Published in final edited form as:

Int Urogynecol J. 2013 October ; 24(10): 1733–1738. doi:10.1007/s00192-013-2103-1.

The Effect of Obesity on Fecal Incontinence Symptom Distress, Quality of Life and Diagnostic Testing Measures in Women

David R. Ellington, MD¹, Michael R. Polin, MD¹, Jeff M. Szychowski, PhD², Luqin Deng, PhD³, and Holly E. Richter, PhD, MD¹

¹Division of Urogynecology and Pelvic Reconstructive Surgery, Department of Obstetrics and Gynecology, University of Alabama at Birmingham, Birmingham, AL

²Department of Biostatistics, University of Alabama at Birmingham, Birmingham, AL

³Department of Epidemiology, University of Alabama at Birmingham, Birmingham, AL

Abstract

Introduction and Hypothesis—Weight-loss has been demonstrated to result in an improvement in fecal incontinence (FI) severity; however, there is a paucity of data addressing differential impact of FI on quality of life (QOL) and results of diagnostic testing across BMI categories. We wished to evaluate symptom distress, QOL, and diagnostic testing parameters among normal, overweight, and obese women with fecal incontinence.

Methods—Women undergoing evaluation for FI between 2003 and 2012 were identified. Participants completed validated, symptom specific distress, impact, and general QOL measures including the Modified Manchester Questionnaire (MMHQ) which includes the Fecal Incontinence Severity Index (FISI), and the mental and physical component summary scores, MCS and PCS, respectively of the Short Form-12. Anorectal manometry measures were also included. Multivariable regression analyses were performed.

Results—Participants included 407 women with a mean age $\pm$ SD of 56 ± 13 . Multivariable analyses revealed no differences in symptom specific distress and impact as measured by MMHQ, MCS and PCS across BMI groups, however, obese women had increased resting and squeeze pressures compared to normal and overweight BMI women ($p < 0.0001$ and $p < 0.0001$; $p = 0.007$ and $p = 0.004$, respectively).

Conclusions—Obese women with FI did not have more general impact and symptom-specific distress and impact on quality of life as compared to normal and overweight women. Obese women with FI had higher baseline anal resting and squeeze pressures suggesting a lower threshold to leakage with pressure increases.

Corresponding Author: David R. Ellington MD, 1700 6th Avenue South, Suite 10382, Birmingham, AL 35233, Phone: (205) 934-7874, Fax: (205) 975-8893, dellington@uabmc.edu.

FINANCIAL DISCLAIMER/CONFLICT OF INTEREST: NONE

DR Ellington: Protocol/project development, data collection, manuscript writing/editing

MR Polin: Protocol/project development, data collection, manuscript writing/editing

JM Szychowski: Data analysis, manuscript writing/editing

L Deng: Data analysis

HE Richter: Protocol/project development, manuscript writing/editing

Presented as a non-oral poster at the 33rd Annual Scientific Meeting of the American Urogynecological Society, Chicago, Illinois, October, 2012

Keywords

anal manometry; fecal incontinence; obesity; quality of life; symptom distress

Introduction

Fecal incontinence (FI), as defined by the International Consultation on Incontinence, is the involuntary loss of flatus, liquid or solid stool that is a social or hygienic problem; anal incontinence is the involuntary loss of flatus [1]. These conditions affect both men and women, however, is seen more commonly in women. Depending upon the population in which it is studied and its definition, fecal incontinence prevalence rates vary between 2% and 10% [2–3]. Both patients and society are significantly impacted by FI. It negatively affects patients' quality of life (QOL) and results in embarrassment, social isolation and loss of self-esteem [4]. FI also represents a significant financial burden to the U.S. healthcare system and is the second leading cause of nursing home admissions [5, 6].

The etiology of FI is multifactorial resulting from direct sphincter injury, denervation of the anal sphincter and/or pelvic floor [7–9], changes in stool consistency, or a combination of these [10]. Risk factors for FI in women include vaginal delivery, obstetric trauma, increasing age, urinary incontinence, pelvic floor dysfunction, chronic diarrhea or loose stool, and disorders resulting in sensory impairment.

