Review

Paradoxical Obesity and Overweight Disparities Among Sexual Minority Men: A Meta-Analysis

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Abstract

This study aims to analyze the prevalence and likelihood of overweight, obesity, and elevated body mass index (BMI) among sexual minority men (i.e., men who have sex with men [MSM], men who have sex with men and women [MSMW], and all sexual minority men), using men who have sex with women (MSW) as the reference group. Studies reporting mean BMIs or prevalence or likelihood of obesity, overweight, or elevated BMI categorized by sexual orientation were included. Data were pooled and analyzed to report mean differences (MDs) of BMIs, prevalence rates, odds ratios (ORs), and their respective 95% confidence intervals (CIs). Forty-three studies were included, with a median of 26,507 participants (median 3.37% sexual minority men). The respective mean overweight, obesity, and elevated BMI prevalence rates among MSM (36%, 23%, and 39%) and MSMW (33%, 27%, and 47%) were lower than those of MSW (44%, 26%, and 55%). This finding was consistent with a significantly lower BMI (MD −1.50 [−1.93, −1.08] kg/m^2) and a decreased likelihood of overweight (OR 0.75 [0.64, 0.88]) and obesity (OR 0.84 [0.78, 0.90]). Sexual minority men present with a lower prevalence and likelihood of obesity and overweight than their heterosexual counterparts. The obesity paradox—a sustained catabolic state presenting with lower BMI—is a feasible explanation for this phenomenon, although further research exploring paradoxical cardiovascular findings is granted.

Keywords

obesity, overweight, elevated BMI, men who have sex with men, sexual minorities, prevalence, obesity paradox, meta-analysis

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Introduction

Obesity is a complex, multidimensional, metabolic disease associated with serious cardiovascular diseases (CVDs), including hypertension, dyslipidemias, and type 2 diabetes mellitus (Flegal et al., 2013; Singh-Manoux et al., 2018). CVD continues to be the leading cause of morbidity and mortality worldwide (Caceres et al., 2020). The body mass index (BMI) is the weight-for-height index most widely used to assess weight status in clinical and epidemiological settings. Despite a better understanding of obesity pathogenesis and management, the prevalence rate of elevated BMI (≥25.0 kg/m^2, i.e., combined overweight and obesity) has shown an upward global trend (Dai et al., 2020). Since 1975, worldwide prevalence rates of elevated BMI have tripled; and estimates from 2016 show that 39% of adults had an elevated BMI while 13% were obese (BMI ≥30.0 kg/m^2; WHO, 2020). In the United States, the crude prevalence rate of

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obesity among adults was estimated at 39.8%, an increase by 9.1% from 1999 (Hales et al., 2017).

Obesity prevalence rates peak between 40 and 60 years of age. Adult women in the United States are more likely to be obese than men (Hales et al., 2017; Purnell, 2000). Worldwide, men present with higher mortality rates and more disability-adjusted life years (DALYs) associated with elevated BMI (Dai et al., 2020). Data from the United States indicate that since 1960, the prevalence rate of overweight (BMI $\geq$25.0 and $<$30.0 kg/m^2) slowly decreased, while the prevalence of obesity and severe obesity (BMI $\geq$40.0 kg/m^2) increased for both genders, more noticeably for men (Fryar et al., 2018).

Among men, a handful of studies have addressed the issue of weight disparities by sexual orientation. Caceres et al. (2017) reviewed 15 studies reporting weight disparities among sexual minority men. The review identified two-thirds of the studies reporting a decreased likelihood of elevated BMI among sexual minority men compared with their heterosexual counterparts (Caceres et al., 2017). The reasons for these disparities can be framed within the Minority Stress Theory, which posits that sexual minority health disparities result in large part from life of stressors induced by nonconformity to a heteronormative environment (Meyer, 2003). These life stressors include general life events (e.g., financial adversity), structural and institutional factors (e.g., laws, policies, and social norms), interpersonal factors (e.g., discrimination, stigma, and violence), and intrapersonal factors (e.g., self-stigma and concealment; Meyer, 2003). Flentje et al. (2020) conducted a systematic review that identified three studies associating 13 minority stressors with changes in the BMI in 31% of these comparisons. Changes in cortisol levels have been posited as a plausible biobehavioral mechanism linking life stressors to poor cardiovascular outcomes (Huebner et al., 2021). The impact of life stressors on biopsychosocial drivers of CVD in general—and obesity in particular—is such that the American Heart Association incorporated them in the conceptual model for cardiovascular health disparities among sexual minority adults (Caceres et al., 2020), and the disparities in obesity prevalence and CVD outcomes are subject of a growing research agenda (cf. VanKim & Laska, 2021).

