Published in final edited form as:

Obes Surg. 2011 April ; 21(4): 457–464. doi:10.1007/s11695-010-0261-5.

Cardiorespiratory Fitness and Health-Related Quality of Life in Bariatric Surgery Patients

Ronette L. Kolotkin^{*,1,2}, Michael J. LaMonte³, Sheldon Litwin⁴, Ross D. Crosby^{5,6}, Richard E. Gress⁴, Frank G. Yanowitz⁷, Steven C. Hunt⁴, and Ted D. Adams^{4,7}

¹Obesity and Quality of Life Consulting, 762 Ninth Street #563, Durham, NC 27705, USA

²Department of Community and Family Medicine, Duke University Medical Center, 318 Hanes House; Box 2914, Durham, NC 27710, USA

³Department of Social and Preventive Medicine, State University of New York at Buffalo, 272 Farber Hall, 3435 Main St. Buffalo, NY 14214, USA

⁴Cardiovascular Genetics Division, Department of Internal Medicine, University of Utah, 420 Chipeta Way, Room 1160, Salt Lake City, UT, 84108, USA

⁵Neuropsychiatric Research Institute, 120 Eighth Street South, P.O. Box 1415, Fargo, ND 58107, USA

⁶University of North Dakota School of Medicine and Health Sciences, 1919 Elm Street North, Room 118, Fargo, ND 58102, USA

⁷The Health and Fitness Institute, LDS Hospital, Intermountain Healthcare, 8th Avenue and C Street, Salt Lake City, UT, 84143, USA

Abstract

Background—Health-Related Quality of Life (HRQOL) is impaired in severely obese individuals presenting for bariatric surgery. Little is known about the relationship between cardiorespiratory fitness (CRF) and HRQOL in these individuals. We hypothesized that better HRQOL would be reported by those with higher CRF.

Methods—In 326 gastric bypass patients (mean BMI = 46.5 ± 7.0 ; mean age = 40.9 ± 10.1 ; 83.4 % female), pre-surgical CRF was quantified as duration (minutes) of a submaximal treadmill test to 80% of age-predicted maximal heart rate (MHR). Patients completed both a general measure of HRQOL [the Medical Outcome Short-Form 36 (SF-36)] and a weight-specific measure of HRQOL [Impact of Weight on Quality of Life-Lite (IWQOL-Lite)]. Mean HRQOL scores were examined, controlling for age, gender, and BMI.

Results—Mean treadmill duration was 9.9 ± 3.1 minutes, and percent age-predicted MHR was 81.2 ± 3.0 percent. Higher cardiorespiratory fitness tended to be associated with better physical and weight-specific HRQOL. Adjustment for differences in gender, age, and BMI attenuated the significance of associations between fitness and physical measures from the SF-36, whereas adjustment eliminated significance of associations between fitness and weight-specific HRQOL in most cases.

*Corresponding author: Ronette L. Kolotkin, Ph.D., Obesity and Quality of Life Consulting; 762 Ninth Street #563, Durham, NC 27705; telephone: (919) 493-9995; fax: (919) 493-9925; rkolotkin@qualityoflifeconsulting.com.

Disclosures: Dr. Kolotkin received consulting fees from University of Utah for her participation in this NIH-funded study. She also receives royalties from Duke University for the use of the IWQOL-Lite.

Conclusions—Results suggest that CRF confers some HRQOL benefits in severely obese adults, though these benefits may largely be explained by differences in age, gender, and BMI.

Keywords

cardiorespiratory fitness; health-related quality of life; IWQOL-Lite; SF-36; gastric bypass surgery; treadmill test

Introduction

Numerous studies have found decreased health-related quality of life (HRQOL) in bariatric surgery patients relative to general population norms [1-4]. Similarly, bariatric surgery patients have reported reduced HRQOL compared to obese individuals who seek non-surgical weight loss interventions as well as those who do not seek any weight loss treatment [5-7].

A variety of factors have been shown to influence HRQOL in obese persons, including presence of comorbid conditions [8, 9], pain [2, 10], depression [2], binge eating disorder [11, 12], and gender (with women showing greater impairments than men) [13]. Other factors may also influence HRQOL, such as cardiorespiratory fitness.