Diagnostic testing of FI in women includes the use of anorectal manometry, endoanal ultrasonography, pudendal nerve terminal motor latency, anal sensation, electromyography, ambulatory manometry, balloon expulsion test, defecography, and magnetic resonance imaging [11–12]. Anorectal manometry evaluates resting and squeeze sphincter pressures corresponding to the internal and external anal sphincter tone, respectively. It also measures the pressure/volume at first sensation (rectal sensory threshold), urgency to defecate (sensation of fullness), and maximum capacity (maximum tolerable volume) [11]. Anorectal manometry can play an important role in behavioral modification via biofeedback and muscle retraining in the treatment of FI. Endoanal ultrasonography allows for direct assessment of the anal sphincter anatomy to determine if a disruption is present that could be surgically repaired.

Obesity is a major public health issue in the United States. It is estimated that greater than 50% of women in the United States are overweight or obese and the prevalence of obesity is rising by 6% per year [13,14]. Obesity is a modifiable risk factor of FI [15–17]. Weight loss has been demonstrated to result in an improvement in both the number and severity of FI episodes [18–20]. However, there is a paucity of data addressing the true impact of FI on QOL and in understanding if there are differential findings of diagnostic testing in the obese as compared to normal body mass index (BMI) woman with FI.

The aim of this study was to characterize differences in symptom distress and impact on QOL as well as baseline anorectal diagnostic testing findings, specifically anal manometry, among normal, overweight, and obese women with FI/AI.

Materials and Methods

The study was a retrospective cohort design. After obtaining approval from the Institutional Review Board, women who underwent evaluation for FI at our institution between 2003 and 2012 were identified. Patients were included in the study if they had evidence of FI as demonstrated by a positive inquiry upon interview regarding incontinence of liquid or solid stool. In addition, women indicating any positive response to validated measures assessing

the presence of solid, liquid, or gas incontinence were included. Patients completed baseline anorectal manometry measures, resting sphincter tone, sphincter squeeze pressure, and rectal capacity, baseline endoanal ultrasonography, measuring whether the external or internal sphincters were intact, and validated intake questionnaires assessing symptom specific distress and impact on QOL. Patient's subjective evaluation included the Modified Manchester Questionnaire (MMHQ), which includes the Fecal Incontinence Severity Index (FISI), and the Short Form 12 (SF-12), which includes the Mental Component Summary Score (MCS) and Physical Component Summary Score (PCS) [21–22].

Participants were stratified into one of three groups based on the World Health Organization BMI classifications: normal weight (BMI <25 kg/m²), overweight (BMI ≥25 and <30 kg/m²), and obese (≥30 kg/m²) [23]. The primary aim was to evaluate the differences in patient symptom perception and impact on QOL among the three groups. The secondary aim was to evaluate the differences in baseline anorectal manometry measurements among BMI classifications as inferences regarding pathophysiology or mechanism may be made. Demographic and medical history data were collected on each patient including: age, race/ethnicity, smoking, hypertension, pulmonary disease, diabetes, prior colorectal surgery, hysterectomy, cholecystectomy, and history of sphincter disruption.

Patient characteristics were examined across the three BMI groups using one-way analysis of variance (ANOVA) for quantitative measures and chi-square tests of association for categorical measures. Both subjective and objective study outcomes were compared across the three BMI groups using one-way ANOVA. Multivariable regression analyses controlling for characteristics significantly differing across BMI groups, including race, history of medical co-morbidities, cholecystectomy, and anal sphincter disruption, were subsequently performed. All statistical tests were two-sided and because of multiple hypothesis testing were evaluated at a 0.01 level of significance. Statistical analyses were conducted using SAS version 9.2 (SAS Institute, Inc., Cary, NC).

Results

Four hundred seven women with evaluable data presenting for FI evaluation during the defined study period were included in this analysis: 160 obese, 123 overweight, and 124 normal BMI. Overall, patients were predominately Caucasian (85%), and had a mean age ± SD of 56 ± 13 years. The proportion of women with diabetes (p<0.001), hypertension (p<0.0001), pulmonary disease (p=0.003) and cholecystectomy (p<0.0001) differed significantly across all three BMI groups. Obese women had higher rates of diabetes, hypertension, respiratory disease, and cholecystectomy than non-obese women. The proportion of Caucasians differed across the BMI groups with fewer obese Caucasians than non-obese Caucasians (p = 0.001). There were no additional statistically significant differences in baseline characteristics among the three groups. (Table 1)

In univariate analyses, there were no significant differences among BMI groups in FI specific symptom distress or impact by baseline MMHQ and FISI score (Table 2). Significant differences were observed among BMI groups in both the MCS (p=0.002) and PCS (p<0.001) subscales of the SF-12. In multivariable analyses controlling for race, diabetes, cholecystectomy, hypertension, pulmonary disease, and anal sphincter disruption, there continued to be no difference in symptom specific distress and impact across BMI groups. Similarly, no differences were observed for the MCS or PCS subscale SF-12 scores (p=0.014 and p=0.246, respectively).