Sexual minority men seem to present with an overall decreased prevalence of elevated BMI (VanKim & Laska, 2021), which does not necessarily translate into a healthier cardiometabolic status. The obesity paradox in CVD asserts that overweight or class I obese (BMI $\geq$30.0 but $<$35.0 kg/m^2) persons may have better CVD outcomes compared with normal-weight (18.5 $\leq$ BMI $<$25.0 kg/m^2) or underweight (BMI $<$18.5 kg/m^2) persons (Antonopoulos & Tousoulis, 2017; Carbone et al., 2019). The poor prognosis for individuals with normal or underweight may be a result of a progressive and sustained catabolic state, with weight loss resulting from disproportionate loss of lean mass (Elagizi et al., 2018). Among sexual minority men, cardiovascular outcomes often associated with obesity—such as hypertension, diabetes, and dyslipidemias (Caceres et al., 2017; López Castillo et al., 2021)—are more prevalent. A first explanation of this paradoxical phenomenon is consistent with life stressors. Sexual minority men report an increased drive for muscularity (Calzo et al., 2013) and more weight-related stigma (Fulton & Srinivasan, 2021; Puhl et al., 2019), which partially explain motivations and behaviors to actively avoid an elevated BMI. A second explanation involves a higher prevalence of HIV infection among sexual minority men. Man-to-man sexual contact continues to be the dominant HIV transmission mechanism (81% of new infections in 2018), with an all-time-high linkage to and retention in antiretroviral therapy (ART; 65% and 49%, respectively) (Centers for Disease Control and Prevention [CDC], 2022). Approximately half of people living with HIV will develop central fat accumulation soon after starting ART (Grunfeld et al., 2010) and both HIV infection and ART are associated with significantly increased BMI, waist circumference, overweight and obesity, and prevalence of abdominal obesity (Nduka et al., 2016; Sarkar & Brown, 2000; Shlay et al., 2007). Cortisol has also been described as a mediator of obesity among people living with HIV receiving ART and developing this Cushing syndrome–like reaction (Stanley & Grinspoon, 2012).

Although previous descriptive work reported disparate prevalence rates of overweight and obesity among sexual minorities (Caceres et al., 2017; Flentje et al., 2020), to date, these disparities have not been quantified using meta-analytic techniques. Given the importance of accurate estimates to advance efforts preventing CVD in populations at increased risk, such as sexual minority men, the current meta-analysis aims to summarize the prevalence and likelihood of overweight, obesity, and elevated BMI among sexual minority men, using men who have sex with women (MSW) as the reference group.

Method

Protocol and Registration

The full keyword search and study research questions were prospectively published in the International Prospective Register of Systematic Reviews (PROSPERO; University of York, United Kingdom; Registration CRD42020213163). The Institutional Review Board (IRB) at the University of Central Florida reviewed the PROSPERO study protocol and determined it did not meet the definition of research involving human subjects and, thus, IRB review and approval were not required (STUDY00002927).

Data Sources and Keyword Search

The keyword search was created, reviewed, and conducted in the following four databases using the native search interface from their date of inception until December 2020: the Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycINFO, the Web of Science, and PubMed. Keyword variants for the MSM population ([[gay OR bisexual OR homosexual OR heterosexual] AND men] OR ["men who have sex with men" OR MSM]) and for the outcome of interest the keywords "obesity" and "overweight" were used. The reference lists of the selected articles were also manually searched for additional relevant records.

Inclusion Criteria

Only original research articles in peer-reviewed publications were included for analysis. Besides this criterion, the search was not restricted by dates, language, geographic area, participants' age, or analytic methods as long as the studies complied with the inclusion criteria. Abstracts from the records obtained were reviewed for relevance and included for data extraction if (a) the article analyzed primary or secondary data sources; (b) the population studied included sexual minority men (either as a single, aggregated category or categorized as men who have sex with men [MSM] and/or men who have sex with men and women [MSMW] as separate categories) defined by either behavior, identity, attraction, or a combination of these; (c) the article reported analyses or subanalyses of obesity, overweight, or elevated BMI specific to sexual minority men; (d) the article included a quantifiable population of MSW, defined by either behavior, identity, attraction, or a combination of these, that could be used as a reference group; and (d) regardless of statistical significance, the article reported at least one measure of prevalence, aggregated descriptive measures of obesity, overweight, or elevated BMI (including, but not limited to BMI or abdominal circumference), or inverse variance measures (i.e., odds ratio [OR], prevalence ratio [PR], or their respective regression coefficients [β] in the case of generalized linear regression models). Because nonbinary and/or transgender populations are both small and diverse, records focusing exclusively on these populations were excluded to reduce the risk of misclassification and to avoid underpowered comparisons.