Cardiorespiratory fitness (CRF) has been associated with better health-related quality of life among adults in the general population [14, 15] and in various patient groups such as persons with diabetes [16] and individuals undergoing liver transplants [17]. Higher doses of exercise have also been associated with larger improvements in HRQOL in a trial of overweight and obese participants [18]. Little is known about the relationship between cardiorespiratory fitness and HRQOL in individuals undergoing bariatric surgery. The purpose of this study was to examine the association between cardiorespiratory fitness and HRQOL in bariatric surgery patients, hypothesizing that higher fitness levels would be associated with better HRQOL in these individuals.

Methods

Participants

Study participants were recruited between March, 2001, and May, 2004 as part of the Utah Obesity Study [19], a prospective study of gastric bypass surgery patients. Exclusion criteria for the original study included: previous gastric surgery for weight loss; gastric or duodenal ulcers in the previous six months; active cancer, with the exception of non-melanoma skin cancer, within the past five years; myocardial infarction in the previous six months; and abuse of alcohol or narcotics. Data for the present study were based on 326 patients who had complete data on both measures of HRQOL (described below) and were not taking medications (e.g. beta blockers, non-dihydropyridine calcium channel blockers) that would alter their heart rate response to exercise. No changes to medications were made as a result of study participation.

This study was approved by the University of Utah IRB, and informed consent was obtained for all participants. All research was conducted in compliance with the Helsinki Declaration.

Procedures

Health-Related Quality of Life Assessment—Participants completed both a weight-specific measure of HRQOL (Impact of Weight on Quality of Life-Lite [IWQOL-Lite]) and a general measure of HRQOL (Medical Outcomes Study Short Form Health Survey (SF-36, Version 2.0).

The 31-item, weight-specific IWQOL-Lite assesses the perceived impact of weight on quality of life. Due to the weight-specific nature of this instrument, most of the items begin with the phrase, “Because of my weight.” The IWQOL-Lite provides a total score composed of scores on five domains (Physical Function, Self-Esteem, Sexual Life, Public Distress, and Work), as well as separate scores for each of these domains [20]. In previous studies the IWQOL-Lite has been shown to have good internal consistency [20], good test-retest reliability [21], and a scale structure supported by confirmatory factor analysis [20]. Scores are transformed to a 0 to 100 scale, where 100 represents the best HRQOL.

The SF-36 is a widely used and psychometrically sound survey instrument that provides a general assessment of the perceived impact of health on quality of life [22]. The SF-36 contains eight domains, four of which assess the physical aspects of HRQOL (Physical Functioning, Role Physical, Bodily Pain, and General Health) and four of which assess the mental aspects of HRQOL (Vitality, Social Functioning, Role Emotional, and Mental Health). There is also a Physical Component Summary score (PCS) based on the first four domains and a Mental Component Summary (MCS) based on the last four domains. Scores are transformed to a 0 to 100 scale, where 100 represents the best HRQOL.

Although there are similar domains included on each of the two instruments (e.g., physical function), the degree to which shared domains are correlated with a specified predictor variable may differ between instruments due to differences in item wording and the instrument’s context (e.g., general assessment versus weight-specific assessment). A previous one-year weight loss trial that included both the SF-36 and IWQOL-Lite found greater improvements on the IWQOL-Lite than the SF-36 and closer correspondence between weight loss and the IWQOL-Lite than the SF-36 (but inconsistent findings with respect to weight gain) [23].

