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Associations of post-bariatric surgery weight loss with snoring, napping, and short sleep duration

Yohannes Adama Melaku

yohannes.melaku@flidners.edu.au

Flinders University

Maya Bassil

Qatar University

Joyce Alzalloua Moawad

Qatar University

Zumin Shi

Qatar University

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Table 1 is available in the Supplementary Files section.

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Conflict of interest

Authors report no relevant conflicts of interest. All authors have read and approved the final version of the manuscript. No funding was received for this study.

Ethical approval

The current study was approved under the IRB-exempt category (Ex-2025-QPHI-RES-ACC-00361-0342), with all participants providing written informed consent.

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Abstract

Objective

This study aimed to examine the association between weight loss following bariatric surgery (BS) and the prevalence of snoring, daytime napping, and short sleep duration, and to explore dose-response relationships.

Methods

We analysed data from 1,635 adults who underwent BS, categorised into quartiles based on total weight loss. Multivariable generalised linear models with inverse probability weighting were used to estimate odds ratios (ORs) for each sleep outcome, adjusting for potential confounders. Dose-response associations were assessed using restricted cubic splines.

Results

Greater weight loss was associated with a reduction in the odds of snoring (Q4 vs Q1: OR = 0.42; 95% CI: 0.36, 0.49) and daytime napping (Q4 vs Q1: OR = 0.63; 95% CI: 0.54, 0.73). However, weight loss showed a mixed association with short sleep duration, with increased odds in the third quartile (OR = 1.24; 95% CI: 1.07, 1.43). Stronger associations were observed in males. Dose-response analyses revealed a consistent inverse relationship between weight loss and snoring, while associations with napping and short sleep duration were non-linear.

Conclusions

Weight loss after bariatric surgery is associated with reduced odds of snoring and daytime napping, with evidence of dose-dependent effects. However, changes in short sleep duration are less consistent.

Keywords: Bariatric surgery, weight loss, sleep apnea, snoring, napping, sleep duration

Study importance

What is already known?

Weight loss following bariatric surgery leads to improvements in obstructive sleep apnoea severity. However, less is known about how differing degrees of postoperative weight loss influence other common sleep disturbances such as snoring, daytime napping, and short sleep duration.

What does this study add?

This study is the first to comprehensively evaluate how varying levels of weight loss after bariatric surgery relate to multiple sleep health outcomes beyond sleep-disordered breathing. Using robust analytical techniques, including inverse probability weighting and dose–response modelling, we show that greater weight loss is associated with substantially lower odds of snoring and daytime napping, while uncovering a non-linear relationship with short sleep duration. These findings highlight sleep dimensions that are often overlooked in bariatric outcomes research.

How might these results change the direction of research or the focus of clinical practice?

These findings broaden the understanding of the sleep-related benefits of bariatric surgery by demonstrating improvements in sleep health that extend beyond obstructive sleep apnoea. They underscore the value of incorporating sleep metrics into postoperative monitoring and suggest new avenues for research examining the multidimensional impact of weight loss on sleep health.

1. Introduction

Obesity is a major global health concern, with its prevalence steadily increasing over the past few decades [1]. In 2022, the World Health Organization (WHO) estimates that 2.5 billion adults were overweight, including over 890 million adults who were living with obesity [2]. In Qatar, the burden of obesity is high, with 51% of adult women and 40% of adult men living with obesity in 2022—significantly higher than the regional average of 10.3% for women and 7.5% for men [3, 4]. The development of obesity is multifactorial, driven by genetic predisposition, poor dietary habits, sedentary lifestyles, and other environmental and behavioural factors [5]. Obesity is a key contributor to various non-communicable diseases (NCDs), metabolic and cardiovascular consequences including type 2 diabetes, hypertension, cardiovascular disease, and certain cancers [6].

Obesity is the strongest known risk factor for obstructive sleep apnea (OSA), with studies showing that even moderate weight gain significantly increases its risk through excess adiposity contributing to airway obstruction, systemic inflammation, and impaired respiratory function [7]. OSA is characterized by repeated airway blockage during sleep, with symptoms including snoring, daytime sleepiness (or an urge to nap), and fatigue [8]. Compelling evidence supports an inverse association between short sleep duration and the risk of obesity. However, evidence on the effect of obesity on short sleep duration remains limited, although some studies suggest a potential positive correlation [9], which may be mediated by OSA.

Given the profound impact of obesity on overall health, effective treatment strategies are essential. Lifestyle interventions, including dietary modification and increased physical activity, are the cornerstone of obesity management but often yield limited long-term success [10]. Pharmacological treatments provide an alternative, yet their effectiveness and sustainability vary [11]. Bariatric surgery (BS) has become the most effective intervention for severe obesity, providing substantial and sustained weight loss while improving metabolic and cardiovascular health [12]. The growing popularity of BS is particularly evident in Gulf Cooperation Council (GCC) countries, where it is increasingly perceived as a convenient alternative to traditional lifestyle modifications for obesity management [13]. In Qatar, for instance, BS as an obesity treatment strategy is widespread, with prevalence estimated at 12% in the general population [14].