Abstraction Process

Articles were reviewed, extracted, synthesized, and study quality was assessed by four reviewers (SC, DV, NN, and IB). Every record was independently reviewed by at least two reviewers to calculate agreement metrics (i.e., Holsti's percentage concordance and Cohen's kappa; Cohen, 1968; Holsti, 1969). Disagreements were resolved by a fifth reviewer (HLC) in consultation with the original reviewers.

When reported, demographic measures of the studies' samples (including, but not limited to, proportion of men and women included, sampling methods, data source, and distribution by age, race/ethnicity, geographic location, and sexual orientation) were extracted for context to understand the role of potential biases and confounders. The keyword search, data abstraction, and study inclusion followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Liberati et al., 2009).

Measures

Sexual Orientation. Self-reported sexual identity and attraction (whether romantic or sexual) often—although not always—align with self-reported sexual behavior (Wolff et al., 2017). Thus, the sexual minority populations to be included (i.e., sexual minority men, MSM, and/or MSMW) were defined preferably through behavioral measures of sexual orientation and, when other measures of sexual orientation were available (i.e., self-reported sexual identity, sexual or romantic attraction, or a combination of these), these were included and assumed to be mostly concordant.

Overweight, Obesity, and Elevated BMI. The authors extracted data from studies reporting mean (standard deviation [*SD*]) values for BMI (in kg/m^2) or mean abdominal circumference (in cm). Prevalence measures of overweight, obesity, and elevated BMI were extracted from self-reported lifetime diagnosis of overweight or obesity (yes/no), crude and/or adjusted measures of prevalence, and inverse variance measures. All studies used the standard calculation for BMI (weight in kg/[height in m]^2) and the agreed-upon categories for overweight (BMI $\geq$25.0 and $<$30.0 kg/m^2), obesity (BMI $\geq$30.0 kg/m^2), severe obesity (BMI $\geq$40.0 kg/m^2), and elevated BMI ($\geq$25.0 kg/m^2, i.e., combined overweight and obesity).

Bias Assessment

Recommendations for bias assessment in observational studies (Hammer et al., 2009) were followed by using a bias assessment tool evaluating the risk of selection, information, and response bias in each article included. In addition, the risk of confounding by four factors (namely, age, education, income, and HIV serostatus) was assessed for each study.

Statistical Analyses

Three, separate meta-analyses were conducted for studies reporting crude or adjusted mean BMI; crude or adjusted prevalence rates of overweight, obesity, or elevated BMI; and crude or adjusted measures of inverse variance. Mean BMIs were pooled and compared using mean differences (MD) with their respective 95% CIs. Prevalence and inverse variance measures were pooled, and weights were assigned to each study using the reciprocal of their variance. All meta-analyses were conducted assuming random effects. As age can operate as a confounder, we conducted an exploratory meta-regression of prevalence and inverse variance measures on age for those studies reporting mean age.

Forest plots were generated by Review Manager v. 5.4.1 (The Cochrane Collaboration; Copenhagen, Denmark) and are presented as supplementary figures following the best practices for forest plots (Higgins et al., 2011). Meta-regressions of prevalence estimates by age were generated with Comprehensive Meta-Analyses v. 3.0 (Biostat, Inc.; Englewood, NJ). Heterogeneity for study comparisons was determined through I^2 (Lin & Chu, 2018), and funnel plot analyses were conducted to assess for study heterogeneity, reporting bias, and chance (Sterne et al., 2011).

Results

The keyword and manual search strategy identified 325 unique records. Titles and abstracts independently screened by four reviewers were found with moderate Holsti's concordance ($r = .750$) and moderate Cohen's κ (mean $\kappa = .513$; range .445–.578). After resolution of disagreements through discussion and consensus, the full text of 111 records was reviewed for compliance with inclusion criteria. Sixty-eight studies were excluded, mostly due to lack of specific subanalyses of sexual minority men ($n = 27$) or lack of original research with primary or secondary data sources ($n = 17$). Supplementary Figure S1 summarizes the PRISMA sequence for screening steps, concluding with the inclusion of 43 studies for meta-analytic comparisons.