Cardiorespiratory Fitness Assessment—Cardiorespiratory fitness was assessed by treadmill exercise duration using a submaximal exercise test protocol. Although the gold standard measure of cardiorespiratory fitness is based on respiratory gas analysis during maximal exertion [24], the study investigators opted for submaximal testing (using a modified Bruce protocol) to avoid potential harm or discomfort that may be incurred during maximal exercise testing in patients whose functional capacity is limited by deconditioning or existing disease [19]. This type of submaximal exercise testing protocol is highly correlated with laboratory measures of maximal cardiorespiratory fitness that use respiratory gas analysis [24]. The submaximal test was composed of three-minute exercise stages beginning at a speed of 26.8 meters per minute (1.0 miles per hour) on a level surface. Increases in the treadmill speed, grade, or both occurred every three minutes. The test endpoint was an exercise heart response of at least 80% of age predicted maximal heart rate (220-age). We are aware that there are limitations to exercise testing using heart response endpoints, principally when used to predict maximal oxygen uptake from observed heart responses or when used for individual exercise prescription [24]. However, using exercise duration to achieve a defined submaximal heart rate response, as in our study, is often used in epidemiologic investigations to broadly categorize group fitness levels [25, 26], including studies on HRQOL [14]. Exercise testing was conducted by an exercise test technologist with a cardiologist in close proximity and was completed in accord with current clinical guidelines [24]. Participants were encouraged to use the handrails only for balance and not to support their body weight during the test. Heart rate, blood pressure, ratings of perceived exertion (RPE) using the 6-20 point Borg scale [24], and a standard 12-lead electrocardiogram were monitored during the exercise and recovery periods.

Statistical Analyses—The distribution of continuous variables was examined using univariate plots (e.g., histograms) and statistics (e.g., skewness and kurtosis). No major

departures from normality were observed. We examined the relationship between fitness and HRQOL using two approaches. To gain a sense of the overall relationship between fitness and HRQOL, we constructed scatterplots and computed Pearson Product-Moment correlations between treadmill exercise duration and the summary scores for the SF-36 (Physical Component Summary, Mental Component Summary) and for the IWQOL-Lite (total score). We used general linear models to compare mean values for each of the HRQOL scale scores across tertiles of treadmill exercise duration (<8.8, 8.8-11.7, >11.7 minutes). The tertile cut-off values were defined from the sample distribution of treadmill exercise duration, as clinically relevant fitness levels for severely obese adults are presently unavailable. Tests of linear trends for mean values of HRQOL scores across categories of fitness were conducted by entering the fitness variable into the model as an ordinal term. Analyses were conducted separately for each of the HRQOL scale scores and summary scores. Analyses were performed with and without selected covariables (gender, age, BMI) that might influence the relationship between fitness and HRQOL. Since differences in effort during the exercise test could possibly influence the relationships between fitness and HRQOL scores, we repeated the analyses further adjusting for maximal heart rate and RPE achieved during the exercise test. Due to potential concerns that categorization of exercise duration may result in a loss of statistical power or create residual confounding [27], additional linear multivariate analyses were conducted using fitness as a continuous variable to predict HRQOL scores with and without the covariates described above. Analyses were conducted using SAS software version 9.2 (SAS Institute, Cary, NC) and reported p-values are for two-sided hypothesis tests at an alpha level of 0.05.

Results

The present sample consisted of 326 adults (83.4% women) whose mean $\pm$ SD values for age and BMI was 40.9 ± 10.1 years (range 19-71) and 46.5 ± 7.0 kg/m² (range 33-72), respectively. The mean treadmill test duration to achieve at least 80% of age-predicted maximal heart rate was 9.9 ± 3.1 minutes (range 2-17) and the mean percentage of age-predicted maximal heart rate at the time exercise tests were stopped was $81.2 \pm 3.0\%$ (range 80-96).

Scatterplots and unadjusted Pearson correlations between treadmill exercise duration and the summary scores for each HRQOL instrument are shown in Figures 1a-1c. Higher fitness levels were associated with better weight-specific and physical HRQOL, but poorer mental HRQOL. Significant positive correlations were seen between treadmill exercise duration and both the IWQOL-Lite total score ($r = 0.21$, $p < 0.001$) and the SF-36 physical component summary score ($r = 0.39$, $p < 0.001$). A significant negative correlation was seen between treadmill duration and the SF-36 Mental Component Summary score ($r = -0.19$, $p < 0.001$).

Table 1 shows mean values for scale and summary scores on each HRQOL instrument according to tertile of treadmill exercise duration. In unadjusted analyses, mean values for each of the IWQOL-Lite scores were significantly higher across incremental fitness categories (linear trend, $P = 0.05$) with the exception of Self-Esteem, which was not related to fitness ($P = 0.79$). After adjusting for differences in gender, age, and BMI, the relationships between fitness and IWQOL-Lite scores no longer were significant.