Beyond its role in weight management, BS is also associated with significant reductions in OSA severity, with many patients experiencing remission of the condition following surgery [15]. Previous studies on the relationship between BS and sleep outcomes have primarily focused on sleepiness scales, the respiratory disturbance index (RDI), or the rate of OSA remission [15]. However, there is limited research exploring the association between the extent of weight loss and the risk of subjective sleep symptoms (snoring, daytime napping, and short sleep duration) following surgery. The present study aims to assess the effect of weight loss on these subjective sleep parameters among individuals who have undergone BS. Understanding these associations is critical for optimizing sleep-related patient outcomes and providing evidence-based recommendations for post-surgical management.

2. Methods

Study design and population

Data from a subsample of the Qatar Biobank (QBB), a population-based cohort study, were used. Details about the QBB and the subsample have been published previously [16, 17]. The QBB, part of Qatar Foundation's Biomedical Research Institute, is a national resource for biomedical research established in collaboration with the Supreme Council of Health and Hamad Medical Corporation. The QBB study was initiated in 2012 and is an ongoing cohort study enrolling Qataris and long-term residents (≥15 years) through various channels, including online platforms and social networks. The QBB collects health and lifestyle data, including biological samples, clinical measurements, and self-reported information from participants [17]. Over 20,000 adults had participated by 2022. Of these participants, the study included 1,893 individuals (713 males and 1,180 females) aged 18 and older with a history of BS, along with available dietary data and diabetes information. After excluding missing values for the exposure (amount of weight loss, n = 176), confounding variables (income, n= 103), 1,635 participants were included in the final analysis. The subsample data lacked information on the timing of measurement of the exposure (weight loss), covariates and outcomes. QBB ethical approval was granted by the Hamad Medical Corporation Ethics Committee (2011) and later by the QBB Institutional Review Board (2017). The current study was approved under the IRB-exempt category (Ex-2023-QF-QBB-RES-ACC-00136-0235), with all participants providing written informed consent. Data analysis for this study was conducted between 8 February and 30 March 2025.

Weight loss

Anthropometric measurements included body weight (kg), standing and sitting height (measured with a Seca stadiometer, centimetre), hip and waist circumferences, and body composition assessed using bioimpedance (Tanita) [17]. Weight loss was determined using the current weight and pre-BS weight. Both continuous and quartiles of absolute weight loss in kilograms were used for analyses. We did not use body mass index [weight/height^2] or percentage of weight loss as primary exposure as ratios are poorly defined measures [18].

Ideal weight was estimated based on sex-specific reference values. For male participants, a baseline ideal weight of 61.2 kg (converted from 135 lb using a conversion factor of 0.4536) was assigned, while for female participants, a baseline ideal weight of 54.0 kg (converted from 119 lb) was used [19]. Excess height was calculated by subtracting sex-specific reference heights (159.62 cm for males and 152 cm for females) from the participant's recorded height. To account for variations in height, an additional weight of 0.54 kg was added for each centimeter of excess height, yielding the final ideal weight [19].

Excess weight was then determined as the difference between a participant's recorded weight and their calculated ideal weight. A histogram was generated to illustrate the distribution of excess weight. Operative excess weight, representing the excess weight intended for reduction, was computed as the difference between the pre-BS weight and the ideal weight. Actual weight loss was calculated by subtracting the post-BS weight from the pre-BS weight [19, 20]. The percentage of excess weight lost (%EWL) was derived by dividing the actual weight loss by the operative excess weight and multiplying by 100. Similarly, the percentage of excess weight remaining (%EWR) was

computed as the proportion of excess weight still present after the intervention relative to the operative excess weight (**Figure 1**) [19, 20].

<Insert Figure 1 here>

Snoring, daytime napping, and sleep duration

Snoring, daytime napping, and short sleep duration were assessed using self-administered questionnaires and nurse-conducted interviews. Participants were asked whether a spouse or relative had mentioned their snoring in the past year, with possible responses: ‘yes’, ‘no’, ‘unsure’, or ‘preferred not to answer’. Participants were also asked about their usual daytime napping habits over the past year, with responses indicating whether they ‘rarely/never’, ‘sometimes’, ‘frequently’, or ‘always’ napped, or if they ‘preferred not to answer.’ Daytime napping, considered as surrogate indicator of excessive daytime sleepiness (one of the cardinal symptoms of OSA) [21], was reported as present ‘frequently’ or ‘sometimes’. Furthermore, participants were asked to report their average sleep duration over a 24-hour period, including naps, during a typical week in the past year. Response options were: ‘less than 5 hours’, ‘between 5 and less than 7 hours’, ‘between 7 and less than 8 hours’, ‘8 hours or more’, ‘do not know’, or ‘prefer not to answer’. Short sleep duration was defined as less than seven hours per day [22]. Participants who reported being ‘unsure’, ‘do not know’, or ‘preferred not to answer’ for the outcomes were excluded from the analysis.

Confounding variables

A directed acyclic graph (DAG) was used to identify confounding variables for the outcomes (**Figure S1**). While no data were available on the exact timeframe of confounder and outcome assessment, both confounders and outcomes were measured at a later time point following BS. A simplified DAG for the three outcomes (snoring, napping and short sleep duration) is shown in **Figure 2**. Socio-economic

status (including age, gender, education, marital status, and employment) and lifestyle behaviours (physical activity, smoking and dietary pattern) were identified as confounding variables (**Table S1**). Non-communicable diseases (such as diabetes, hypertension, cardiovascular disease, and cancer) were considered mediators. Additionally, baseline weight was found to be an ancestor of exposure rather than a confounder.

<Insert Figure 2 here>

Statistical analysis

Variables were presented using proportions for categorical data, means with standard deviations for continuous and symmetrical data, and medians with interquartile ranges for continuous and asymmetrical data.