Significant differences were seen in both resting and squeeze pressures across the three BMI groups (p's < 0.0001) (Table 3). These differences in resting and squeeze pressures

remained significant ($p<0.0001$, $p=0.005$, respectively) in multivariable regression models adjusting for race, diabetes, sphincter disruption, cholecystectomy, hypertension and pulmonary disease. Variations in rectal capacity were not observed among BMI groups.

Discussion

As FI is such a devastating issue with resultant impact on quality of life, it was interesting to find no differential effect of symptom specific distress and impact among the three BMI cohorts as measured by the MMHQ and FIS. Given that obesity can have a significant impact on emotional and general health, it was also surprising to observe no differences between PCS and MCS subscales of the SF-12 among the three BMI cohorts after controlling for other known medical comorbidities associated with obesity.

BMI is a known modifiable risk factor of FI and therefore, it is unclear why differences were not seen in symptom distress severity across the three cohorts. Several studies have investigated the effect that non-surgical and surgical weight loss and have demonstrated that FI symptom improvement occurs with weight loss [19, 24]. This would infer that we may have seen a difference in symptom distress severity among our BMI cohorts. However, it may be that this improvement in symptoms is a result of the change in a patient's BMI and not a patient's BMI category. Thus, comparing our cohorts and the symptom distress that those respective patients experienced at a singular point in time may not be expected to mirror the results of studies that evaluated change in symptom distress with concomitant change in BMI over time.

Initially, univariate analysis of obese women with FI did reflect worse general mental and physical impact on quality of life; however, this effect was nullified for both the MCS and PCS scores in multivariable regression models adjusting for race, diabetes, sphincter disruption, cholecystectomy, hypertension, and pulmonary co-morbidities. Though not statistically significant at a 0.01 level of significance in the regression model, the effect of BMI class on MCS scores trended toward statistical significance ($p=0.014$) with covariate-adjusted MCS means decreased with increasing BMI. In looking at SF-12 scores from a sampling of the general US population where normal MCS and PCS scores are 50, those with serious physical conditions had a mean PCS and MCS of 38.75 ± 1.0 and 52.51 ± 0.8 , respectively [25, 26]. Our study population demonstrated overall lower scores on both the PCS and MCS subscales as compared to the normal population, 41.2 ± 11.7 and 42.1 ± 12.0 , respectively. It is not surprising that co-morbid conditions alone lower PCS and MCS scores in this population of women, and clearly when controlling for these variables among this study population, the impact of obesity on fecal incontinence symptoms distress and quality of life is diminished. One study noted that patients with congestive heart failure, widely considered a significant chronic medical condition, had a mean PCS and MCS of 31.5 ± 8.8 and 46.7 ± 11.2 , respectively. This same study revealed patients with chronic wounds had mean PCS and MCS of 39.5 ± 10.9 and 50.6 ± 10.2 , respectively. Other medical conditions, including renal failure, heart failure, multiple sclerosis, and osteoarthritis noted a trend of lower PCS scores, but not MCS scores [27]. The trend of lower MCS scores in this study was interesting, as perhaps this potential impact that FI has on patient's mental quality of life is a result of the limitations that this condition places on their social life and other areas associated with generalized mental contentment; however, it has been previously reported that higher BMI alone was associated with lower PCS subscale scores, but not MCS subscale scores [28].

Diagnostic testing with anal manometry showed that obese women with fecal incontinence had higher baseline anal resting tone and squeeze pressures as compared to normal women. This variation in anal manometry measures persisted when controlling for race, diabetes

status, hypertension, pulmonary disease, history of cholecystectomy, and whether the patient had an intact or disrupted anal sphincter. The mechanism behind this observation is unclear and data addressing this issue is scarce.

However, there have been studies that have looked at the impact obesity has on the evaluation of the urinary sphincter. One such study showed that obese women report worse symptom distress and quality of life despite better urethral function on baseline urodynamics [29]. The authors in that study suggested that while obese women had higher leak point pressures, they also had higher resting pressures. This may reflect a decreased threshold to leak. The authors attributed this finding to Henneman's principle, postulating that the higher resting tone required more muscle fiber recruitment to maintain resting pressure [30]. As a result, there were less motor units available to recruit to prevent urinary leakage. Though considered a potential theory, an analogous situation may be seen here as an explanation for the variation in anorectal manometry measurements, however, further studies to help further understand the pathophysiology are needed.

