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# Baseline BMI, gender, & age as predictive factors for intragastric balloon weight loss outcomes

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# Baseline BMI, Gender, & Age as Predictive Factors for Intragastric Balloon Weight Loss Outcomes

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## ABSTRACT

**Objective**: To determine whether obese and morbidly obese patients aged 18-75 with a lower baseline BMI (BMI 30-39.9 kg/m2) who received an intragastric balloon (IGB), have a higher percentage of total body weight loss (%TBWL) and percentage of excess weight loss (%EWL) compared to those with a higher baseline BMI (BMI > 40 kg/m2). Secondary objective was to ascertain whether gender and age are also predictors of weight loss outcomes following an IGB procedure.

**Design**: Systematic literature review

**Methods**: Literature searches of PubMed and SpringerLink were conducted using the search terms: "intragastric balloon, weight loss, and "BMI" and then limited to publications within the years 2010-2020. The following limits were used: study available in the English language, patients 18 years or older, results stratification by BMI, and study designs that were randomized control trials, cohorts, or case controls followed for six months total.

**Results**: Using the keywords mentioned above in PubMed and SpringerLink, three studies met the inclusion and exclusion criteria: a prospective cohort study by Diab et al., a case control study by Lopez-Nava et al., and a prospective cohort study Lecumberri, et al.

**Conclusion**: No significant difference in %TBWL was found in all the studies reviewed. All three studies concluded that gender had little difference in weight loss outcomes, however there was variability in conclusions on age and baseline BMI. Two out of three studies ascertained that younger patients and patients with lower baseline BMI show greater %EWL, concluding that baseline BMI and age can be used as predictors of IGB weight loss outcomes.


## INTRODUCTION

Since the 1970s, obesity has become a serious health epidemic affecting Americans of all races, gender, and ages.[1] Obesity is the result of complex associations of genetics, diet, socioeconomic status, culture, medical and pharmacological factors.[1,2] Data from the Behavioral Risk Factor Surveillance System Survey (BRFSS) collected between 1990 through 2016 predict that by 2030, there will be an estimated 33% increase in obesity, and 130% increase in severe (morbid) obesity. This means that in ten years, at least 1 in 2 Americans adults will be obese, and nearly 1 in 4 morbidly obese.[3,4]

According to the Center for Disease Control and Prevention (CDC), obesity is defined as a Body mass index (BMI) of 30.0 or higher.[5] Morbid obesity, also known as severe, extreme, or class 3 obesity, is defined as a BMI of 40.0 or greater.[5] In the last five decades, the alarming increase in obesity rates in the United States (U.S.) can be attributed to unhealthy diets and increased sedentary lifestyles.[1,2,6] Of the top ten leading causes of death in the U.S., risk factors for seven of them include obesity, including heart disease and cancer which rank as the top two on the list.[7] Additionally, chronic lower respiratory diseases, cerebrovascular accidents, Alzheimer's, diabetes, and kidney disease also have obesity as a risk factor[7] Other major health conditions associated with obesity include sleep apnea, hepatobiliary disease, osteoarthritis, gynecological and psychiatric disorders.[1,2] Individuals with obesity are at a much higher risk of mortality related to associated complications of these diseases.[1,2]

Obesity is currently managed with a combination of approaches that include lifestyle and dietary changes, pharmaceutical therapy, and in more severe cases bariatric procedures. Out of the various management strategies, Roux-en-Y gastric bypass (RYGP), and various other bariatric surgeries are

considered the most successful long-term interventions for weight loss compared to intensive behavioral modification or pharmaceutical therapy either combined or alone.[8,9] However, all bariatric surgeries come with significant complications and limitations that bar the majority of obese patients from receiving them. For example, gastric bypass recipients are at risk for long-term vomiting and diarrhea, gastric ulcers, strictures, small bowel obstructions, hernias, dumping syndrome and malnutrition in addition to typical surgical risks of infection, blood clots, and internal bleeding.[10] In recent years, alternatives to gastric bypass surgery for severe obesity treatment, such as endoscopic intragastric balloon systems, have been explored.