The relationships between SF-36 HRQOL scores and fitness tertiles (Table 1) were less consistent than those seen for the IWQOL-Lite scores. In unadjusted analyses, higher mean values for SF-36 scores across incremental fitness categories were observed for most of the physical aspects of HRQOL: Physical Functioning, Role Physical, and Bodily Pain items, as well as for the Physical Component Summary score (linear trend, $P = 0.001$). No significant trends across fitness categories were seen in mean scores for vitality, social functioning, role

emotional, and mental health. However, significantly lower mean values for the Mental Component Summary score were seen across higher fitness levels ($P = 0.007$). Relationships between fitness and SF-36 scales remained significant after adjustment for age, gender and BMI, except for Bodily Pain ($P = 0.07$) and the Mental Component Summary score ($P = 0.44$). Adjusting for maximal heart rate and RPE achieved during the exercise test did not change the results presented in Table 1 (data not shown).

Table 2 presents results of linear regression analyses of the IWQOL-Lite and SF-36 on continuous exercise duration, reporting both unadjusted and adjusted (for age, gender, and BMI) models. Results using exercise as a continuous variable are generally consistent with results when exercise duration is treated categorically. In the unadjusted model total score and four out of five IWQOL-Lite scales are statistically significant (all except Self-Esteem). After adjusting for age, gender, and BMI, total score and Public Distress remain significant, a finding that differs from categorical analyses. Four of the eight SF-36 scales (Physical Functioning, Role Physical, Bodily Pain, and Mental Health), as well as the Physical and Mental Component Summary scores are statistically significant. In the model adjusting for age, gender, and BMI, three of the SF-36 scales remain significant (Physical Functioning, Role Physical, and Bodily Pain), as well as the Physical Component Summary score.

Discussion

In this sample of severely obese gastric bypass surgical candidates, higher cardiorespiratory fitness, as assessed by submaximal exercise test duration, tended to be associated with better physical and weight-specific HRQOL. Adjustment for differences in gender, age, and BMI attenuated the significance of associations between fitness and physical measures from the SF-36, whereas adjustment eliminated significance of associations between fitness and weight-specific HRQOL in most cases. Overall, these results suggest that higher fitness confers some HRQOL benefits in severely obese adults but these benefits are largely explained by differences in age, gender, and BMI among study participants.

Other studies also have reported on the relationship between fitness and HRQOL in adults. Using submaximal treadmill testing and the Physical and Mental Components Summary scores (PCS and MCS) from a modified SF-36 instrument (SF-12), Sloan et al. [14] examined this association in apparently healthy U.S. Naval servicemen (mean age = 32; BMI = 29 kg/m²). After adjustment for age, BMI, and other covariables, odds ratios for HRQOL scores ≥ 50 (e.g., higher HRQOL) on PCS were 2-fold higher, and on MCS were 4-fold higher among men in the highest compared to the lowest quartile of fitness.

Using maximal treadmill exercise testing, Galper et al. [15] examined associations between cardiorespiratory fitness and two components of HRQOL, depressive symptoms and emotional well-being, in adults (mean BMI = 26 kg/m², ages 20-88) undergoing a wellness examination. After adjustment for age and BMI, there was a significant dose-response for lower mean scores of depressive symptoms, and significantly higher means scores of emotional well-being, across incremental tertiles of cardiorespiratory fitness.

Rejeski et al. [16] reported a significant interaction effect of fitness (using maximal treadmill exercise testing) and BMI on HRQOL (PCS from SF-36 and Beck Depression scores) in overweight and obese adults, ages 45-74 years, with type 2 diabetes mellitus. When participants were grouped into BMI-defined categories of overweight/obesity, the adverse effect of obesity on HRQOL was significantly more marked in participants with low fitness, whereas it was ameliorated in those with higher fitness.