This study has inherent limitations due to its retrospective design, however, all participants completed questionnaires on their own as a part of general clinic intake and standardized protocols were performed with the diagnostic testing. The data presented represents the responses of women with fecal incontinence within each of the three BMI groups upon their respective presentation for evaluation thus conclusions regarding how changes in BMI affect fecal incontinence symptom impact, distress, and patient quality of life overtime cannot be generated. Furthermore, the main statistical limitation is of multiple hypothesis testing, however, we defined statistical significance at the 0.01 level and modeled at the association of symptoms and diagnostic testing variables and BMI held controlling for confounders. Strengths of this study include a large study population with robust clinico-demographic characterization. A spectrum of validated measures were utilized to characterize both symptom specific and general impact on quality of life. Finally, the clinical question is particularly pertinent with the markedly increasing prevalence of obesity world-wide.

Due to the significant impact FI has on quality of life and the current limitations with regard to long term treatment success for FI, it is imperative that more robust prospective studies are pursued to improve our understanding of the pathophysiology of FI in obese women. A better understanding of variations in diagnostic evaluation and treatment approaches of FI in obese women including weight loss, may impact management of this complex condition.

Acknowledgments

Partially funded by the National Institutes of Diabetes and Digestive and Kidney Diseases 2K24-DK068389

Funding:

Partially supported by the National Institute of Diabetes and Digestive and Kidney Diseases to HER 2K24-DK068389.

References

1. Norton, C.; Whitehead, W.; Bliss, DZ.; Harari, D.; Lang, J. Conservative and Pharmacological Management of Faecal Incontinence in Adults. In: Abrams, P.; Cardozo, L.; Khoury, S.; Wein, A., editors. Incontinence. Paris, France: Health Publication Ltd; 2009. p. 1343
2. Nelson RL, et al. Epidemiology of fecal incontinence. *Gastroenterology*. 2004; 126:3–7. [PubMed: 14699475]
3. Quander CR, Morris MC, Melson J, et al. Prevalence of and factors associated with fecal incontinence in a large community study of older individuals. *Am J Gastroenterol*. 2005; 100:905–9. [PubMed: 15784039]