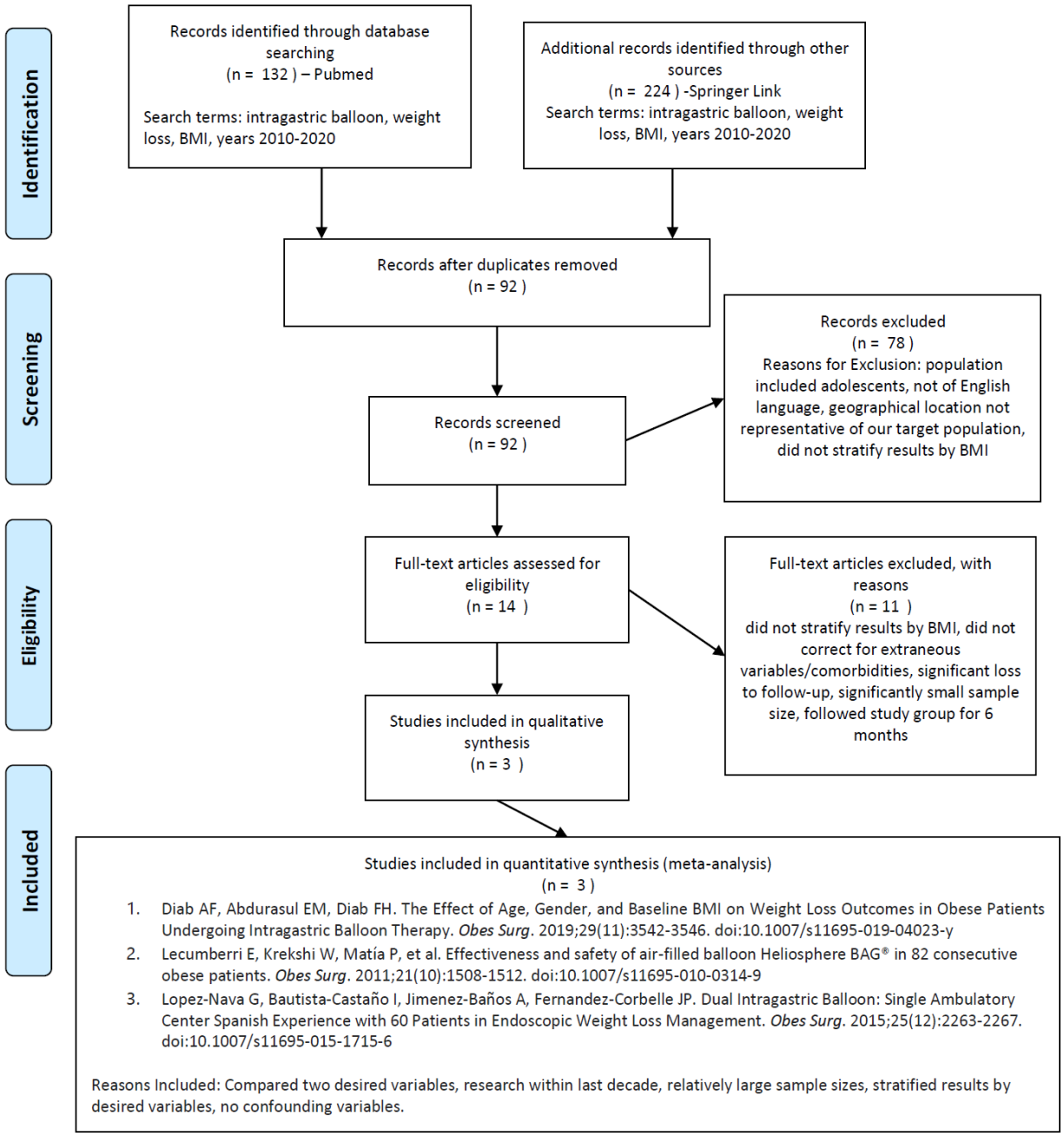
Intragastric balloon (IGB) systems were first approved in the US for the treatment of obesity in 1985.[11] Since then, there have been many different IGB systems developed to be utilized as an effective, minimally invasive method of weight loss in obese individuals. These balloon systems lead to weight loss by inducing early satiety, ultimately leading to decreased food intake.[11] IGBs used today are made of silicone, polyurethane, nylon, titanium, gelatin or polymer films which can be swallowed, or more commonly, endoscopically placed.[11,12] These balloons are then filled with 250-900 milliliters of nitrogen, air, or saline.[11,12] The total number of balloons placed can range from 1-3 and can remain intragastric for up to 12 months. The balloons can be removed endoscopically, or excreted naturally.[11,12] The complications associated with IGB range from mild, self-limiting complications such as pain, nausea and vomiting to more serious complications such as intestinal obstruction, perforations, and bleeding.[13] A meta-analysis on the safety and effectiveness of IGBs of more than 3,000 patients found that only 4.2% experienced complications significant enough to warrant early removal of the balloons.[14] The hope with the intragastric balloon is to reach obese patients ineligible for bariatric surgery with a less invasive, reversible, and affordable option that can be used as an adjunct to other weight loss methods.

Several studies on gastric bypass surgery have ascertained that patients with lower baseline BMI see more weight loss success following the procedure than those with higher baseline BMI.[15,16,17,18,19] However, the presence of predictive factors such as baseline BMI, gender, and age have not yet been systematically reviewed and established for intragastric balloons. Defining predictors of weight loss success will help guide the selection of patients best eligible for the intragastric balloon, and in turn save on healthcare costs and reduce patient complications.[18,19] The goal of this systematic review is to ascertain whether the limiting factor of higher baseline BMI as a predictor for gastric surgery weight loss outcomes, is similarly associated with the less invasive intragastric balloon procedure.

## METHODS

Literature searches of both PubMed and SpringerLink were conducted in September 2020 using the search terms: “intragastric balloon, weight loss, and “BMI” limited to publication within the years 2010-2020. The following other limits were used: study available in the English language, patient sample only including those 18 years or older, stratification of results by BMI, and only randomized control trials, cohorts, or case controls which followed the study group for six months. Studies that were case reports, meta-analyses, and literature reviews were excluded, as well as studies that were noted to have confounding variables, did not compare the desired variables, had significantly small sample sizes, or had significant loss to follow-up. Based on these inclusion and exclusion criteria, three articles comparing baseline BMI and weight loss outcomes following an intragastric balloon procedure were identified and included in this literature review. This process is outlined in the form of a PRISMA flowchart in Figure 1.

# PRISMA 2009 Flow Diagram




*From:* Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

**For more information, visit www.prisma-statement.org.**

## RESULTS

**Study 1:** *The Effect of Age, Gender, and Baseline BMI on Weight Loss Outcomes in Obese Patients Undergoing Intragastric Balloon Therapy.*[20]

### Study Objective

To evaluate age and gender and baseline BMI as predictors of weight loss in obese patients treated with intragastric balloons.

### Study Design

This was a prospective cohort study that enrolled and followed 229 patients receiving an Orbera intragastric balloon procedure between June 2014 and December 2017 at the Khaldi Medical Center in Amman, Jordan.

After obtaining informed consent, the patients were sedated with propofol for endoscopic balloon placement. Esophagogastroduodenoscopy was performed followed by placement of the Orbera intragastric balloon down the esophagus into the stomach. The balloons were filled with 600-650 ml of normal saline and 10 ml of methylene blue. Placement of the balloons within the stomach were confirmed with endoscope visualization during the procedure. For the six-month period, patients were placed on a thousand calorie diet and followed by a multidisciplinary team.

Six months following the procedure at the time of balloon removal, data was collected on percent excess weight loss (%EWL), total body weight loss (TBWL), and percent total body weight loss (%TBWL). The data was stratified into categories based on gender, age groups, and baseline BMI. Patients were categorized according to two age groups: age less than 40 years and age ≥50 years. Patients who were 40-49 years of age were later excluded from the study. The patients were also studied in two baseline BMI groups: BMI <35 and BMI >40. No patients with the BMI of 35-40 were ultimately included in the study. Following these exclusions, 184 patients, 80% of which being female and 73% younger than 40 years old, were ultimately enrolled in this study.

Primary outcomes measured were the effect of age, gender, and baseline BMI on weight loss and means of TBWL, %EWL, and %TBWL amongst the stratified groups.