The 43 studies included (Table 1) were published between 1996 and 2020; and almost half of them ($n = 21$) were published within the last five years of that date range (i.e., 2016-2020). Despite the lack of language restriction in this search, all studies were published in English and used secondary data from country- or state-level surveys. Most studies ($n = 38$) were conducted in the United States, two in the United Kingdom (Calzo et al., 2018; Conner et al., 2004), one each in Canada (Brennan et al., 2010) and Denmark (Frisch & Zdravkovic, 2010), and one multinational study across Brazil, Mexico, and the United States (Nyitray et al., 2019). Twenty-five of the 38 studies conducted in the United States were nationally representative; 12 were conducted at the state level (7 in California, 2 in Washington, and 1 each in Massachusetts, Minnesota, and Oregon), and one at an unspecified northeastern university college. All studies had an observational design and analyzed cross-sectional, single-timepoint data.

The number of male participants ranged between 58 (Conner et al., 2004) and 11,767,858 (Deputy & Boehmer, 2010) with a median (interquartile range [IQR]) of 26,507 (5,710, 63,704) participants. The percentage of sexual minority men included in the studies as a proportion of all male participants ranged from 0.07% (Frisch & Zdravkovic, 2010) to 79.64% (Davids & Green, 2011), with a median (IQR) of 3.37% (2.63%, 4.70%).

Mean BMI

Figure 1 presents the forest plot from the 12 studies reporting BMI means and their respective variance for the populations of interest. For these studies, the overall MDs (95% CIs) by subgroups were −2.00 (−4.35, 0.36) kg/m^2 for all sexual minority men (Subgroup 1.A), −1.50 (−1.93, −1.08) kg/m^2 for MSM (Subgroup 1.B), and 0.12 (−1.55, 1.78) kg/m^2 for MSMW (Subgroup 1.C.). Overall, heterogeneity for the subgroup comparisons was high (I^2=99%) with a statistically significantly lower BMI (MD −1.42; 95% CI [−1.88, −0.95 kg/m]^2) for the pooled subgroup analysis.

Prevalence Estimates

Table 2 presents a summary of the point estimates of prevalence rates for overweight, obesity, and elevated BMI by sexual orientation for all studies included. Study-by-study forest and funnel plots are presented in Supplementary Figures S2 and S3, respectively.

Crude prevalence rates were calculated from the studies reporting sexual orientation-specific data for overweight ($n = 16$), obesity ($n = 26$), and elevated BMI ($n = 5$). Crude prevalence estimates for all three outcome categories (i.e., overweight, obesity, and elevated BMI) for sexual minority men, MSM, and MSMW were consistently lower than the respective outcome estimates for MSW. Statistically significant lower crude prevalence rates were identified for overweight and obesity estimates but not for the crude prevalence rate of elevated BMI.

Given that age can confound prevalence estimates of the outcomes of interest, crude prevalence estimates were adjusted through an exploratory meta-regression across studies reporting mean age using random-effects estimation (Table 3). Meta-regression showed that the effect of age increases with BMI. While age did not show a tangible overall effect on the prevalence of overweight (R^2 analog = 0), small and moderate effects were

Table 1. Characteristics of the 43 Studies Included in the Meta-Analysis.