Generalized linear models (GLMs) with a binomial distribution and logit link function were used to estimate odds ratios and 95% confidence intervals, assessing the association between weight loss and snoring, napping, and short sleep duration. Models were adjusted for age (continuous); sex (male, female); educational level (low, medium, and high); income (No income, ~20,000, 20,001-50,000, >50,000); physical activity level (metabolic equivalent hours/week); smoking (none, smoker, and non-smoker) and dietary pattern (traditional, prudent and sweets/fast foods) derived from factor analysis based on a food frequency questionnaire. A detailed description of covariates is provided in **Table S1**.

For all models, inverse probability of treatment weighting (IPTW) [23] was applied to balance the distribution of confounding by weighting each participant using the inverse probability. Assuming all relevant confounders were measured and adjusted for, IPTW was used to create a balanced '*pseudopopulation*' across exposure groups. Each

participant was weighted using the inverse probability of belonging to their specific exposure category—quartiles of weight loss. Balance was assessed using the mean difference between post-IPTW exposure groups, which remained ≤1% (*data not shown*), indicating adequate adjustment. IPTW was applied separately for each outcome, and estimates represent the average treatment effect in the population. Estimated associations were reported as odds ratios (ORs) and 95% confidence intervals (CIs). R version 4.4.2 statistical software (R Core Team, 2024) was used, employing the *glm [24]* and *WeightIt [25]* functions.

Further analyses were conducted: 1) to determine the association of every 5 kg weight loss and excess with sleep parameters; 2) to determine the association between quartiles of percentage of weight loss and excess weight, and the sleep parameters; and 3) to assess dose-response relationships using weight loss and excess weight as continuous variables. Restricted cubic splines with four knots were used to model these associations using *rcs* function in *RMS* package [26] and adjusting for all confounders (age, sex, income, educational status, smoking, physical activity level and dietary patterns). Non-linearity was tested by comparing a model with a linear term to one with the spline term using the likelihood ratio test [26].

3. Results

Characteristics of participants

Table 1 summarizes the baseline characteristics of participants categorized into quartiles of weight loss following BS (N = 1,635). The mean age of participants was 39 years (SD: 10), with those in the highest weight loss quartile (Q4) being younger (35 years) compared to those in the lowest quartile (Q1: 41 years). A higher proportion of men achieved greater weight loss, comprising 66.4% of Q4 compared to 23.9% in Q1. Socioeconomic factors (education and income levels) were generally comparable

across quartiles. However, smoking prevalence was higher among participants with greater weight loss, with 41% of Q4 classified as current smokers, compared to 11% in Q1. Participants in the highest weight loss quartile (Q4) had the highest median leisure time physical activity of 11 MET hours/week (IQR: 0–38), while those in the lowest quartile (Q1) had a median of 5 MET hours/week (IQR: 0–20).

Weight-related characteristics varied substantially across groups. Mean weight loss was 51 kg (38%) in Q4, compared to 7 kg (7%) in Q1. Distribution of pre-BS, post-BS, ideal weight and weight lost are depicted in **Figure S2**. The proportion of obese individuals declined with increasing weight loss, from 73% in Q1 to 39% in Q4.

The prevalence of snoring decreased progressively from 42% in Q1 to 23% in Q4. Similarly, daytime napping prevalence was lower among those who lost more weight (28% in Q4 vs 37% in Q1). In contrast, the proportion of participants with short sleep duration remained relatively stable across weight loss quartiles (68% in Q4 vs 63% in Q1).

<Insert Table 1 here>

**Mean (SD); @median (interquartile range)*

Figure 3 illustrates the overlap between snoring, daytime napping and short sleep duration among study participants. The majority of individuals (539, 33%) experienced only one of these sleep disturbances, while 246 (15.1%) had two co-occurring conditions, and 202 (12.4%) exhibited all three conditions simultaneously. Smaller subsets of individuals presented with varying combinations of these disturbances (**Figure 3**).

<Insert Figure 3 here>

Association of weight loss with snoring, napping and short sleep duration

Compared to individuals in the lowest quartile of weight loss (reference group), those in higher weight loss quartiles had lower odds of snoring. The odds of snoring were 25% lower in the second quartile (OR = 0.75; 95% CI: 0.66, 0.87), 44% lower in the third quartile (OR = 0.56; 95% CI: 0.49, 0.65), and 58% lower in the highest quartile (OR = 0.42; 95% CI: 0.36, 0.49). These findings indicate a dose-response relationship, where greater weight loss is associated with a progressive reduction in the likelihood of snoring (**Figure 4**).

<Insert Figure 4 here>

Weight loss was associated with reduced odds of daytime napping. Compared to the reference group, participants in the third (OR = 0.77; 95% CI: 0.67, 0.90) and fourth quartiles (OR = 0.63; 95% CI: 0.54, 0.73) had lower odds of napping. However, the association for the second quartile was not statistically significant (OR = 0.90; 95% CI: 0.78, 1.04). In contrast to snoring and daytime napping, weight loss showed a positive association with short sleep duration. Individuals in the third quartile had 24% higher odds of short sleep duration compared to the reference group (OR = 1.24; 95% CI: 1.07, 1.43). For every 5 kg weight loss, the odds of snoring decreased by 12% (OR = 0.88; 95% CI: 0.86, 0.91). However, this was not associated with daytime napping (OR = 1.02; 95% CI: 0.99, 1.04). For short sleep duration, each 5 kg weight loss was associated with a 4% reduction in the odds of experiencing short sleep (OR = 0.96; 95% CI: 0.93, 0.98). A similar trend of associations was observed when weight loss was expressed as a percentage change from baseline (**Figure 4**).