**Table 1**. Study #1 Patient Criteria

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| 1. Age less than or equal to 30 and greater than or equal to 50<br>2. Baseline BMI less than or equal to 35 and greater than or equal to 40<br>3. Patients who had not received weight loss therapy for at least 8 months before placement of the intragastric balloon<br>4. Patients who completed the full 6 months period of balloon placement with successful balloon removal | 1. Age 40-49<br>2. Baseline BMI 35-40<br>3. Previous esophageal or gastric surgery<br>4. More than 2 cm hiatal hernia<br>5. Active gastric ulcers<br>6. Coagulopathy<br>7. Early balloon removal<br>8. Spontaneous balloon deflation |

### Study Results

The study found that %TBWL was not found to be significantly different between age groups or genders, however TBWL was higher amongst males compared to females. The study also concluded that higher baseline BMI had higher TBWL compared to lower baseline BMI in both sexes. Additionally, there was a significant effect of age on weight loss in females, with percent excess weight loss of 47.34% in females under age 40 and 38% in those over age 50. As displayed in Table 2, no significant difference ("N.S.") in %EWL was found between age groups in the male patients (50.21% in younger males and 47.05% in older males, p value=0.836).

**Table 2.** Study #1 Outcome after 6 months of intragastric balloon therapy based on age.

| | Female patients (148) | | | Male patients (36) | | |
|---|---|---|---|---|---|---|
| | < 40 year | ≥ 50 year | *p* value | < 40 year | ≥ 50 year | *p* value |
| Number | 106 | 42 | | 29 | 7 | |
| *TBWL (kg) | 12.5 ± 5.4 | 14 ± 6.7 | N.S. | 17.2 ± 6.3 | 16.4 ± 4.9 | N.S. |
| %TBWL | 12.9% ± 5.2 | 11.9% ± 6.9 | N.S. | 14.2% ± 4.7 | 13.9% ± 2.7 | N.S. |
| %EWL | 47.3% ± 28% | 38% ± 22.5% | 0.04 | 50.2% ± 39% | 47% ± 10% | 0.84 |

*When comparing male and female groups, TBWL was significantly higher in males (*p* value = 0.000)

Lower baseline BMI was found to have a significant impact on %EWL compared to higher baseline BMI in both genders: 53.7% for females with lower baseline BMI compared to 32.5% for females with higher baseline BMI; and 50.1% for males with lower baseline BMI compared to 32.2% for males with higher baseline BMI (p value <0.01) (see Table 3). Neither TBWL or %TBWL were significantly different between baseline BMI groups among either gender group. However, when results from both males and females were combined, higher baseline BMI had statistically significant higher TBWL compared to the lower baseline BMI group.

**Table 3**. Study #1 Outcome after 6 months of intragastric balloon therapy based on baseline BMI.

| | | Baseline BMI < 35 | Baseline BMI > 40 | *p* value |
|---|---|---|---|---|
| %EWL | Females | 53.72% ± 22.3% | 32.5% ± 16.7% | < 0.01 |
| | Males | 50.1% ± 12.3% | 32.1% ± 17.1% | < 0.02 |
| %TBWL | Females | 12.63% ± 5.5% | 13.2% ± 6.4% | N.S. |
| | Males | 11.8% ± 2.8% | 12.9% ± 7.2% | N.S. |
| *TBWL | Females | 10.3 ± 4.7 | 14.9 ± 6.5 | N.S. |
| | Males | 11.7 ± 3.4 | 18.9 ± 8.6 | N.S. |

*When both sexes were combined, higher baseline BMI group had significantly more TBWL compared with the BMI < 35 group (*p* value = 0.000)

The study also performed a Durbin Watson test, which analyzes serial correlations between variables and assigns a value of 0-4 where 2 means no correlation. The study found there were no residual correlations between age, gender, or baseline BMI amongst four age and sex subgroups (see Table 4).

**Table 4**. Study #1 Outcomes for age, gender, baseline BMI subgroups.

| | Females < 40 year | Females ≥ 50 year | Males < 40 year | Males ≥ 50 year |
|---|---|---|---|---|
| Age | $p = 0.046$ | $p = 0.837$ | $p = 0.688$ | $p = 0.909$ |
| Baseline BMI | $p = 0.001$ | $p = 0.002$ | $p = 0.007$ | $p = 0.003$ |
| Durbin-Watson | 2.04 | 2.42 | 1.85 | 2.41 |

Dependent variable: weight loss

**Study Critique**

One of this study's strengths is strict inclusion criteria of those physical constraints that would diminish the patient's tolerance of the balloon such as active gastric ulcers. As a result of these criteria, large loss to follow-up risk was reduced and an adequate sample size was maintained. Another strength is strict adherence to post-procedure protocol for dietary restrictions and follow-up visits with a multidisciplinary team, to reduce influence on weight loss outcomes from extraneous variables outside of intragastric balloon placement.

There were many limitations to this study. The study excludes ages 40-49 and BMI 35-40 without explanation as to why. Given that these exclusions were made, the conclusions of their study cannot be extrapolated to patients of intermediate age or BMI. There is a possibility that the results of the study and their statistical significance may have been different if the participants of the study within those age and BMI ranges had not been excluded following recruitment. Additionally, the study has a small sample size for males. The researchers admit that they could not be confident that the lack of significant effect of age in males is not just because of a type 2 error. The researchers also pointed out that they did not take into account comorbidities such as hypertension, hyperlipidemia, or diabetes mellitus which could have influenced the weight loss outcomes of the study participants. Lastly, the study did not include patients that received the balloon and had it removed before the 6 month expected period, meaning the study provided results using per protocol analysis, rather than intention-to-treat analysis and thus did not compare the approaches nor prove their equivalence. By not calculating results with and without those that dropped-out due to early balloon removal, it leaves the question whether the results with exclusions were significantly different compared to results if all participants had been included.

**Study 2:** *Dual Intragastric Balloon: Single Ambulatory Center Spanish Experience with 60 Patients in Endoscopic Weight Loss Management.*[21]

**Study Objective**

To study the safety and efficacy of the Dual Intragastric Balloon (DIGB) and to see how factors such as the degree of obesity, age and gender of participants affected their response to treatment.

**Study Design**

This was a case control study following 60 participants, 49 women and 11 men, at a bariatric endoscopy unit at the Madrid Sanchinarro University Hospital in Spain. The participants were patients who were admitted to the unit between September of 2012 and June of 2013 and chosen based on the inclusion and exclusion criteria listed in Table 5.

