating hormone; 25 OH vit D = 25-hydroxy vitamin D; Z-score: bone density compared to that of a healthy peer

[a]Pearson (r) ≥ 0.7; spearman (r_s) ≥ 0.7

*Statistical significance was set at significance level of $\alpha = 0.05$ ($p < 0.05$)

Statistical models of blood and anthropometric variables on %EWL

Two multivariate models were established, the anthropometric model consisted of six anthropometric parameters; weight; BMI; total fat mass; Z-score; android fat mass, A/G ratio; as well as the fixed covariates (age; sex; smoking status). The multivariate blood variable model consisted of three blood parameters; LDL; triglycerides; Fasting glycemia; and the fixed covariates (age; sex; smoking status)(Table 4).

After simplifying the anthropometric model using the backwards procedure (with retention of the fixed covariates), with the aim to maximize the adjusted R-square, a model with an adjusted R-square of .352 and an AICc of 1540.73 was obtained ($p < .001$). This model consisted of BMI, android fat mass and A/G ratio, with BMI being the only significant variable ($p < .001$). The parameter estimate for BMI was -3.77, indicating that for every 1-unit increase in BMI, %EWL decreased by 3.77 units. The different VIF values for all independent variables in the model were less than three, indicating that there was no significant multicollinearity among the predictors.

After simplifying the blood parameter model using the backwards procedure (with retention of the fixed covariates), with the aim to maximize the adjusted R-square, a model with an adjusted R-square of .128 and an AICc of 1592.37 was obtained ($p < .001$). This model consisted of LDL, fasting glycaemia and triglycerides, with LDL ($p < .004$) and fasting glycaemia ($p = .020$) being the only significant variables. The parameter estimate of LDL was 0.14, indicating that for every 1-unit increase in LDL, %EWL increased by 0.14 units. The parameter estimate of fasting glycaemia was -0.15, indicating that for every 1-unit increase in fasting glycaemia, %EWL decreased by -0.15 units. The VIF values for all independent variables in the model were less than two, indicating that there was no significant multicollinearity among the predictors.

A multivariate model was developed by combining the remaining anthropometric and blood parameters from the simplified models (Table 4). This model was further simplified with the aim to maximize the adjusted R-square while retaining the fixed covariates. This combined, simplified model had an adjusted R-square of .411 and an AICc of 1527.51 ($p < .001$). BMI was the only significant anthropometric parameter ($p < .001$). The parameter estimate was -3.57.

LDL was the only significant blood parameter ($p = .001$). The parameter estimate was 0.13. The VIF values for all independent variables in the model were less than three.

Table 4

Multivariate Analysis: Anthropometric, Blood Variable and Combined Model

	p-value	
	Total Model	Simplified Model
Anthropometric Model	**<.001***	**<.001***
Age	**.012***	**.015***
Sex	.532	.095
Smoking status	.095	.073
Weight (kg)	.726	/
BMI (kg/m²)	**<.001***	**<.001***
Total fat mass (g)	.712	/
Z-score	.415	/
Android fat mass (g)	.086	.084
A/G ratio	.094	.102
Blood Variable Model	**<.001***	**<.001***[a]
Age	.948	.948
Sex	.147	.147
Smoking status	.125	.125
LDL (mg/dL)	**.004***	**.004***
Triglycerides (mg/dL)	.064	.064

Fasting glycemia (mg/dL)	**.020**	**.020**
Combined Model	**<.001***	**<.001***[a]
Age	.190	.190
Sex	.208	.208
Smoking status	.087	.087
BMI (kg/m²)	**<.001***	**<.001***
Android fat mass (g)	.109	.109
A/G ratio	.169	.169
LDL (mg/dL)	**.001***	**.001***
Triglycerides (mg/dL)	.082	.082
Fasting glycemia (mg/dL)	.119	.119

	R^2adjused	
	Total Model	Simplified Model
Anthropometric model	.347	.352
Blood value model	.128	.128
Combined model	.411	.411

Note. BMI = Body Mass Index; LDL = Low density lipoproteins. Simplified model: simplifying (backwards procedure) with the aim to maximize the adjusted R-square while retaining the fixed covariates.

[a]The simplified model was maintained identical to the total model, as any simplification led to a reduction in adjusted R^2.