Compared to the reference group, participants in the third quartile of excess weight had 25% higher odds of snoring (OR = 1.25; 95% CI: 1.08, 1.45), while those in the fourth quartile had nearly twice the odds (OR = 1.91; 95% CI: 1.65, 2.21). For daytime

napping, higher excess weight was associated with increased odds, particularly in the third quartile (OR = 1.29; 95% CI: 1.12, 1.49), while the fourth quartile showed a slight decrease (OR = 0.88; 95% CI: 0.76, 1.02). For short sleep duration, percentage of excess weight loss increased the odds, especially in the third quartile (OR = 1.33; 95% CI: 1.15, 1.54), while weight loss showed mixed effects, with the third quartile showing a 18% higher risk (OR = 1.18; 95% CI: 1.02, 1.36) and the fourth quartile showing no significant association (OR = 0.98; 95% CI: 0.84, 1.13). In contrast, percentage of excess weight loss was associated with reduced odds of snoring, with the third quartile showing a 54% reduction (OR = 0.46; 95% CI: 0.40, 0.53) and the fourth quartile showing a 64% reduction (OR = 0.36; 95% CI: 0.31, 0.41). Percentage of weight loss was protective against napping, with participants in the highest quartile showing 28% lower odds (OR = 0.72; 95% CI: 0.62, 0.84) (**Figure 4**). We found stronger inverse associations of weight loss with snoring and short sleep duration in males than females **(Figure S2)**.

Dose-response relationships

Figure 5 presents the dose-response relationships between weight loss (in kilograms), percentage weight loss, excess weight, and percentage excess weight loss with snoring, daytime napping, and short sleep duration. A consistent inverse relationship was observed between both weight loss (in kilograms) and percentage weight loss and the odds of snoring, with greater weight reduction associated with a progressive decline in odds (p for non-linearity = 0.2656). However, for daytime napping (p for non-linearity = 0.0021) and short sleep duration (p for non-linearity = 0.0041), the associations appeared to be non-linear. Excess weight was linearly associated with increased odds of snoring (p for non-linearity = 0.6608). In contrast, the percentage of

excess weight loss was associated with a reduced risk of snoring (p for non-linearity = 0.0021).

<Insert Figure 5 here>

4. Discussion

Our study demonstrates a significant dose-response association between weight loss and snoring and daytime napping following BS. Individuals who lost more weight exhibited progressively lower odds of snoring, with reductions of 25%, 44%, and 58% in the second, third, and highest quartiles of weight loss, respectively. This inverse association was also evident in the dose-response analysis, where each 5 kg weight loss was associated with a 12% reduction in the odds of snoring. A similar trend was observed for daytime napping, with participants in the higher weight loss quartiles experiencing a reduced likelihood of napping (10%, 23% and 37% reduction in second, third and fourth quartiles, respectively). In contrast, the relationship between weight loss and short sleep duration was more complex, showing a non-linear association, with a moderate weight loss initially increasing the odds of short sleep before stabilizing or declining with greater weight reduction. These findings highlight the differential effects of weight loss on various sleep-related outcomes, reinforcing the importance of considering sleep disturbances as part of post-BS surgery weight management.

Weight loss interventions have been shown to significantly improve OSA and daytime sleepiness in overweight and obese individuals [27]. BS has emerged as an effective treatment for severe obesity, demonstrating impressive results in reducing OSA severity and associated cardiometabolic abnormalities [15]. A systematic review and meta-analysis revealed a clear dose-response relationship between weight loss and improvement in daytime sleepiness, with surgical interventions showing larger effects

compared to non-surgical approaches [28]. These findings alongside with findings from the current study support the hypothesis of a causal relationship between body weight, upper airway obstruction and daytime sleepiness, emphasizing the importance of weight management in addressing sleep-related issues.

The prevalence of OSA in BS candidates is as high as 70% [29]. BS significantly reduces body weight and improves sleep quality in obese patients with OSA [30]. Our results showed that post-BS weight loss is associated with decreased snoring in dose-response relationship. Weight loss following BS leads to craniofacial changes, including reduced craniocervical length, increased velopharyngeal air space, and altered hyoid bone position [31]. These changes are associated with improved respiratory function and a reduction in nasal obstruction symptoms, including snoring and daytime sleepiness. Furthermore, the reduction in inflammation associated with post-BS weight loss may contribute to the improvement of OSA symptoms [32]. Importantly, improvement in OSA symptoms following weight loss is associated with a lower incidence of diabetes and hypertriglyceridemia, suggesting additional health benefits beyond weight loss alone [16, 33]. However, it is important to note that, despite significant improvements in OSA symptoms following bariatric surgery, complete resolution is not guaranteed. Patients may require ongoing treatment to manage residual symptoms and minimise associated complications. For instance, a meta-analysis reported a reduction in the mean apnea-hypopnea index (AHI) from 54.7 to 15.8 events per hour post-surgery, indicating the persistence of moderately severe OSA [34].