After sedation, gastric pathologies were first excluded using standard diagnostic endoscopy. Next, with the participants in the left lateral decubitus position, a guide wire was positioned through the

endoscope into the stomach and advanced through the pylorus. A balloon delivery catheter was then advanced and the DIGB was positioned at the greater curvature of the stomach. The DIGB consisted of two independent silicone balloons which were bonded to a flexible silicone shaft which was attached to the delivery catheter. Following delivery of the balloons into the stomach, under endoscopic visualization, they were each filled with 450 cc of sterile saline/methylene blue solution using an automated pump.. Mean implantation time was 12 minutes, and mean duration of treatment was 6.9 months. .

Participants followed a specific diet consisting of a liquid diet 1 day prior to procedure and continued until one-week post-placement of the balloons. Small semi-solid meals were progressively started over the second week, hypo-caloric meals starting in the second week and continued until month 6-7. Individual preferences and energy requirements were taken into consideration. Participants were also to follow-up with nutritionists and psychologists weekly or bi-weekly, as well as emphasizing initiating an exercise program with progressive increase in intensity.

For assessing the participant's progress, their height and weight were measured using calibrated scales and wall mounted stadiometers without shoes, and indoor clothing kept on. Outcomes measured included change in body weight (TBWL), percentage loss of initial body weight (%TBWL), and percentage of excess weight loss (%EWL) which was the current weight minus the weight corresponding to BMI 25 $kg/m^2$.

Statistical analysis methods included using the test of proportion for qualitative variables, measurements of central tendencies (mean), and dispersion (standard deviation) for quantitative variables. Student's t-test for related pairs was used for statistical analysis of association of changes comparing initial and final values of weight parameters. SPSS 17.p was used for data analysis with the statistical significance set at a two tailed probability level of </= 0.05.

**Table 5.** Study #2 Patient Criteria.

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| -both male & female<br>-clinically obese (BMI above 30)<br>-willing & able to follow strict dietary and exercise guidelines post-procedure<br>-willing & able to attend follow-up with a multidisciplinary team post-procedure | - had an absolute contraindication to anesthesia |

**Study Results**

Among morbidly obese and non-morbidly obese participants, morbidly obese patients had a greater TBWL than non-morbidly obese participants: 20.52 $\pm$ 10.39, and 14.49 $\pm$ 8.07, respectively. There was no significant difference found with TBWL regarding age or gender and no statistically significant difference in %TBWL with regard to gender, age, or obesity grade. Women participants had a higher %EWL compared to men: 50.73 $\pm$ 26.68 for women, and 30.92 $\pm$ 21.03 for men. This can be attributed to the lower number of males in the study, as well as the fact that the women had a higher excess weight at baseline compared to the male participants. Non-morbidly obese participants also had a higher %EWL than morbidly obese participants, 52.27 $\pm$ 28.72 and 37.48 $\pm$ 19.72, respectively.

Regarding safety, there were no incidences of migration in the 6month life of the balloon. There was one incidence of early removal due to patient intolerance, one early deflation, but without migration, and finally one gastric perforation. 14 patients also had gastric ulcers or erosions at the time of removal, however these were clinically insignificant.

**Table 6.** Study #2 results of TBWL, %TBWL and %EWL based on obesity grades, gender, and age >40 years or </=40 years.

| | | Total weight loss (kg) (mean ± SD) | % of weight loss (%) | % of excess weight loss (%) |
|---|---|---|---|---|
| | Total ($n$ = 60) | 16.60 ± 9.33 | 15.45 ± 7.95 | 47.1 ± 4 26.72 |
| Obesity grade | BMI <40 kg/m$^2$ ($n$ = 39) | 14.49 ± 8.07* | 14.90 ± 7.71 | 52.27 ± 28.72* |
| | BMI ≥ 40 kg/m$^2$ ($n$ = 21) | 20.52 ± 10.39* | 16.46 ± 8.47 | 37.48 ± 19.72* |
| Gender | Male ($n$ = 11) | 15.79 ± 9.66 | 12.09 ± 7.63 | 30.92 ± 21.03* |
| | Female ($n$ = 49) | 16.78 ± 9.34 | 16.20 ± 7.89 | 50.73 ± 26.68* |
| Age | ≤40 years ($n$ = 34) | 16.94 ± 9.75 | 15.56 ± 8.01 | 48.49 ± 26.72 |
| | >40 years ($n$ = 26) | 16.15 ± 8.90 | 15.31 ± 8.02 | 45.28 ± 27.13 |

Comparisons of absolute means between groups were with $T$ of Student:
*$p < 0.05$

**Study Critique**

The study had several strengths. The researchers discuss that the use of regular counseling and multidisciplinary teams increase patient commitment to weight loss and long-lasting results. They endorse the use of the psychological, nutritional, and physical activity support teams that had extensive experience with the use of IGBs for treatment of obesity. Frequent visits with professionals yield increased follow-ups, better monitoring and therefore better outcomes. This multidisciplinary approach could be an important factor in higher %EWL. The authors also describe that the design with a dual balloon decreases the risk of migration and therefore decreases the risk of perforations and other adverse effects. The study also investigated a lower cost and more accessible alternative to bariatric surgery which has the potential to fill a significant gap in treatment for a major public health crisis. Finally, this study was one of the first to compare intragastric balloon weight loss outcomes amongst genders, ages, and degrees of obesity.

The study also had a few weak points. Women had a higher %EWL but this could be attributed to less male participants or higher excess weight at baseline for males. This limitation makes it difficult to extrapolate results and apply them to both male and female obese and morbidly obese patients. Additionally, the study did not specify inclusion and exclusion criteria when recruiting their participants, therefore some inferences needed to be made. Not including this information explicitly, especially regarding patient age and BMI ranges, makes it difficult to extrapolate to other patient populations, compare results amongst studies, and to reproduce this study in the future. The researchers did not disclose possible limitations of their study, did not discuss the possibility of confounding variables nor specify in what ways they controlled for such possibilities.

**Study 3**: *Effectiveness and Safety of Air-Filled Balloon Heliosphere BAG® in 82 Consecutive Obese Patients.*[22]

**Study Objective**

To describe the effectiveness, in regards to absolute weight loss, BMI loss, percentage of body weight loss (%BWL), and percentage excess weight loss (%EWL), and complications 6 months post-insertion of the air-filled balloon in obese patients.

**Study Design**

Prospective study involving 84 patients from an outpatient endocrinology clinic following insertion of an endoscopically placed air-filled intragastric balloon. Sixty-three of the participants were women, with a mean age of 39 years and mean BMI of 39.1 $kg/m^2$ among all participants.