4. Sailer M, Bussen D, Debus ES, et al. Quality of life in patients with benign anorectal disorders. *Br J Surg.* 1998; 85:1716–9. [PubMed: 9876082]
5. Johansson JK, Lafferty J, et al. Epidemiology of fecal incontinence: The silent affliction. *Am J Gastroenterol.* 1996; 91:33–6. [PubMed: 8561140]
6. Szurszewski JH, Holt PR, Schuster MM, et al. Proceedings of a workshop entitled Neuromuscular function and dysfunction of the gastrointestinal tract. *Dig Dis Sci.* 1989; 34:1135–46. [PubMed: 2545427]
7. Bharucha A, et al. Fecal incontinence. *Gastroenterology.* 2003; 124:1672–85. [PubMed: 12761725]
8. Sultan AH, Kamm MA, Hudson CN, et al. Anal sphincter disruption during vaginal delivery. *N Engl J Med.* 1993; 329:1905–1911. [PubMed: 8247054]
9. Snooks SJ, Henry MM, Swash M, et al. Faecal incontinence due to external sphincter division in childbirth is associated with damage to the innervation of the pelvic floor musculature. *Br J Obstet Gynaecol.* 1985; 92:824–828. [PubMed: 4027205]
10. Madoff RD, Parker SC, Varma MG, et al. Faecal incontinence in adults. *Lancet.* 2004; 364:621–32. [PubMed: 15313364]
11. Giordano P, Wexner SD, et al. The assessment of fecal incontinence in women. *J Am Coll Surg.* 2001; 193(4):397–406. [PubMed: 11584968]
12. Rao SC, et al. Diagnosis and management of fecal incontinence. American College of Gastroenterology Practice Parameters Committee. *Am J Gastroenterol.* 2004; 99:1585–1604. [PubMed: 15307881]
13. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity related health risk factors, 2001. *JAMA.* 2003; 289:76–9. [PubMed: 12503980]
14. Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA.* 2006; 295:1549–55. [PubMed: 16595758]
15. Melville JL, Fan MY, Newton K, et al. Fecal incontinence in US women: a population-based study. *Am J Obstet Gynecol.* 2005; 193:2071–6. [PubMed: 16325618]
16. Erekson EA, Sung VW, Myers DL, et al. Effect of body mass index on the risk of anal incontinence and defecatory dysfunction in women. *Am J Obstet Gynecol.* 2008; 198:596e1–4. [PubMed: 18455543]
17. Altman D, Falconer C, Rossner S, et al. The risk of anal incontinence in obese women. *Int Urogynecol J Pelvic Floor Dysfunct.* 2007; 18:1283. [PubMed: 17356799]
18. Cuicchi D, Lombardi R, Cariani S, Leuratti L, Lecce F, Cola B, et al. Clinical and instrumental evaluation of pelvic floor disorders before and after bariatric surgery in obese women. *Surg Obes Relat Dis.* 2013; 9:69–76. [PubMed: 21978747]
19. Burgio KL, Richter HE, Clements RH, Redden DT, Goode PS. Changes in urinary and fecal incontinence symptoms with weight loss surgery in morbidly obese women. *Obstet Gynecol.* 2007; 110:1034–40. [PubMed: 17978117]
20. Sileri P, Franceshilli L, Cadeddu F, De Luca E, D'Ugo S, Tognoni V, Camperchiolo I, Benavoli D, Di Lorenzo N, Gaspari AL, Gentileschi P. Prevalence of defaecatory disorders in morbidly obese patients before and after bariatric surgery. *J Gastrointest Surg.* 2012; 16:62–6. discussion 66–67. [PubMed: 21948149]
21. Kwon S, Visco AG, Fitzgerald MP, Ye W, Whitehead WE. Pelvic Floor Disorders Network (PFDN) Validity and reliability of the Modified Manchester Health Questionnaire in assessing patients with fecal incontinence. *Dis Colon Rectum.* 2005 Feb;48:323–31. 331–4. [PubMed: 15616750]
22. Luo X, Lynn GM, Kakouras I, Edwards CL, Pietrobon R, Richardson W, Hey L. Reliability, validity, and responsiveness of the short form 12-item survey (SF-12) in patients with back pain. *Spine.* 2003; 28:1739–45. [PubMed: 12897502]
23. BMI Classification. Global Database on Body Mass Index. WHO; 2006. Retrieved October 18, 2012
24. Markland AD, Richter HE, Burgio KL, Myers DL, Hernandez AL, Subak LL. Weight loss improves fecal incontinence severity in overweight and obese women with urinary incontinence. *Int Urogynecol J.* 2011; 22:1151–1157. [PubMed: 21567259]

25. Ware JE Jr, Kosinski M, Keller SD. A 12-item short-form health survey: Construction of scales and preliminary tests of reliability and validity. *Med Care*. 1996; 34:220–233. [PubMed: 8628042]
26. Tarlov AR, Ware JE, Greenfield S, et al. The medical outcomes study: An application of methods for monitoring the results of medical care. *J Am Med Assoc*. 1989; 262:925.
27. Hopman WM, Harrison MB, Coe H, et al. Associations between chronic disease, age, and physical and mental health status. *Chronic Disease in Canada*. 2009; 29:108–16.
28. Wee CC, Davis RB, Hamel MB, et al. Comparing the SF-12 and SF-36 health status questionnaires in patients with and without obesity. *Health Qual Life Outcomes*. 2008; 6:11–18. [PubMed: 18234099]
29. Richter HE, Kenton K, Huang L, Nygaard I, Kraus S, Whitcomb E, Chai TC, Lemack G, Sirls L, Dandreo KJ, Stoddard A. The impact of obesity on urinary incontinence symptoms, severity, urodynamic characteristics and quality of life. *J Urol*. 2010; 183:622–8. [PubMed: 20018326]
30. Henneman E, Somjen G, Carpenter DO. Excitability and inhibitability of motoneurons of different sizes. *J Neurophysiol*. 1965; 28:599–620. [PubMed: 5835487]

Brief Summary

Although no differences in general impact and FI symptom distress and impact across BMI groups, obese women exhibited higher resting and squeeze pressures on anal manometry testing.