The current study identified a non-linear relationship between post-bariatric surgery weight loss and napping. Consistent with this finding, a systematic review reported a non-linear dose-response relationship between weight loss and improvements in

daytime sleepiness, with surgical interventions demonstrating greater effects than non-surgical approaches [35]. Obesity is strongly associated with excessive daytime sleepiness, with weight loss promoting its remission [36]. The mechanisms linking this association extend beyond OSA and may involve hormonal, metabolic, and inflammatory pathways. Evidence indicates that obesity, even in the absence of sleep apnoea, is associated with an increased prevalence of hypersomnolence. Furthermore, studies suggest that bariatric surgery can lead to significant improvements in hypersomnolence, even before the resolution of obstructive sleep apnoea [37]. Additionally, improvements in daytime sleepiness following BS have been associated with reductions in depressive symptoms [36, 38]. Together, the findings from the current and previous studies support a causal relationship between obesity and daytime sleepiness, highlighting the importance of addressing sleep issues in obese patients. These findings have important clinical implications, as they suggest that BS may provide therapeutic benefits for sleep disturbances beyond OSA, particularly for individuals with obesity-related hypersomnolence. Clinicians should consider screening for excessive daytime sleepiness in patients undergoing bariatric surgery, as improvements in sleep-related symptoms may enhance overall quality of life and mental health outcomes.

Research suggests a complex relationship between sleep and weight. Short sleep duration and poor sleep quality are associated with reduced weight loss in behavioural interventions [39]. However, successful weight loss can lead to increased sleep duration, particularly in short and average sleepers [40]. This bidirectional relationship is supported by longitudinal studies showing short sleep duration predicts future weight gain, especially in younger individuals. During puberty, changes in weight are inversely correlated with changes in sleep duration, and this relationship persists into adulthood

[41]. Importantly, weight loss interventions can improve sleep quality [39, 41]. These findings highlight the intricate interplay between sleep and weight management. In the current study, unlike snoring and napping, the non-apparent association between post-BS weight loss and short sleep duration may be attributed to the behavioural nature of sleep duration, whereas snoring and napping are more strongly influenced by adiposity and metabolic factors.

A key strength of this study is its large sample size, derived from a community-based study. It is also important to note that this study has few limitations. First, the subsample we use from QBB did not have timeframe of data collection on weight loss, confounding variables and outcomes. Second, outcomes were self-reported which might not necessarily reflect clinical diagnosis. Third, although balancing of identified and available confounding variables was performed using propensity score, residual confounding may affect the estimates.

5. Conclusions

In conclusion, this study provides strong evidence of a dose-response relationship between post-BS weight loss and improvements in snoring and daytime napping, with greater weight loss associated with progressively lower odds of these sleep disturbances. However, the relationship between weight loss and short sleep duration appears more complex, with an initial increase in short sleep followed by decline with greater weight reduction. These findings underscore the diverse effects of weight loss on sleep-related outcomes, reinforcing the need to integrate sleep assessments into post-surgical weight management strategies. Future research should explore the long-term effects of post-surgical weight loss on sleep patterns using objective sleep measures. Additionally, future studies should investigate how weight loss, sleep

health, and mental health interact to enhance clinical care, as sleep disturbances and mental health disorders frequently co-exist.

Abbreviations list

BS – Bariatric Surgery
GCC – Gulf Cooperation Council
WHO – World Health Organisation
QBB – Qatar Biobank
NCD – Non-communicable diseases
OR – Odds ratio
OSA – Obstructive Sleep Apnea
NHMRC – National Health and Medical Research Council of Australia
GLM – Generalized linear models
IPTW – Inverse probability treatment weighting

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Non-Financial Disclosure

All authors declare no non-financial conflicts of interest relevant to this manuscript.

Supplementary Material

The supplementary material file includes: Table S1 (Confounding variables), Figure S1 (Direct acyclic graph depicting the hypothesised relationships for weight loss and snoring), Figure S2 (Distribution of body weight in kilograms), and Table S2 (Association of quartiles of weight loss (kg) with snoring, napping and short sleep duration by sex).

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List of Tables

Table 1| Characteristics of participants across the quartile of post-bariatric surgery weight loss

List of Figures

Figure 1| Weight loss and excess weight calculation. *BS – Bariatric Surgery*

Figure 2| Simplified direct acyclic graph

Figure 3| Post-bariatric surgery overlap between snoring, daytime napping and short sleep duration

Figure 4| Association of post-bariatric surgery weight loss (in kg and percentage) with snoring, napping and short sleep duration**.** *Odds ratios were determined based on generalised linear model with inverse probability weighting. Each model was adjusted for age, sex, income, educational status, smoking, physical activity level and dietary patterns.*

Figure 5| Dose-response relationship of weight loss post-bariatric surgery with snoring, napping and short sleep duration. *Odds ratio was determined based on generalised linear model with inverse probability weighting. Each model was adjusted for age, sex, income, educational status, smoking, physical activity level and dietary pattern.*