*Statistical significance was set at significance level of $\alpha = 0.05$ ($p < 0.05$)

Discussion

This retrospective observational study aimed to give insight into the predictive value of preoperative anthropometric and blood parameters on postoperative weight loss success following bariatric surgery (expressed as %EWL). In this study, when looking at the adjusted R-square of the model combining both the blood parameters and anthropometric parameters, LDL and BMI could be labeled as predictors for the effects of bariatric surgery. The BMI of the patient is negatively associated with %EWL, and LDL is positively associated with %EWL. The predictiveness of the combined model ($r^2 = .411$) leads to superior results compared to the separate anthropometric ($r^2 = .352$) and blood value ($r^2 = .128$) models.

In the systematic review by Livhits et al. (2011), preoperative predictors of weight loss following bariatric surgery were examined. The review included 62 studies with a total of 24,326 patients and assessed the relationship between preoperative BMI (among other factors) and postoperative weight loss. Supporting the current study's results, the majority of studies in the review (37 out of 62) found a negative association between preoperative BMI and weight loss, suggesting that individuals with a higher BMI before surgery tended to lose a smaller percentage of their excess weight. Coupaye et al. (2010) and Nickel et al. (2019) analyzed predictors of %EWL after bariatric surgery in patient groups comparable to the current study. In Coupaye et al., univariate analysis showed that %EWL was negatively correlated with weight, BMI, and waist circumference. However, the multivariate analysis revealed that only initial BMI was independently and negatively associated with %EWL, corroborating our current findings. Similarly, Nickel et al. confirmed that higher preoperative BMI was significantly associated with lower %EWL, consistent with our results. These findings support the importance of BMI in predicting postoperative weight loss outcomes.

In relation to the blood parameters, the study by Coupaye et al. (2010) showed that %EWL was positively correlated with fasting triglycerides, suggesting that higher triglyceride levels may be associated with greater excess weight loss after bariatric surgery. However, in the multivariate models of the current study, this association was not found to be significant. In the longitudinal, prospective pilot study conducted by Stumpf et al. (2022), 35 patients who underwent bariatric surgery were followed. Lower fasting blood glucose was correlated with a lower BMI at 12 months post-surgery. Although Stumpf et al. described a positive correlation with postoperative BMI and the current study reports a negative association with %EWL, these outcomes are consistent because a higher postoperative BMI corresponds to lower excess weight loss. Thus, both studies demonstrate that a higher preoperative fasting glycemia, potentially indicative for worse glycemic control, is linked to less successful weight loss after bariatric surgery. This also corresponds with the prospective cohort study conducted by Gil Faria et al. (2014), in which elevated fasting blood glucose was independently associated with significantly poorer %EWL outcomes at 12 months postoperatively. Of interest, the findings reported by Aliakbarian et al. (2020) and Neves et al. (2019) do not align with the current study. Aliakbarian et al. (2020) found that CRP had a significant negative correlation with maximal total body weight loss. Similarly, Neves et al. (2019) indicated that high levels of Free Triiodothyronine (FT3) were linked to greater weight loss after bariatric surgery, with elevated serum TSH levels observed in these individuals. In contrast, the current study found no significant relationship between TSH and %EWL, nor between CRP and %EWL. In recent literature, no evidence was found that supported the results of LDL as a predicting factor for %EWL following bariatric surgery.

A first limitation of this research is the disproportionate distribution of postoperative outcomes, few participants experienced a negative postoperative outcome on %EWL. However, 15–35% of patients do not reach their weight loss goal two years after receiving bariatric surgery (Cadena-Obando et al., 2020). Secondly, it should be noted that these results are based on the %EWL only one year after bariatric surgery. This relatively short follow-up period may limit the ability to draw long term conclusions from these findings. Especially if achieving and maintaining more than 50% EWL for at least two years postoperatively has been traditionally considered a benchmark for successful bariatric surgery (Masnyj et al., 2020). The third limitation is that, although %EWL is an important outcome measure for the success of bariatric surgery, it is important to note that improvements in quality of life and the reduction of obesity-related comorbidities are also key indicators of bariatric surgery success (Masnyj et al., 2020). Another limitation is that the analysis was restricted to anthropometric and blood factors to maintain a manageable study scope, which may have resulted in the exclusion of other potentially important determinants such as psychological and social factors (van Hout et al., 2005). A final limitation is the presence of multiple biases. Specific statistical tests were relied upon in certain instances due to the inability to reliably assess homoscedasticity and linearity based on the visual inspection of the residual by predicted plots. This could introduce linearity assumption bias, as both simple linear regression and Pearson correlation require a linear relationship between variables. If this assumption is violated, it may result in inaccurate findings. Selection bias is yet another possible limiting factor, as the sample may not fully represent the target population. More specifically, there was a disproportionate distribution of postoperative outcomes, with relatively few participants experiencing a negative outcome in terms of %EWL. As previously mentioned, this proportion is exceptionally low compared to existing literature (15-35%) (Cadena-Obando et al., 2020). This imbalance may limit the generalizability of the results, especially regarding conclusions about parameters associated with less postoperative success. The data used in this study was previously measured and collected in the study of Verboven and Bouckaert (2023). Therefore, it is uncertain whether measurements and collection was performed accurately, which introduces a risk of information bias.