Prior to insertion, anthropometrics were measured. The measurements were also repeated after balloon removal. Height and weight were also measured in light clothing, without shoes, on a wall mounted stadiometer. Balloons were inserted via endoscopic control following general anesthesia with propofol 2mg/kg IV. After insertion, the balloons were inflated with 960cc of air to a final inflation volume of 700cc. Following the procedure, patients fasted for 6-8 hours and were prescribed a high-protein liquid diet for the first 24-72 hours. A soft low calorie to normal diet was initiated thereafter with a goal of 800-1200 kcal/day. For any persistent nausea and vomiting for the first few days following insertion, patients were prescribed Cisapride 10 mg BID or TID. Proton pump inhibitors were also prescribed for the duration of balloon treatment. Patients were also advised to avoid alcohol, coffee, cola, and gastric secretion stimulants and had planned monthly dietitian visits. Balloons were planned for endoscopic removal 6 months after insertion. Median time of removal was 182 days ranging from 63 days to 238 days.

**Table 7**. Study #3 Patient Criteria.

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| - Overweight and obese patients (BMI > 27) following insertion of air-filled intragastric balloon | - Serious psychiatric disorders<br>- Drug abuse<br>- Age <18 years, or >70 years<br>- Previous gastrointestinal surgery<br>- Active peptic ulcer<br>- Big hiatal hernia<br>- Severe gastritis or esophagitis<br>- Coagulation disorders<br>- Anti-inflammatory agents<br>- Glucocorticoid therapy<br>- Neoplasia<br>- Potential for decompensation of renal or heart disease |

**Study Results**

Statistical analysis included paired t-test and McNemar test to compare baseline and outcome variables; Linear regression analysis was used to evaluate for the associations of age, gender, initial BMI with weight loss, BMI loss, percentage of initial body weight loss, and % EWL. Interaction and confusion were also evaluated. Due to an outlier patient, analysis was done after excluding this data and results were reported if differences were found to be significant (bilateral $\alpha < 0.05$). SPSS 15.0 software was used for computer analysis.

Only one early surgical removal was required due to technical problems with endoscopic extraction, and there were two spontaneous deflations without migrations. One patient gained 6.4kg after balloon placement due to a psychiatric disorder suspected after balloon placement. With the exception of

that case, weight loss ranged from 0.5kg to 43.5kg with a mean of 14.5kg (SD, 8.2; 95% Confidence Interval (CI) for difference 12.7−16.4; $p < 0.001$). BMI loss ranged from 0.2-13.4kg/㎡, with an average loss of 5.3kg/㎡ (SD 2.8; 95% CI for difference 4.7−5.9; $p < 0.001$). See Figure 1 and table 8 below for a summary of the BMI changes before and after balloon removal. With adjustments for age and sex, analysis of the results showed that the higher the baseline BMI, the greater the absolute weight loss and BMI loss. However, a higher baseline BMI was found to have a lower percentage of EWL. The percentage of BWL was not associated with the BMI at baseline, prior to balloon insertion. Age was found to be inversely related to weight loss with multivariate regression analysis. There was also an association found between age and BMI loss, %BWL, and %EWL, but only after exclusion of an outlier patient.

Mean %BWL loss was 13.4% (SD 7.0) and a mean %EWL was 33.2% (SD 19.20). Table 8 below summarizes the absolute weight loss, BMI loss, %BWL, and %EWL categorized by sex and initial BMI.

Secondary findings also include that the longer the balloon was in place, the greater the absolute changes in most outcomes measured compared to those removed earlier, around the six-month mark. Thirty-nine patients who had the balloon in place for longer than six months compared to patients with removal at six months had an average absolute weight loss of 17.25kg vs 12.42kg (p=0.013), average BMI loss was 6.23 kg/㎡ vs 4.56kg/㎡ (p=0.012), average %BWL was 15.43% vs 11.85% (p=0.024). There was no statistical difference in the average %EWL comparing removal time groups (35.08% vs 31.87% (p=0.459)), nor between men and women regarding weight loss, BMI loss, percentage of BWL, and percentage of EWL.

**Figure 1.** Study # 3 BMI distribution by sex (a) before balloon insertion and (b) after balloon removal.

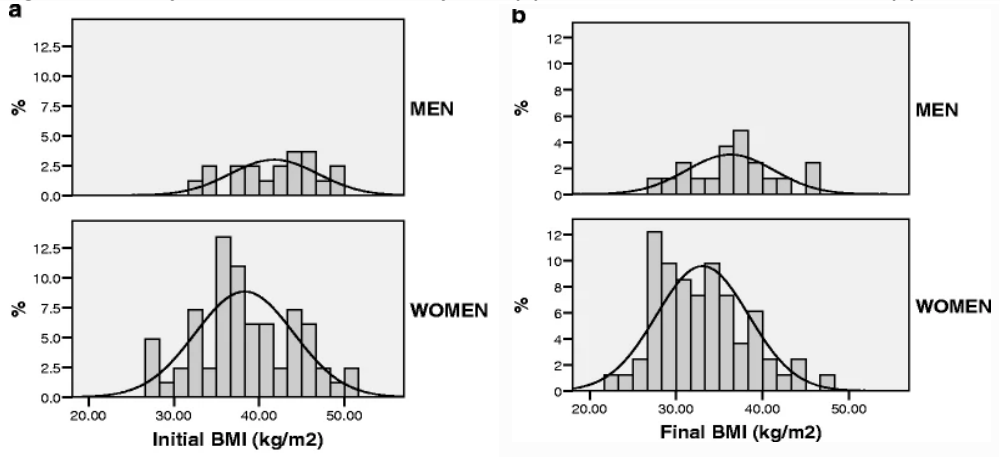


**Table 8.** Study #3 Weight loss, BMI loss, percentage of BW, and percentage of EWL according to sex and initial BMI.

| Initial BMI ($kg/m^2$) | Men | | | | Women | | | |
|---|---|---|---|---|---|---|---|---|
| | WL (kg) | BMIL ($kg/m^2$) | Percentage of BWL | Percentage of EWL | WL (kg) | BMIL ($kg/m^2$) | Percentage of BWL | Percentage of EWL |
| 25.0–29.9 | – | – | – | – | 4.5 (3.0) | 1.8 (1.2) | 6.4 (4.1) | 33.9 (21.8) |
| 30.0–34.9 | 11.7 (0.9) | 4.3 (0.5) | 12.8 (1.5) | 39.5 (6.4) | 9.7 (1.7) | 3.5 (0.6) | 10.9 (1.8) | 35.6 (6.0) |
| 35.0–39.9 | 10.5 (2.4) | 3.5 (0.8) | 9.1 (2.2) | 21.9 (5.6) | 14.6 (1.2) | 5.4 (0.4) | 14.7 (1.1) | 37.8 (3.0) |
| >40.0 | 20.1 (3.2) | 6.5 (0.5) | 14.4 (2.3) | 29.0 (4.8) | 16.7 (1.9) | 6.5 (0.7) | 14.8 (1.6) | 30.3 (3.5) |