Figures

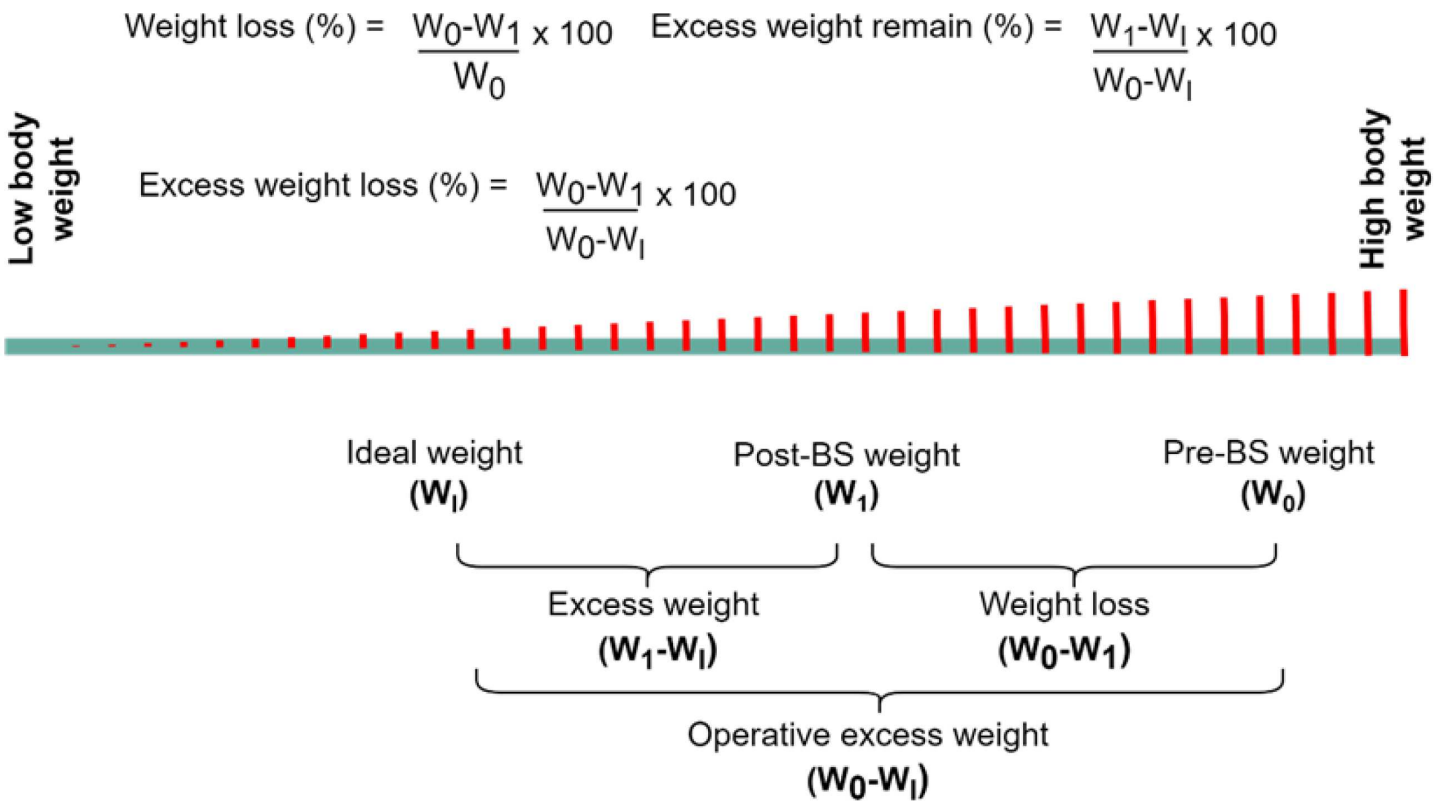


Figure 1

Weight loss and excess weight calculation. *BS – Bariatric Surgery*

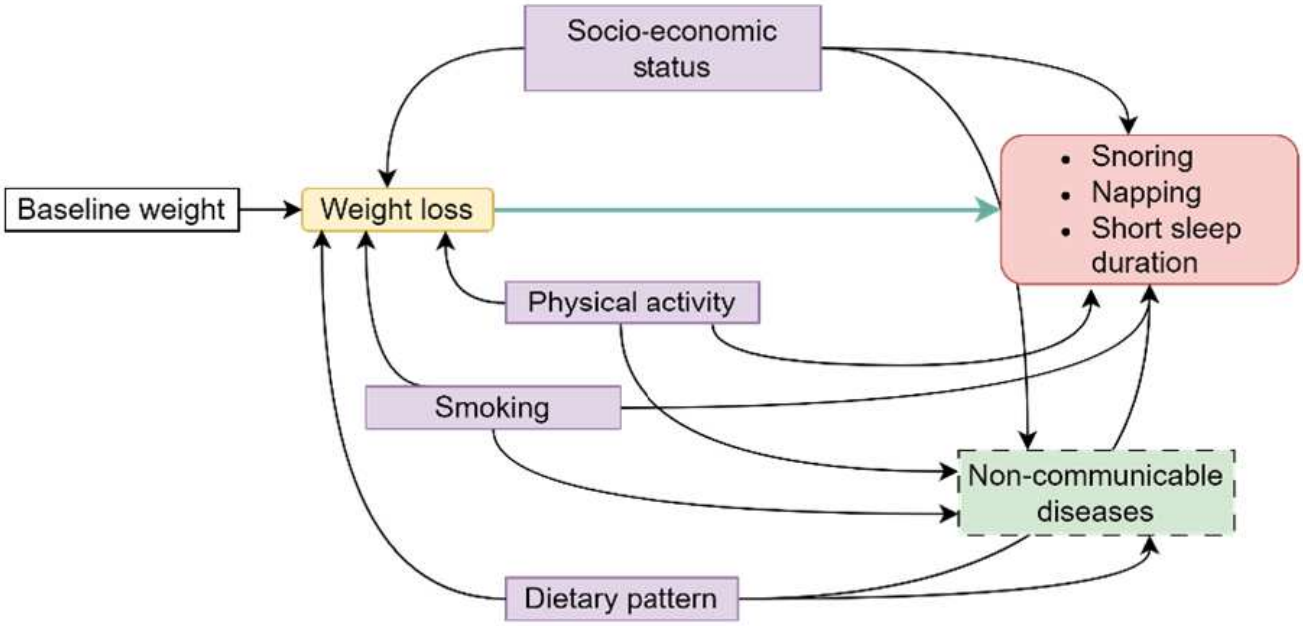


Figure 2