Our findings are broadly consistent with those from the studies discussed above. As reported by Sloan et al. [14] and Rejeski et al. [16], higher fitness is associated with better physical

HRQOL scores, even after accounting for the influence of age, gender, and BMI. To our knowledge, the findings from our study and those reported by Rejeski et al. are the only published data relating objectively assessed cardiorespiratory fitness with HRQOL in severely obese adults. Contrary to previously reported findings [14-16], we did not observe a significant favorable association between fitness and mental HRQOL. This may owe, in part, to differences between studies in the instruments used to assess mental HRQOL, the approaches to data analysis, the type of exercise testing (e.g. submaximal versus maximal) used to assess fitness, or chance differences between study populations. Collectively, available published data, including those reported in the present study, suggest that higher fitness levels seem to confer positive HRQOL benefits in a variety of adult populations, but may also dampen the adverse effect of obesity on HRQOL among adults. Additional studies using standardized assessment protocols are needed to clarify and expand the limited amount of published data in this increasingly important area of bariatric medicine and public health.

A strength of the current study is that two types of HRQOL measures were used: a general measure of HRQOL and a weight-specific measure. Previous studies have used only instruments that provide general measures of HRQOL. Whereas general measures are intended to be applicable to all populations, condition-specific measures (such as the weight-specific IWQOL-Lite) address the issues and concerns most salient to patients with the condition. Nevertheless, one cannot say that one instrument is better than the other; results from each instrument provide useful information about the patient's experience of his/her quality of life. Although several domains of weight-specific HRQOL showed significant associations with fitness (**albeit small effects**), these effects were no longer significant after adjusting for BMI, age, and gender. On the other hand, favorable associations between SF-36 scales and fitness remained significant even after adjusting for covariables. It is possible that a greater association between IWQOL-Lite scores and BMI (average correlation of 0.22) compared to the association between SF-36 scores and BMI (average correlation of 0.12) may partly explain the attenuation of IWQOL-Lite findings after adjustment for BMI, age, and gender.

Other strengths of the current study include the relatively large sample size, use of established valid assessments of HRQOL, and use of an objective assessment of cardiorespiratory fitness rather than self-report of physical functioning via questionnaire. Although our use of submaximal exercise testing may be seen as a study limitation, we chose not to use maximal exercise testing with direct assessment of pulmonary gas exchange in order to minimize the administrative burden on the patients and study staff and to better ensure patient safety during exercise testing. Because we used submaximal exercise testing to assess fitness in our patient population, we are unable to directly compare our sample's fitness levels with those in patients who have completed maximal exercise tests [16, 28]. While this precludes determination across studies of a clinically relevant fitness level, it does not threaten the internal validity of the associations observed in our study. We believe our findings make an important contribution to the literature in this understudied area. Other published studies have since demonstrated the safety and feasibility of maximal exercise testing in obese populations [16, 28]. Thus, when practical and resources allow, we encourage the use of maximal exercise testing pre- and post-surgery to obtain the most accurate information about cardiorespiratory fitness. Future studies using standardized maximal exercise test protocols will provide critical dose-response information to determine whether a threshold level of fitness is required to favorably affect health parameters in severely obese adults.

Clinical implications of our study findings are as follows. First, patients presenting for bariatric surgery need to be carefully evaluated prior to surgery for the presence of

cardiovascular disease and the likelihood of being physically able to withstand the surgical intervention. Indeed, a recent study showed that the short-term incidence of complications following bariatric surgery were significantly lower in adults with higher compared with lower pre-surgical fitness [28]. Second, patients' awareness of their pre-surgery fitness level may serve as a motivator for improving fitness levels after surgery as well as maintaining weight loss, especially if they understand the positive association between HRQOL and fitness, as well as the several other established health benefits of being physically fit. In a recent study of physical activity (using accelerometers) in bariatric surgery candidates, low levels of physical activity were found relative to normal weight controls, with study authors concluding that physical activity was of insufficient duration and intensity to maintain and improve health [29]. In another study the findings suggested that bariatric surgery patients who became physically active post-operatively achieved greater improvements in HRQOL, as well as greater weight losses, than those who remained inactive [30]. Third, a large amount of epidemiological data indicate that higher levels of fitness confer a variety of clinical health benefits, including lower risk of fatal and nonfatal disease endpoints, and better measures of mental and functional health, in adults across a wide range of BMI-defined weight status [31]. Most of these studies, however, do not include sufficiently large enough samples of adults with BMI levels $>40 \text{ kg/m}^2$ to report study findings specific to the severely obese. Findings from the present study and other recent investigations [16, 28] begin to more firmly establish cardiorespiratory fitness and functional capacity as an important aspect of health and well-being among severely obese adults.