A portion of this study's data included overweight participants with a BMI of 27.1-29.9 with significant comorbidities (poorly controlled diabetes, hypertension, dyslipidemia, obstructive sleep apnea, etc.) that they believed would benefit from the IGB. This portion of the data does not fit the inclusion criteria of this literature review. Results excluding this data have been calculated by the writers of this paper and provided in parentheses in Table 10 within the discussion section.

**Study Critique**

Some strengths of this study included its exclusion criteria as they were reasonable in order to safely use individuals from the target population and to avoid any serious adverse effects for the patients, as well as to avoid any factors that could alter the results of the IGB treatment. Another strength of this study was the involvement of pharmacological therapy and dietitians to maximize the safety, tolerability and benefits of the IGB treatment. Patients were prescribed PPIs for the treatment period and scheduled to follow up monthly with the dietitians.

Some of the weaknesses include a disproportionately small number of male study participants. This makes it difficult to extrapolate results regarding obese and morbidly obese male patients. The study defined obesity as BMI > 27, which is not the most accepted definition per the American Medical Association or the World Health Organization; this makes comparing and extrapolating results somewhat difficult. Additionally, in the results section the researchers describe that one of the participants was excluded from data analysis because a psychiatric disorder was suspected after balloon insertion. This was also the only patient that gained weight during the study. Although the authors state that "results were reported if differences were found", it is not clear how many individuals were excluded and how many used in their research. In the results section, the authors only describe two different patients excluded from a previous total of 84, but for different reasoning: loss of measuring initial BMI in one individual and final weight loss in another. The lack of clarity regarding exclusion of participants undermines the validity of the analysis and results of the study.

**DISCUSSION**

The obesity epidemic in America is continuing to affect millions of Americans and is a major risk factor for many of the top preventable causes of death. Several studies regarding gastric bypass have ascertained that patients with lower baseline BMI see more weight loss success following the procedure

than those with higher baseline BMI.[15,16,17,18,19] Many obese and morbidly patients fail nutritional and pharmaceutical therapy, and may not be candidates for gastric bypass. Lopez-Nava etl al. describe that although bariatric surgery result in significant weight loss in obese patients, <1% of the population worldwide is eligible and able to receive the treatment. Intragastric balloon systems are a promising, minimally invasive strategy to significantly reduce BMI in obese patients. This would safely allow them to reach the parameters to ultimately receive bariatric surgery and therefore sustained weight loss and improvement of comorbid conditions. In addition to exploring the differences in weight loss in relation to baseline BMI, the studies included also reviewed other demographics such as age,gender, and the correlation of weight loss success with the use of intragastric balloons. Table 9 and 10 summarize the characteristics and findings of the systematically reviewed studies.

**Table 9**. Overview of Study Characteristics

| | **Study #1: Diab et al.** | **Study #2: Lopez-Nava et al.** | **Study #3: Lecumberri et al.** |
|---|---|---|---|
| **Study type** | Prospective Cohort | Case Control | Prospective Cohort |
| **Sample Size** | 184 | 60 | 84 |
| **Population** | Aged ≤ 30 years old and ≥ 50 years old with baseline BMI ≤ 35 kg/㎡ and ≥ 40 kg/㎡ | Aged 18 or older with BMI ≥ 30 kg/㎡ | Aged 18-70 Overweight with significant comorbidity and obese patients. |
| **Location** | Al Khalidi Medical Center in Amman, Jordan | Madrid Bariatric Endoscopic Unit of the Sanchinarro University Hospital in Madrid, Spain | Endocrinology and nutrition department of San Carlos University Hospital and endocrinology department of Santa Elena Clinic in Madrid, Spain |
| **Balloon Type** | Orbera; 600-650 cc saline and 10cc methylene blue solution | Dual Intragastric Balloon; each filled with 450cc saline/methylene blue solution | 700cc Air filled Heliosphere bag |
| **Loss to Follow-Up** | - | - | 2 patients were excluded due to weight or height data missing. 1 patient was found to have a psychiatric disorder affecting their weight and was removed from the study. |
| **Complications** | - | 1 early removal due to patient intolerance. 1 early deflation without | 1 surgical removed due to technical problems with endoscopic |

| | | | | | |
|---|---|---|---|---|---|
| | | migration or surgical removal.<br>1 gastric perforation.<br>14 gastric ulcers or erosions at time of removal, however clinically insignificant. | extraction.<br>2 spontaneous deflations without migrations. |

The primary endpoint of these studies was to determine safety and efficacy of the IGB. Secondary endpoints included analyzing for a difference in percentage of excessive weight loss and percentage of total body weight loss amongst two baseline BMI groups, and %EWL and %TBWL differences amongst gender and age. The results stratified into subgroups is provided below in Table 10.