Simplified direct acyclic graph

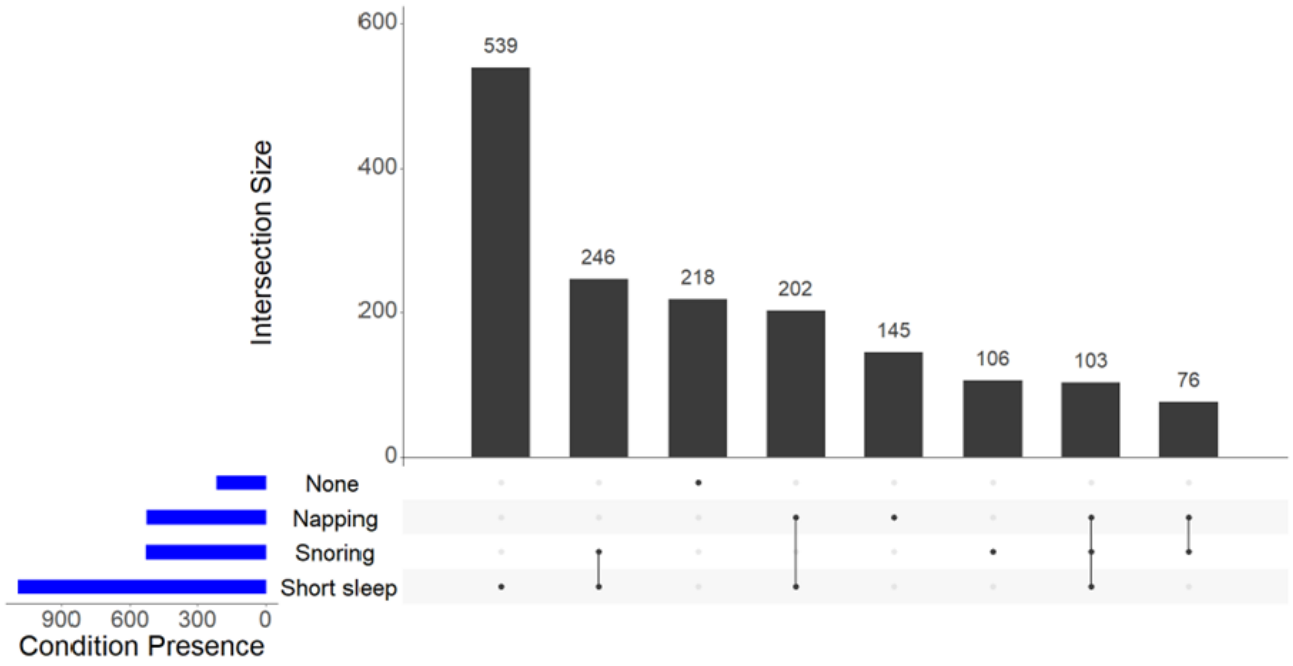


Figure 3

Post-bariatric surgery overlap between snoring, daytime napping and short sleep duration