Author(s), year	Study site	Data source	Objective	Measure of obesity	Measure of sexual orientation	Gender	Male participants[a]		
							Sexual orientation	Age (*y*)	Race/ethnicity
Austin et al., 2009[b]	United States	1998–2005 GUTS	To describe how sexual orientation–related weight-status patterns may vary by gender and age from early through middle to late adolescence.	BMI calculated from self-reported height and weight.[c] Reported as likelihood of elevated BMI.[d]	Combined sexual identity and attraction. Reported as H, mostly H, B, G, or not sure.	22,161 M 34,829 W	93.85% H 4.26% mostly H 0.51% B 1.30% G	12–14: 24.83% 15–16: 23.00% 17–18: 20.44% 19–20: 15.99% 21–23: 10.60%	NR
Azagba et al., 2019	United States	2014–2017 BRFSS	To examine whether overweightness and obesity vary by sexual minority subgroup.	BMI calculated from self-reported height and weight. Reported as likelihood of obesity[f] and elevated BMI.[d]	Sexual identity. Reported as H, G, B, and other/don't know/not sure.	346,681 M 369,928 W	Total[g] 48.5% H 60.9% LG 35.4% B 41.6% other	Total[g] 18–24: 11.86% 25–34:15.80% 35–44: 16.04% 45–54: 17.65% 55–64:17.64% ≥65: 20.98%	Total[g] White: 65.17% H/L: 15.20% AA/B: 11.52% Others: 8.11%
Bankoff et al., 2016	United States	Knowledge Networks-GfK Research Panel	To examine the associations between sexual orientation, BMI, disordered eating behaviors, and food addiction in a sample of male veterans.	BMI calculated from self-reported height and weight. Reported as $\bar{X}$ (*SD*) BMI.	Sexual identity. Reported at H and sexual minority (G, B, and other).	642 M	96.26% H 3.74% sexual minority	$\bar{X}$ (*SD*) 64.11 (11.20) min 22 max 89	White: 85.5%
Beach et al., 2018	United States	2014 BRFSS	To compare the prevalence of self-reported diabetes and diabetes risk factors among adult sexual minority and heterosexual populations.	BMI calculated from self-reported data. Reported as prevalence of overweight[e] and obesity.[f]	Sexual identity. Reported as H, G, and B.	60,689 M 85,939 W	97.13% H 1.75%G 1.12% B	18–29: 10.41% 30–39: 10.32% 40–49: 13.84% 50–64: 33.76% ≥65: 31.03% Missing 0.64%	White: 81.94% AA/B: 5.85% H/L: 3.45% Others: 7.27% Missing: 1.49%
Blosnich et al., 2014	10–state sample in the United States	2010 BRFSS	To compare health indicators by gender and sexual orientation statuses.	BMI calculated from self-reported height and weight. Reported as $\bar{X}$ (*SD*) BMI and prevalence and likelihood of overweight[e] and obesity.[f]	Sexual identity. Reported as H, G, and B.	34,124 M	97.40% H 1.92% G 0.68% B	H $\bar{X}$(*SD*) 45.1 (0.19) G $\bar{X}$ (*SD*) 42.7 (1.22) B $\bar{X}$(*SD*) 41.9 (2.08)	White: 79.85% AA/B: 2.24% H/L: 9.82% Others: 7.02%