The results of this study may help to tailor the preoperative parameters of the patient to optimize the results of bariatric surgery or to recommend alternative interventions (GLP-1 receptor agonists) that could lead to better outcomes. It could then be possible to provide appropriate education to enhance their understanding of the potential outcomes.

In conclusion, BMI could be a potential predictor for the success of bariatric surgery, which this study tries to highlight. However, limited information was found related to the predictability of LDL, which indicates the need for future research. Future research should therefore include longer follow-up periods, more outcome measures for the success of bariatric surgery to get a broader profile of successful patients and investigate additional factors, such as psychological or social variables, to improve prediction models.

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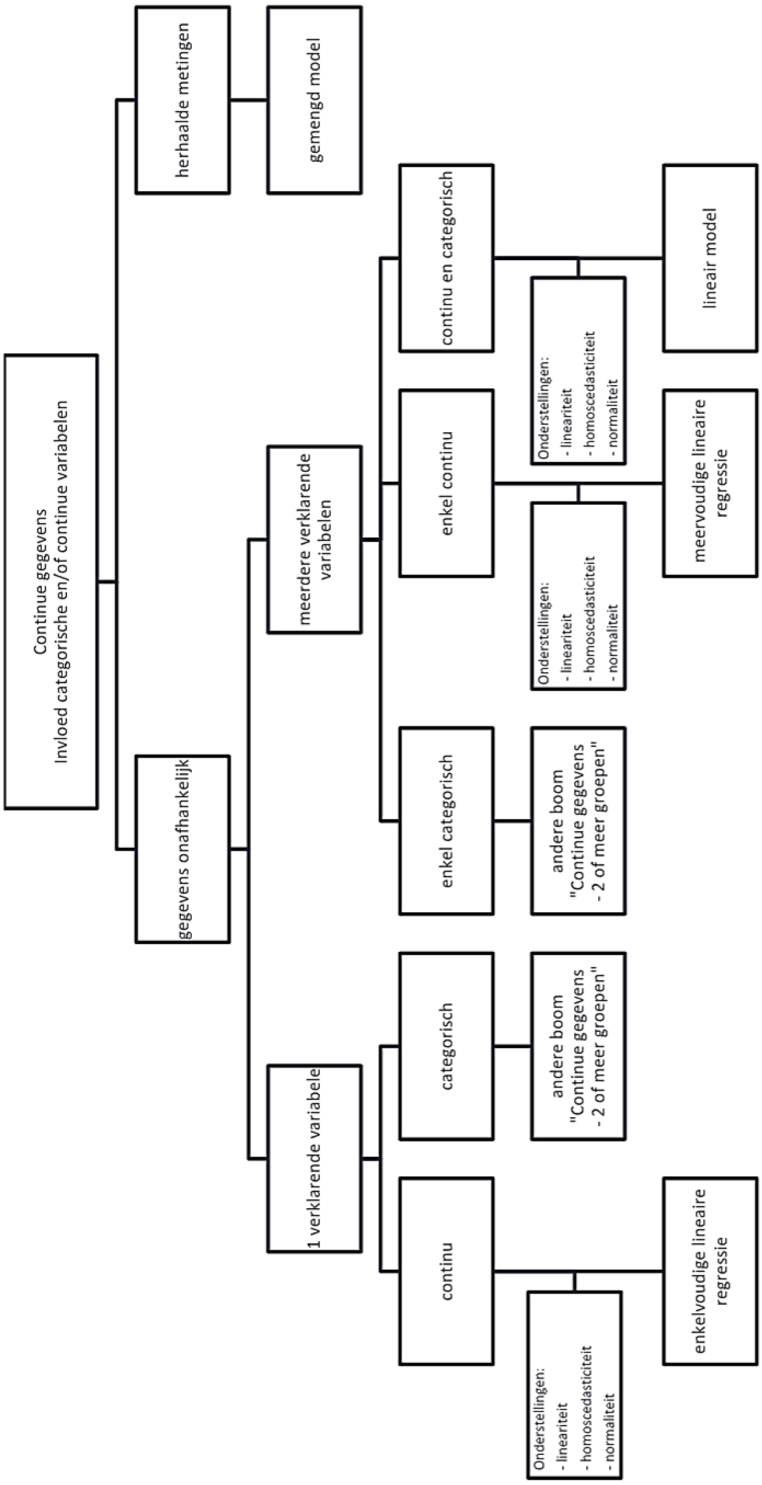
Appendix