Table 1

Patient demographics

Characteristic	Overall (n = 407)	Normal (n = 124)	Overweight (n = 123)	Obese (n = 160)	p
Age	56.4 ±13.4	57.7 ±15.0	55.7 ±14.3	56.0 ±11.4	0.444
Race					0.001
Caucasian/White	346(85%)	117(94%)	103(84%)	126(79%)	
AA/Other	61(15%)	7(6%)	20(16%)	34(21%)	
Smoking	64(16%)	17(14%)	18(15%)	29(18%)	0.553
Diabetes	78(19%)	12(10%)	21(17%)	45(28%)	<0.001
Prior Colorectal Surgery	54(13%)	17(31%)	20(16%)	17(11%)	0.377
Hysterectomy	278(68%)	85(69%)	79(64%)	114(71%)	0.452
Cholecystectomy	127(31%)	29(23%)	30(24%)	68(43%)	<0.001
Sphincter disruption	124(30%)	37(30%)	45(37%)	42(26%)	0.170
Hypertension	187(46%)	38(31%)	52(42%)	97(61%)	<0.0001
Pulmonary Disease	91(22%)	17(14%)	25(20%)	49(31%)	0.003

Table 2

Baseline Symptoms Specific and General Quality of Life Measures (unadjusted)

Characteristic	Overall (n = 272)	Normal (n = 85)	Overweight (n = 83)	Obese (n = 104)	p
MMHQ	48.0 ± 24.3	45.1 ± 25.5	49.1 ± 24.5	49.4 ± 23.0	0.425 [‡]
FISI	Overall (n = 356) 28.8 ± 13.1	Normal (n = 110) 27.5 ± 12.7	Overweight (n = 108) 31.1 ± 11.7	Obese (n = 138) 28.1 ± 14.3	0.090 ^{‡‡}
SF-12 MCS *	Overall (n = 361) 42.1 ± 12.0	Normal (n = 110) 45.3 ± 11.6	Overweight (n = 111) 41.6 ± 12.5	Obese (n = 140) 40.0 ± 11.5	0.002 [‡]
SF-12 PCS **	Overall (n = 361) 41.2 ± 11.7	Normal (n = 110) 43.7 ± 12.2	Overweight (n = 111) 42.4 ± 11.3	Obese (n = 140) 38.3 ± 11.2	<0.001 ^{‡‡}

* Obese is significantly lower than Normal (p<0.0001) but not Overweight (p=0.283).

** Obese is significantly lower than both Normal (p<0.0001) and Overweight (p=0.0006).

[‡] Effect remains non-significant (p=0.611) in multivariable regression models adjusting for race, diabetes, sphincter disruption, and cholecystectomy.^{‡‡} Effect remains non-significant (p=0.083) in multivariable regression models adjusting for race, diabetes, sphincter disruption, and cholecystectomy.[‡] Effect is nullified (p=0.014) in multivariable regression models adjusting for race, diabetes, sphincter disruption, cholecystectomy, hypertension and pulmonary comorbidity.^{‡‡} Effect is nullified (p=0.246) in multivariable regression models adjusting for race, diabetes, sphincter disruption, cholecystectomy, hypertension and pulmonary comorbidity.

Table 3

Anal Manometry Parameters (unadjusted)

Characteristic	Overall (n = 407)	Normal (n = 124)	Overweight (n = 123)	Obese (n = 160)	p
Resting Pressure* mmHg	36.2 ± 19.6	31.2 ± 18.1	32.5 ± 17.1	43.0 ± 20.6	<0.0001 [‡]
Squeeze Pressure** mmHg	74.0 ± 36.5	68.0 ± 32.3	67.6 ± 31.5	83.6 ± 41.0	<0.0001 ^{‡‡}
Capacity Cc	114.9 ± 55.0	104.3 ± 46.9	117.5 ± 59.5	121.1 ± 56.4	0.031 [‡]

* Obese is significantly greater than both Overweight (p<0.0001) and Normal (p<0.0001).

** Obese is significantly greater than both Overweight (p<0.001) and Normal (p<0.001).

[‡] Effect remains significant (p<0.0001) in multivariable regression models adjusting for race, diabetes, sphincter disruption, cholecystectomy, hypertension and pulmonary co-morbidity. Obese is significantly greater than both Overweight (p<0.0001) and Normal (p<0.0001).

^{‡‡} Effect remains significant (p=0.005) in multivariable regression models adjusting for race, diabetes, sphincter disruption, cholecystectomy, hypertension and pulmonary co-morbidity. Obese is significantly greater than both Overweight (p=0.004) and Normal (p=0.007).

[‡] Effect remains non-significant (p=0.062) in multivariable regression models adjusting for race, diabetes, sphincter disruption, cholecystectomy, hypertension and pulmonary co-morbidity.