Blosnich et al., 2016	United States	2003–2011 MEPS	To examine associations between sexual minority status and medical conditions.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of overweight,[e] obesity,[f] and elevated BMI.[d]	Partnership or marriage. Reported as same- and opposite-sex partnerships or marriages.	496 M 492 W	50.00% opposite-sex partnered 50.00% same-sex partnered	NR	NR
Boehmer et al., 2012	California, United States	2001, 2003, & 2005 CHIS	To identify differences by sexual orientation in health behaviors of cancer survivors.	BMI calculated from self-reported height and weight. Reported as $\bar{X}$ (*SD*) BMI and prevalence and likelihood of elevated BMI.[d]	Sexual identity. Reported as H, G, and B.	3,690 M 7,252 W	94.20% H 4.39% G 1.41% B	H $\bar{X}$ (*SD*) 59.9 (0.3) G $\bar{X}$ (*SD*) 49.8 (1.2) B $\bar{X}$ (*SD*) 57.4 (1.5)	White: 84.36% H/L: 6.61% Asian: 3.01% AA/B: 2.90% Other: 3.06
Boehmer et al., 2014	California, United States	2001, 2003, 2005, & 2007 CHIS	To estimate the prevalence of health conditions among young, middle age, and older age groups to examine sexual orientation differences while stratifying by gender.	BMI calculated from self-reported height and weight. Reported as prevalence of elevated BMI.[d]	Sexual identity. Reported as H, G, and B.	66,109 M 93,242 W	95.78% H 3.06% G 1.16% B	20–39: 46.39% 40–59: 41.25% ≥60: 12.37%	White: 50.51% H/L: 26.14% Asian: 11.69% AA/B: 5.20% Other: 6.07%
Brennan et al., 2010	Canada	2003 CCHS	To determine whether health status and health risk behaviors of Canadian men vary based on sexual orientation identity.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of elevated BMI.[d]	Sexual identity. Reported as H, G, and B.	49,901 M	98.32% H 1.07% G 0.60% B	H $\bar{X}$(95% CI) 44.4 (44.3, 44.5) G $\bar{X}$ (95% CI) 39.9 (38.4, 41.4) B $\bar{X}$(95% CI) 39.3 (36.5, 42.1)	NR
Brown & Keel, 2015	Northeastern United States	Waves 3 and 4 of a longitudinal study at a northeastern university in 1982, 1992, and 2002 and followed at 10-year intervals.	To examine how romantic relationships impact the trajectory of eating pathology in gay and bisexual versus heterosexual men.	BMI calculated from self-reported height and weight. Reported as $\bar{X}$ (*SD*) BMI.	Sexual identity. Reported as H, G, and B.	573 M	91.10% H 8.90% GB	H $\bar{X}$ (*SD*): 29.41 (8.65) GB $\bar{X}$ (*SD*): 27.40 (9.09)	NR