Figure 1

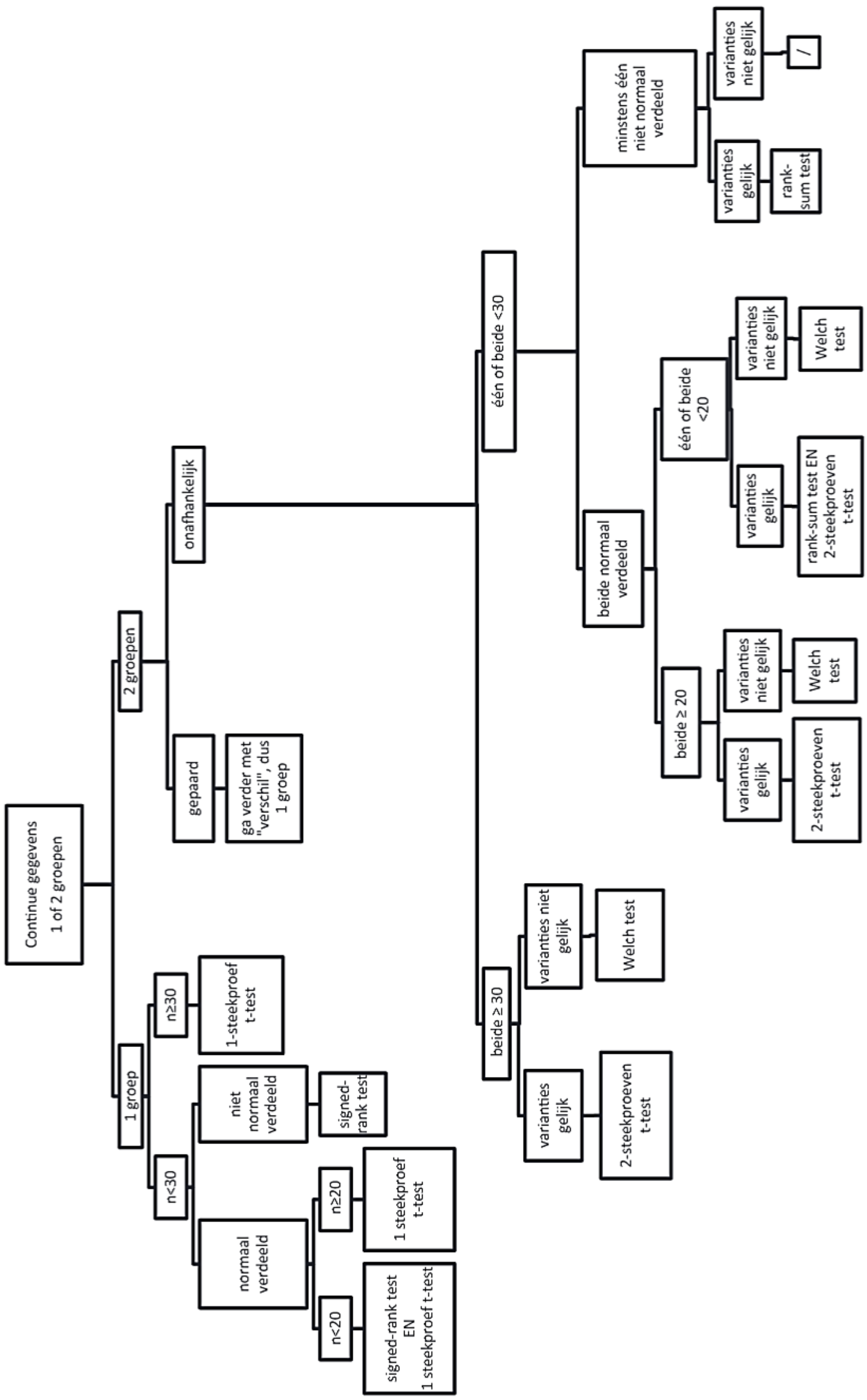
Decision Tree Anthropometric and Blood Parameters



Note. Meesen, R., & Verstraelen, S. (2022). *Wetenschappelijke vorming (WV2).* Acco

Figure 2

Decision Tree Anthropometric and Blood Parameters



Note. Meesen, R., & Verstraelen, S. (2022). *Wetenschappelijke vorming (WV2).* Acco