We conclude that in a defined sample of severely obese adults presenting for bariatric surgery, favorable associations are observed between pre-surgical levels of submaximal cardiorespiratory fitness and HRQOL scores. The relevance of cardiorespiratory fitness to other aspects of health and clinical status in severely obese adults should be a focus of forthcoming research aimed at improving the management and prognosis in this increasingly prevalent patient population.

Acknowledgments

This research was supported by grants from the NIH/NIDDK (DK-55006) and the National Center for Research Resources (MO1-RR00064).

References

1. Choban PS, Onyejekwe J, Burge JC, et al. A health status assessment of the impact of weight loss following Roux-en-Y gastric bypass for clinically severe obesity. *J Am Coll Surg.* 1999; 188:491–497. [PubMed: 10235576]
2. Dixon JB, Dixon ME, O'Brien PE. Quality of life after lap-band placement: influence of time, weight loss, and comorbidities. *Obes Res.* 2001; 9:713–21. [PubMed: 11707538]
3. Sullivan M, Karlsson J, Sjostrom L, et al. Swedish obese subjects (SOS)--an intervention study of obesity. Baseline evaluation of health and psychosocial functioning in the first 1743 subjects examined. *Int J of Obes.* 1993; 1743:503–512.
4. Schok M, Geenen R, van Antwerpen T, et al. Quality of life after laparoscopic adjustable gastric banding for severe obesity: postoperative and retrospective preoperative evaluations. *Obes Surg.* 2000; 10:502–8. [PubMed: 11175956]
5. Kolotkin RL, Crosby RD, Williams GR. Health-related quality of life varies among obese subgroups. *Obes Res.* 2002; 10:748–56. [PubMed: 12181383]
6. Kolotkin RL, Crosby RD, Pendleton R, et al. Health-related quality of life in patients seeking gastric bypass surgery vs. non-treatment-seeking controls. *Obes Surg.* 2003; 13:371–377. [PubMed: 12841896]
7. Karlsson J, Sjostrom L, Sullivan M. Swedish obese subjects (SOS)--an intervention study of obesity. Two-year follow-up of health-related quality of life (HRQL) and eating behavior after