(continued)

Table 1. (continued)

Author(s), year	Study site	Data source	Objective	Measure of obesity	Measure of sexual orientation	Gender	Male participants[a]		
							Sexual orientation	Age (y)	Race/ethnicity
Caceres et al., 2018	United States	2001–2012 NHANES	To examine sexual orientation differences in modifiable risk factors for CVD and CVD diagnoses in men.	BMI calculated from measured height and weight. Reported as prevalence and likelihood of obesity.[f]	Combined sexual identity and behavior. Reported as exclusively H, H-identified MSM, G, and B.	7,731 M	94.31% exclusively H 2.32% H-identified MSM 1.90% G 1.51% B	20–29: 24.8% 30–39: 24.9% 40–49: 26.3% 50–59: 23.9%	White: 70.4% AA/B: 10.2% H/L: 14.1% Other: 5.3%
Caceres et al., 2019	United States	2014–2016 BRFSS	To investigate sexual orientation differences in CVD risk and CVDs.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of obesity.[f]	Sexual identity. Reported as H, G, and B.	177,096 M 218,058 W	97.03% H 2.03% G 1.25% B	18–24: 10.63% 25–34: 16.46% 35–44: 16.81% 45–54: 19.13% 55–64: 18.88% ≥65: 18.65%	White: 69.90% AA/B: 10.41% H/L: 12.31% Other: 7.37%
Caceres et al., 2022	United States	2001–2016 NHANES	To examine racial/ethnic differences in physiological risk factors for CVD among sexual minority and heterosexual adults.	BMI calculated from measured height and weight. Reported as $\bar{X}$ (*SD*) BMI and prevalence of overweight[e] and obesity.[f]	Sexual identity. Reported as H, G, B, and not sure/something else.	11,310 M 10,995 W	95.5% H 1.94% G 1.48% B 1.34% not sure	H $\bar{X}$ (*SD*) 38.8 (0.2) G $\bar{X}$ (*SD*) 40.5 (1.2) B $\bar{X}$ (*SD*) 38.6 (1.2) Not sure $\bar{X}$ (*SD*) 40.6 (1.3)	White: 66.91% AA/B: 11.62% H/L: 17.05%
Calzo et al., 2018	United Kingdom	1991–1992 ALSPC	To examine the associations of sexual orientation and eating disorder symptoms among adolescents.	BMI calculated from measured height and weight. Reported as prevalence of overweight[e] and obesity.[f]	Combined sexual identity and attraction. Reported as: completely H, mostly H, and combined GB.	2,367 M 2,681 W	91.30% completely H 6.17% mostly H 2.53% GB	NR	White: 93%
Conner et al., 2004	England, United Kingdom	Primary data collection in bars in Leeds, England	To examine the impacts of gender and sexual orientation on eating motives and eating styles in addition to body image.	BMI calculated from self-reported height and weight. Reported as $\bar{X}$ (*SD*) BMI.	Sexual identity. Reported as H and G.	58 M 63 W	51.72% H 28 48.28% G	H $\bar{X}$ (*SD*) 23.1 (3.27) G $\bar{X}$ (*SD*) 23.9 (4.41)	NR
Conron et al., 2010	Massachusetts, United States	2001–2008 State BRFSS	To provide estimates of several leading US adult health indicators by sexual orientation identity and gender.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of overweight[e] and obesity.[f]	Sexual identity. Reported as H, G, and B.	26,507 M 40,852 W	95.77% H 3.48% G 0.73% B	18–33: 22.20% 34–49: 41.31% 50–64: 36.49%	White: 82.17% AA/B: 4.92% H/L: 8.34% Asian: 2.92% Other: 1.66%
Davids & Green, 2011	United States	Online Survey from various recruitment sites	To examine psychological predictors of body dissatisfaction and eating disorder symptoms among gay, bisexual, and heterosexual men.	BMI calculated from self-reported height and weight. Reported as $\bar{X}$ (*SD*) BMI.	Sexual identity. Reported as H, G, and B.	167 M 272 W	20.36% H 57.49% G 22.16% B	H $\bar{X}$ (*SD*) 23.74 (7.08) G $\bar{X}$ (*SD*) 26.28 (8.53) B $\bar{X}$ (*SD*) 33.22(13.95)	Lost due to error in software data collection program.
Deputy & Boehmer, 2010	California, United States	2005 CHIS	To investigate eating habits and exercise behaviors as mediators in the relationship between sexual orientation and BMI in men.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of overweight[e] and obesity.[f]	Sexual identity. Reported as H and sexual minority (GB).	14,982 M, unweighted 11,767,858 M, weighted	96.39% H 3.61%14 sexual minority men	H $\bar{X}$ 40.5 Sexual minority men $\bar{X}$ 39.9	White 58.46% Non-White 41.64%
Deputy & Boehmer, 2014	California, United States	2007–2011 CHIS	To determine differences in weight at age 18 y and at current age and weight change by sexual orientation within different racial/ethnic populations, stratifying by gender.	BMI calculated from self-reported height and weight. Reported as likelihood of elevated BMI.[d]	Sexual identity. Reported as H, G, and B.	54,095 M 66,179 W	95.89% H 3.03% G 8.08% B	H $\bar{X}$ (*SE*) 40.7 (60.0) G $\bar{X}$ (*SE*) 40.7 (60.4) B $\bar{X}$ (*SE*) 40.1 (60.9)	White: 55.68% H/L: 27.81% Asian: 10.57% AA/B: 6.31%
Dilley et al., 2010	Washington, United States	2003–2006 State BRFSS	To identify health disparities for a statewide population of LGB men and women compared with their heterosexual counterparts.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of elevated BMI.[d]	Sexual identity. Reported as H, G, and B.	30,845 M 48,655 W	97.62% H 1.61% G 0.76% B	18–29: 22.14% 30–39: 20.09% 40–49: 20.96% 50–59: 17.68% 60–69: 4.45% ≥70: 0.90%	White: 83.76% AA/B: 2.19% Asian/PI: 4.07% NA: 1.41% Other: 0.40% Multi: 0.20% H/L 8.04%