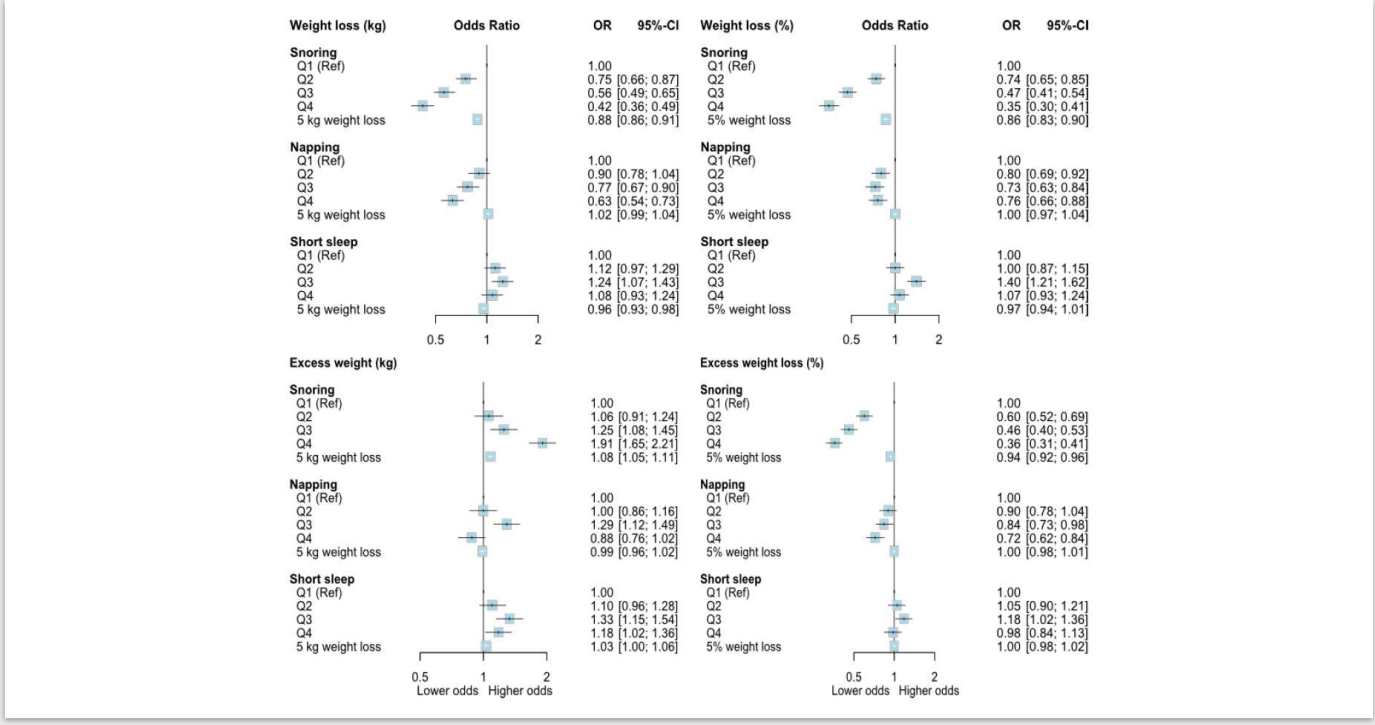


Figure 4

Association of post-bariatric surgery weight loss (in kg and percentage) with snoring, napping and short sleep duration**.** *Odds ratios were determined based on generalised linear model with inverse probability weighting. Each model was adjusted for age, sex, income, educational status, smoking, physical activity level and dietary patterns.*

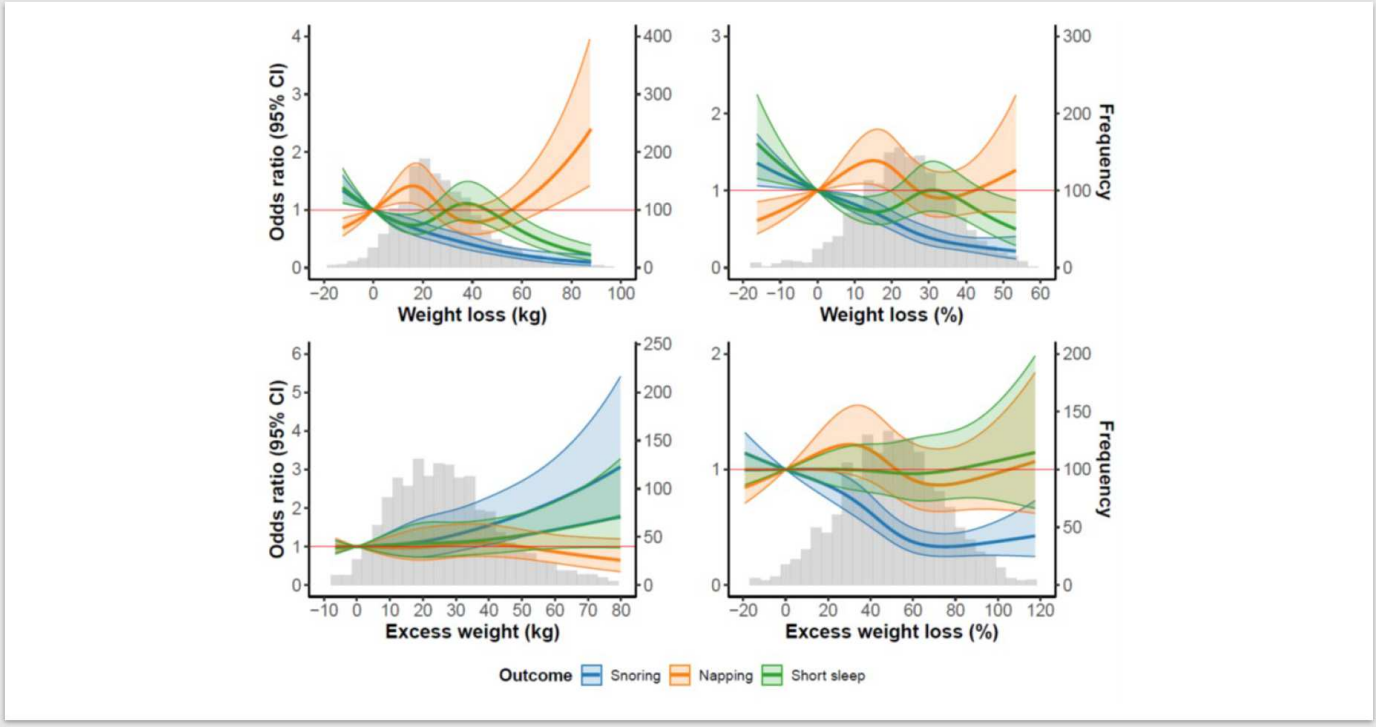


Figure 5

Dose-response relationship of weight loss post-bariatric surgery with snoring, napping and short sleep duration. *Odds ratio was determined based on generalised linear model with inverse probability weighting. Each model was adjusted for age, sex, income, educational status, smoking, physical activity level and dietary pattern.*

Supplementary Files

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- Table1.docx
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