**Table 10**. Overview of Study Results

| | Study #1: Diab et al. | | Study #2: Lopez-Nava et al. | | | Study #3: Lecumberri et al. | | |
|---|---|---|---|---|---|---|---|---|
| | %EWL | %TBWL | | %EWL | %TBWL | | %EWL | %TBWL |
| **Male, BMI <40** | 50.1±12.3 | 11.8±2.8 | **All participants** | 41.7± 26.72 | 15.4±7.95 | **All participants** | 33.2 (32.4) | 13.4 (12.8) |
| **Male, BMI ≥40** | 32.1±17.1 | 12.9±7.2 | **BMI <40, Total** | 52.27± 28.72 | 14.90±7.71 | **Male, BMI <40** | 30.7 | 11 |
| **Female, BMI <40** | 53.72± 22.3 | 12.63±5.5 | **BMI ≥40, Total** | 37.48± 19.72 | 16.46±8.47 | **Male, BMI ≥40** | 29 | 14.4 |
| **Female, BMI ≥ 40** | 32.5±16.7 | 13.2±6.4 | **Males, Total** | 30.92± 21.03 | 12.09±7.63 | **Female, BMI <40** | 35.8 (36.7) | 10.7 (12.8) |
| **Male, Age <40 years old** | 50.2±39 | 14.2± 4.7 | **Females, Total** | 50.73± 26.68 | 16.2± .89 | **Female, BMI ≥ 40** | 30.3 | 14.8 |
| **Male, Age > 40 years old** | 47±10 | 13.9±2.7 | **Age ≤40 years old** | 48.49± 26.72 | 15.56±8.01 | | | |
| **Female, Age < 40 years old** | 47.3±28 | 12.9±5.2 | **Age >40 years old** | 45.28± 27.13 | 15.31±8.02 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Female, Age >40 years old** | 38±22.5 | 11.9± 6.9 | | | | | | |

It is important to note that a portion of data provided by Lecumberri et al. included five overweight participants with a BMI of 25-29.9, making up 6.1% of the study sample size. These participants do not fit the inclusion criteria of this literature review; results excluding this data have been calculated by the writers of this paper and provided in parentheses in Table 10. The %EWL and %TBWL in women with BMI <40 as well as all participants overall differ minimally between this data excluded and included. Given the small sample distribution, the minimal differences in %EWL and %TBWL, and the ability to exclude the necessary data, the writers of this review found it adequate to utilize this study's results to compare IGB weight loss outcomes of lower versus higher baseline BMI participants.

Overall effectiveness and safety

The primary goal of each study was to confirm safety and efficacy of the IGB. Each study found generally similar effectiveness with overall significant weight loss achieved following IGB placements. %TBWL ranged from 12.8% to 16.46% and %EWL ranged from 29% to 53.72% across subgroups. As with other trials using gastric balloons, Lopez-Nava et al found that their trial with the IGB produced a greater %EWL compared to other trials using behavioral and/or pharmacological treatments alone. All three studies confirmed the EGB was a safe procedure, with minor side effects (nausea, gastric erosion, etc.) and infrequent events of balloon migration or need for early removal.

Baseline BMI

Each study had a secondary objective of analyzing whether baseline BMI, age, and gender played a role in weight loss outcomes. All three studies found that participants with lower baseline BMI had higher %EWL after six months post-treatment. Diab et al reported higher %EWL in lower baseline BMI participants across age and gender subgroups. Lopez-Nava et al reported %EWL was significantly higher on non-morbidly obese participants than the morbidly obese (50.7 vs 30.9%). Lecumberri et al reported that %EWL was higher in lower baseline BMI groups. Across the three studies, no difference was found in %TBWL between obesity grades.

Gender

Lecumberri et al found no statistical difference between men and women regarding all weight loss parameters. Similarly, Diab et al found that gender made no difference in %EWL and %TBWL. In contrast, Lopez-Nava et al had dissimilar results where women had higher %EWL compared to men (50.73 + 26.68 for women, and 30.92 + 21.03 for men). However, Lopez-Nava et al present a caveat where these results may be influenced by the lower number of men in their sample size and by the higher excess weight at baseline in the male participants. This variability in associations between gender and IGB weight loss outcomes across the studies is likely influenced by the uneven distribution of gender that occurred in all three study patient populations. Further studies involving IGBs that recruit more male participants are warranted to learn more about the influence of gender on IGB weight loss.

Age

Lecumberri et al found after adjusting for gender and initial BMI and excluding the outlier patient, all weight loss endpoints were inversely proportional to age. Alternatively, Diab et al stratified for gender

and age, and found that there was a significant effect of age in females, where women under age 40 had on average 47.34%EWL while older women had 38%EWL. There was no significant difference between %EWL based on the age of males in their study. Lopez-Nava et al found no statistically significant difference in %EWL between age groups.

While the three studies do not agree on age and weight loss correlations after IGB use, there are hypotheses that attempt to explain why age is considered a hindrance to achieving significant weight loss. Older patients typically have more comorbidities and decreased mobility compared to younger patients, making it difficult to lose and keep off excess weight.[23] Additionally, increasing age inversely correlates with energy requirements and lipolysis.[24]

As previously mentioned, studies on gastric bypass surgery have ascertained that younger patients with lower baseline BMI see more weight loss success following the procedure than those with higher baseline BMI.[15,16,17,18,19] However, these studies don't have similar conclusions regarding gender. Ma et al found that male gender is one of the predictors of higher %EWL with the RYGBP, whereas Melton et al found that weight loss is suboptimal following a RYGBP with male participants. Questions have emerged whether the influence of gender, age, and baseline BMI on gastric bypass weight loss outcomes would reflect similarly in IGB weight loss outcomes; this systematic review discovered that this is not the case.

Regarding the studies included in this review, Lopez-Nava et al did not make a formal conclusion in regard to age, gender, or baseline BMI and IGB weight loss outcomes, but overall their findings suggest no correlation. Conversely, Diab et al concluded that age (in females only) and baseline BMI can be used as predictors of weight loss outcome in patients treated with IGB. Lecumberri et al had a similar conclusion to Diab et al, where younger patients and lower baseline BMI patients had better weight loss outcomes. Finally, further studies are warranted to investigate the relationship of gender and weight loss outcomes in both IGBs and gastric bypass surgeries.

## CONCLUSION

*Clinical question: Didobese and morbidly obese patients aged 18-75 with a lower baseline BMI (BMI 30-39.9 kg/m2) who received an intragastric balloon (IGB), have a higher percentage of total body weight loss (%TBWL) and percentage of excess weight loss (%EWL) compared to those with a higher baseline BMI (BMI > 40 kg/m2)?*

There are various approaches to weight loss, each with favorable factors that lead to more successful management of obesity. As with gastric bypass surgery, this review found that a lower baseline BMI was similarly associated with greater weight loss following IGB placement. All three studies reviewed found those with lower baseline BMI had a higher %EWL than those with a higher baseline BMI. However, there was no significant difference in %TBWL. Additionally, the studies all concluded that IGB is a safe treatment for obese patients and is significantly more effective than behavioral modifications and/or pharmaceutical management alone. All three studies concluded that gender had little difference in weight loss outcomes, however there was variability in conclusions on age and baseline BMI. Further studies with larger, more proportionate sample sizes are required to determine the success of IGBs in relation to other factors such as age and gender.