- gastric surgery for severe obesity. *Int J Obes Relat Metab Disord.* 1998; 22:113–26. [PubMed: 9504319]
8. Doll HA, Petersen SEK, Stewart-Brown SL. Obesity and physical and emotional well-being: Associations between body mass index, chronic illness, and the physical and mental components of the SF-36 questionnaire. *Obes Res.* 2000; 8:160–170. [PubMed: 10757202]
 9. Torquati A, Lutfi RE, Richards WO. Predictors of early quality-of-life improvement after laparoscopic gastric bypass surgery. *Am J Surg.* 2007; 193:471–5. [PubMed: 17368291]
 10. Barofsky I, Fontaine KR, Cheskin LJ. Pain in the obese: impact on health-related quality-of-life. *Ann Behav Med.* 1997; 19:408–10. [PubMed: 9706368]
 11. Kolotkin RL, Westman EC, Ostbye T, et al. Does binge eating disorder impact weight-related quality of life? *Obes Res.* 2004; 12:999–1005. [PubMed: 15229340]
 12. Rieger E, Wilfley DE, Stein RI, et al. A comparison of quality of life in obese individuals with and without binge eating disorder. *Int J Eat Disord.* 2005; 37:234–40. [PubMed: 15822089]
 13. Kolotkin RL, Crosby RD, Gress RE, et al. Health and health-related quality of life: differences between men and women who seek gastric bypass surgery. *Surg Obes Relat Dis.* 2008; 4:651–8. [PubMed: 18586572]
 14. Sloan RA, Sawada SS, Martin CK, et al. Associations between cardiorespiratory fitness and health-related quality of life. *Health Qual Life Outcomes.* 2009; 7:47. [PubMed: 19476640]
 15. Galper DI, Trivedi MH, Barlow CE, et al. Inverse association between physical inactivity and mental health in men and women. *Med Sci Sports Exerc.* 2006; 38:173–8. [PubMed: 16394971]
 16. Rejeski WJ, Lang W, Neiberg RH, et al. Correlates of health-related quality of life in overweight and obese adults with type 2 diabetes. *Obesity (Silver Spring).* 2006; 14:870–83. [PubMed: 16855197]
 17. Painter P, Krasnoff J, Paul SM, et al. Physical activity and health-related quality of life in liver transplant recipients. *Liver Transpl.* 2001; 7:213–9. [PubMed: 11244162]
 18. Martin CK, Church TS, Thompson AM, et al. Exercise dose and quality of life: a randomized controlled trial. *Arch Intern Med.* 2009; 169:269–78. [PubMed: 19204218]
 19. Adams TD, Avelar E, Cloward T, et al. Design and rationale of the Utah obesity study. A study to assess morbidity following gastric bypass surgery. *Contemp Clin Trials.* 2005; 26:534–51. [PubMed: 16046191]
 20. Kolotkin RL, Crosby RD, Kosloski KD, et al. Development of a brief measure to assess quality of life in obesity. *Obes Res.* 2001; 9:102–111. [PubMed: 11316344]
 21. Kolotkin RL, Crosby RD. Psychometric evaluation of the Impact Of Weight On Quality Of Life-Lite Questionnaire (IWQOL-Lite) in a community sample. *Qual Life Res.* 2002; 11:157–171. [PubMed: 12018739]
 22. Ware, J.; Snow, K.; Kosinski, M., et al. SF-36 Health Survey: Manual and Interpretation Guide. The Health Institute, New England Medical Center; Boston: 1993.
 23. Kolotkin RL, Norquist JM, Crosby RD, et al. One-year health-related quality of life outcomes in weight loss trial participants: comparison of three measures. *Health Qual Life Outcomes.* 2009; 7:53. [PubMed: 19505338]
 24. American College of Sports Medicine. Guidelines for exercise testing and prescription. Seventh ed.. Lippincott Williams and Wilkins; Philadelphia: 2006.
 25. Ekelund LG, Haskell WL, Johnson JL, et al. Physical fitness as a predictor of cardiovascular mortality in asymptomatic North American men. The Lipid Research Clinics Mortality Follow-up Study. *N Engl J Med.* 1988; 319:1379–84. [PubMed: 3185648]
 26. Slattery ML, Jacobs DR Jr. Physical fitness and cardiovascular disease mortality. The US Railroad Study. *Am J Epidemiol.* 1988; 127:571–80. [PubMed: 3341361]
 27. Royston P, Altman DG, Sauerbrei W. Dichotomizing continuous predictors in multiple regression: a bad idea. *Stat Med.* 2006; 25:127–41. [PubMed: 16217841]
 28. McCullough PA, Gallagher MJ, Dejong AT, et al. Cardiorespiratory fitness and short-term complications after bariatric surgery. *Chest.* 2006; 130:517–25. [PubMed: 16899853]

29. Bond DS, Jakicic JM, Vithiananthan S, et al. Objective quantification of physical activity in bariatric surgery candidates and normal-weight controls. *Surg Obes Relat Dis*. 6:72–8. [PubMed: 19837009]
30. Bond DS, Phelan S, Wolfe LG, et al. Becoming physically active after bariatric surgery is associated with improved weight loss and health-related quality of life. *Obesity (Silver Spring)*. 2009; 17:78–83. [PubMed: 18997679]
31. LaMonte MJ, Chumlea WC. Obesity and health: survival of the fittest? *International Journal of Body Composition Research*. 2006; 4:19–25.

A.

B.

C.

Figure 1. Scatterplot of cardiorespiratory fitness (treadmill exercise time) and (a) IWQOL-Lite total score, (b) SF-36 Physical Component Summary score, and (c) SF-36 Mental Component Summary score.

Table 1
Mean values for IWQOL-Lite and SF-36 by tertiles of submaximal cardiorespiratory fitness.