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## REFERENCES


1. Williams EP, Mesidor M, Winters K, Dubert PM, Wyatt SB. Overweight and Obesity: Prevalence, Consequences, and Causes of a Growing Public Health Problem. *Curr Obes Rep* 4, 363–370 (2015).

2. Apovia CM. Obesity: Definition, Comorbidities, Causes, and Burden. American Journal of Medical Care. 2016; 22(7).

3. Finkelstein EA, Khavjou OA, Thompson H, et al. Obesity and severe obesity forecasts through 2030. *Am J Prev Med*. 2012;42(6):563-570. doi:10.1016/j.amepre.2011.10.026

4. Ward ZJ, Bleich SN, Cradock AL, et al. Projected U.S. State-Level Prevalence of Adult Obesity and Severe Obesity. *N Engl J Med*. 2019;381(25):2440-2450. doi:10.1056/NEJMsa1909301

5. Division of Nutrition, Physical Activity, and Obesity, National Center for Chronic Disease Prevention and Health Promotion, 2020. Defining Adult Overweight And Obesity | Overweight & Obesity | CDC. [online] Cdc.gov. Available at: <https://www.cdc.gov/obesity/adult/defining.html> [Accessed 1 December 2020].

6. Rolls BJ. The Supersizing of America: Portion Size and the Obesity Epidemic. *Nutr Today*. 2003;38(2):42-53. doi:10.1097/00017285-200303000-00004

7. CDC National Center for Health Statistics, 2020. Faststats. [online] Cdc.gov. Available at: <https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm> [Accessed 1 December 2020].

8. Schauer PR, Kashyap SR, Wolski K, et al. Bariatric surgery versus intensive medical therapy in obese patients with diabetes. N Engl J Med. 2012;366(17):1567–76.

9. O'Brien PE, Brennan L, Laurie C, Brown W. Intensive medical weight loss or laparoscopic adjustable gastric banding in the treatment of mild to moderate obesity: long-term follow-up of a prospective randomised trial. Obes Surg. 2013;23(9):1345-1353. doi:10.1007/s11695-013-0990-3

10. Cottam A, Cottam D, Zaveri H, et al. An Analysis of Mid-Term Complications, Weight Loss, and Type 2 Diabetes Resolution of Stomach Intestinal Pylorus-Sparing Surgery (SIPS) Versus Roux-En-Y Gastric Bypass (RYGB) with Three-Year Follow-Up. Obes Surg. 2018;28(9):2894-2902. doi:10.1007/s11695-018-3309-6

11. Kim SH, Chun HJ, Choi HS, Kim ES, Keum B, Jeen YT. Current status of intragastric balloon for obesity treatment. *World J Gastroenterol*. 2016;22(24):5495-5504. doi:10.3748/wjg.v22.i24.5495

12. Choi SJ, Choi HS. Various Intragastric Balloons Under Clinical Investigation. *Clin Endosc*. 2018;51(5):407-415. doi:10.5946/ce.2018.140

13. Velotti N, Bianco P, Bocchetti A, et al. Acute complications following endoscopic intragastric balloon insertion for treatment of morbid obesity in elderly patients. A single center experience. Minerva Chir. 2020;75(2):72-76. doi:10.23736/S0026-4733.18.07712-X

14. Imaz I, Martínez-Cervell C, García-Alvarez EE, Sendra-Gutiérrez JM, González-Enríquez J. Safety and effectiveness of the intragastric balloon for obesity. A meta-analysis. Obes Surg. 2008;18(7):841-846. doi:10.1007/s11695-007-9331-8

15. Contreras JE, Santander C, Court I, Bravo J. Correlation between age and weight loss after bariatric surgery. *Obes Surg*. 2013;23(8):1286-1289. doi:10.1007/s11695-013-0905-3

16. Sjøberg EJ, Andersen E, Hoel R, Reinertsen S, Søreide O. Gastric banding in the treatment of morbid obesity. Factors influencing immediate and long-term results. *Acta Chir Scand*. 1989;155(1):31-34.

17. Ma Y, Pagoto SL, Olendzki BC, et al. Predictors of weight status following laparoscopic gastric bypass. Obes Surg. 2006;16(9):1227-1231. doi:10.1381/096089206778392284

18. Lutfi R, Torquati A, Sekhar N, Richards WO. Predictors of success after laparoscopic gastric bypass: a multivariate analysis of socioeconomic factors. *Surg Endosc*. 2006;20(6):864-867. doi:10.1007/s00464-005-0115-8

19. Melton GB, Steele KE, Schweitzer MA, Lidor AO, Magnuson TH. Suboptimal weight loss after gastric bypass surgery: correlation of demographics, comorbidities, and insurance status with outcomes. J Gastrointest Surg. 2008;12(2):250-255. doi:10.1007/s11605-007-0427-1

20. Diab AF, Abdurasul EM, Diab FH. The Effect of Age, Gender, and Baseline BMI on Weight Loss Outcomes in Obese Patients Undergoing Intragastric Balloon Therapy. *Obes Surg*. 2019;29(11):3542-3546. doi:10.1007/s11695-019-04023-y

21. Lopez-Nava G, Bautista-Castaño I, Jimenez-Baños A, Fernandez-Corbelle, JP. Dual Intragastric Balloon: Single Ambulatory Center Spanish Experience with 60 Patients in Endoscopic Weight Loss Management. *OBES SURG* 25, 2263–2267 (2015). https://doi.org/10.1007/s11695-015-1715-6

22. Lecumberri E, Krekshi W, Matía P, Hermida, C, García de La Torre N, Cabrerizo L, Rubio MÁ, Effectiveness and Safety of Air-Filled Balloon Heliosphere BAG® in 82 Consecutive Obese Patients. *OBES SURG* 21, 1508–1512 (2011). https://doi.org/10.1007/s11695-010-0314-9

23. Giordano S, Victorzon M. Bariatric surgery in elderly patients: a systematic review. Clin Interv Aging. 2015;10:1627–35. https://doi.org/10.2147/CIA.S70313.

24. Blaak EE. Adrenergically stimulated fat utilization and ageing. Ann Med. 2000;32(6):380–2.