		Tertile of treadmill test duration, min			
		<8.8	8.8-11.7	>11.7	P-trend
					P-trend adjusted for age, gender, and BMI
N		104	114	108	
IWQOL-Lite scales					
Physical function		24.6	29.9	32.3	0.009
Self-esteem		22.1	22.4	20.7	0.79
Sexual life		39.0	41.1	48.6	0.05
Public distress		31.6	38.7	41.2	0.004
Work		41.2	49.5	50.2	0.02
Total score		29.1	33.6	35.6	0.01
SF-36 scales					
Physical functioning		31.9	42.6	47.8	<0.001
Role physical		27.2	38.4	45.8	0.001
Bodily pain		37.8	44.9	47.7	0.001
General health		42.5	46.2	44.3	0.16
Vitality		26.2	28.5	27.8	0.64
Social functioning		48.7	51.9	49.5	0.63
Role emotional		51.3	43.6	41.7	0.22
Mental health		61.4	58.9	55.9	0.12
Physical Component		28.9	34.2	36.6	<0.001
Summary					
Mental Component Summary		43.3	40.5	38.2	0.007
					0.44

Table 2

Linear regression of health-related quality of life scales on submaximal cardiorespiratory fitness (treadmill time, min).

	Regression coefficient	95% CI	R ² **	P-value
<u>IWQOL-Lite scales</u>				
Physical function				
Unadjusted	1.41	0.76, 2.05	0.054	<0.001
Adjusted *	0.62	−0.13, 1.37	0.008	NS
Self-esteem				
Unadjusted	−0.12	−0.84, 0.59	0.000	NS
Adjusted *	0.25	−0.58, 1.07	0.001	NS
Sexual life				
Unadjusted	1.46	0.39, 2.52	0.022	<0.001
Adjusted *	0.90	−0.36, 2.17	0.006	NS
Public distress				
Unadjusted	1.67	0.89, 2.44	0.052	<0.001
Adjusted *	1.04	0.22, 1.85	0.019	<0.05
Work				
Unadjusted	1.33	0.39, 2.26	0.024	<0.01
Adjusted *	1.02	−0.09, 2.12	0.010	NS
Total score				
Unadjusted	1.10	0.54, 1.66	0.044	<0.001
Adjusted *	0.69	0.04, 1.35	0.014	<0.05
<u>SF36 scales</u>				
Physical functioning				
Unadjusted	2.37	1.65, 3.08	0.116	<0.001
Adjusted *	1.71	0.87, 2.55	0.047	<0.001
Role physical				
Unadjusted	2.63	1.34, 3.92	0.047	<0.001
Adjusted *	2.34	0.81, 3.88	0.027	<0.01
Bodily pain				
Unadjusted	1.51	0.81, 2.22	0.052	<0.001
Adjusted *	1.18	0.34, 2.03	0.023	<0.01
General health				
Unadjusted	0.17	−0.34, 0.68	0.001	NS
Adjusted *	0.49	−0.09, 1.09	0.008	NS
Vitality				
Unadjusted	0.32	−0.33, 0.98	0.003	NS
Adjusted *	0.75	−0.03, 1.52	0.011	NS
Social functioning				

	Regression coefficient	95% CI	R ² **	P-value
Unadjusted	0.17	−0.72, 1.07	0.001	NS
Adjusted *	0.42	−0.63, 1.48	0.002	NS
Role emotional				
Unadjusted	−1.47	−2.96, 0.03	0.011	NS
Adjusted *	−0.03	−1.78, 1.72	0.000	NS
Mental health				
Unadjusted	−0.71	−1.39, −0.02	0.012	<0.05
Adjusted *	−0.31	−1.11, 0.49	0.002	NS
Physical component				
Unadjusted	1.11	0.82, 1.40	0.149	<0.01
Adjusted *	0.83	0.49, 1.17	0.067	<0.01
Mental component				
Unadjusted	−0.72	−1.14, −0.31	0.035	<0.001
Adjusted *	−0.26	−0.74, 0.21	0.004	NS

NS = not significant.

* Adjusted for age, gender, BMI.

** R² (unadjusted model) or partial r² (adjusted model), when multiplied by 100, represent the percent variance in the HRQOL score explained by fitness.