(continued)

Table 1. (continued)

Author(s), year	Study site	Data source	Objective	Measure of obesity	Measure of sexual orientation	Gender	Male participants[a]		
							Sexual orientation	Age (y)	Race/ethnicity
Epel et al., 1996	United States	Random sample of 500 personal ads published in 1992 from 7 publications serving the groups of interest.	To assess body shape ideals across gender, sexual orientation, race, SES, and age.	BMI calculated from self-reported height and weight. Reported as $\bar{X}$ (*SD*) BMI and prevalence of elevated BMI.[d]	Sexual identity. Reported as H, G, and B.	140 M[h] 48 W	75.71% H 24.29% G	Total[g] $\bar{X}$ (*SD*) 42.3 (14.0)	White or mostly white
Everett & Mollborn, 2013	United States	Wave IV AddHealth	To determine if gay and bisexual persons are more likely to be hypertensive than heterosexual-identified persons and to assess if indicators of victimization and discrimination, cardiovascular risk factors explain differences in hypertension by sexual orientation.	BMI calculated from measured height and weight data. Reported as prevalence of overweight[e] and obesity.[f,i]	Combined sexual identity and attraction. Reported as H, B/mostly H, and G/mostly G.	6,678 M 7,555 W	93.41% completely H 4.06% B/mostly H 2.67% G/mostly G	NR	NR
Frederick & Essayli, 2016	United States	Five surveys posted on the official news website of for two weeks each in 2003, 2006, 2010, 2011, and 2012.[j]	To examine the extent to which gay and heterosexual men differed on measures related to body image.	BMI calculated from self-reported height and weight. Reported as $\bar{X}$ (*SD*) BMI and prevalence of elevated BMI[d] and obesity.[f]	Sexual identity. Reported as H and G.	**Study 1.** 2003 Sex and Body Image Survey. 27 237 M	94.41% H 5.59% G	H $\bar{X}$ (*SD*) 37 (12) G $\bar{X}$ (*SD*) 35 (10)	NR
						Study 2. 2010 Sex, Stress, and Success Survey. 11 470 M	97.11% H 2.89% G	H $\bar{X}$ (*SD*) 45 (12) G $\bar{X}$ (*SD*) 40 (12)	NR
						Study 3. 2012 TV Viewing Habits Survey. 3237 M	87.12% H 12.88% G	H $\bar{X}$ (*SD*) 50 (11) G $\bar{X}$*SD*) 47 (11)	NR
						Study 4. 2006 Sex and Relationship Survey. 32,080 M	97.72% H 2.28% G	HV(*SD*) 40 (11) G $\bar{X}$ (*SD*) 38 (10)	White: 89.98% AA/B: 2.98% H/L 3.02% Asian 2.00% Other 2.02%
Fredriksen-Goldsen et al., 2013	Washington, United States	2003–2010 State BRFSS	To investigate health disparities among LGB adults aged ≥50 y.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of obesity.[f]	Sexual identity. Reported as H, G, B, and something else.	37,820 M 58,319 W	98.21% H 1.22% G 0.57% B	Range 50–98 H $\bar{X}$ (*SD*) 62.35 (0.07) G $\bar{X}$ (*SD*) 59.26 (0.45) B $\bar{X}$ (*SD*) 60.22 (0.75)	White: 90.45%
Fricke et al., 2019	California, United States	2008, 2011, and 2014–2015 Kaiser Permanente Northern California Member Health Surveys	To test if sexual minorities were less likely than heterosexuals to meet the physical activity guidelines.	BMI calculated from measured height and weight. Reported as prevalence of obesity.[f]	Sexual identity. Reported as H or sexual minority (GB).	19,392 M 23,142 W	95.51% H 4.49% sexual minority men	20–44: 25.07% 45–64: 33.16% 65–79: 35.59% ≥80: 6.18%	White: 65.08% AA/B: 5.35% H/L: 10.77% Asian: 15.93% Other: 2.68%
Fricke & Sironi, 2020	United States	Waves III and IV of AddHealth	To analyze the effect of depression on sexual identity change and BMI, obesity, and physical activity.	BMI calculated from self-reported height and weight. Reported as prevalence of obesity.[f]	Combined sexual identity and attraction. Reported at H, mostly H, B, mostly G, and G.	5,400 M 5,949 W	93.6% H 3.5% mostly H 0.5% B 0.7% mostly G 1.7% G	$\bar{X}$ 28.9	White: 66.5% AA/B: 13.8% H/L: 12.0% Asian: 3.8% Other: 3.9%
Frisch & Zdravkovic, 2010	Denmark	Civil Registration System	To study the associations between weight, length, and body mass index (BMI) at birth and same-sex marriage in young adulthood.	BMI calculated from measured height and weight. Reported as $\bar{X}$ (*SD*) BMI.	Partnership or marriage. Reported as same- and opposite-sex partnerships or marriages.	419,112 M 399,400 W	99.93% opposite-sex partnered 0.07% same-sex partnered	NR	NR

(continued)

Table 1. (continued)

Author(s), year	Study site	Data source	Objective	Measure of obesity	Measure of sexual orientation	Gender	Male participants[a]		
							Sexual orientation	Age (y)	Race/ethnicity
Garland-Forshee et al., 2014	Oregon, United States	2005–2008 State BRFSS	To examine health-related disparities among LGB men and women compared with heterosexual men and women.	BMI calculated from self-reported height and weight. Reported as likelihood of obesity.[f]	Sexual identity. Reported as H, G, B, and other.	16,475 M 26,271 W	97.63% H 1.63% G 0.75% B	18–34: 31.86% 35–54: 38.26% >55: 29.89%	White: 85.93% All other races & H/L: 14.07%
Gonzales & Henning-Smith, 2017	United States	2014–2015 BRFSS	To examine differences by sexual orientation in an array of health outcomes and health risk factors.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of obesity.[f]	Sexual identity. Reported as H, G, and B.	129,343 M 179,203 W	97.01% H 1.83% G 1.16% B	18–24: 13.07% 25–34: 16.20% 35–44: 16.21% 45–54: 18.25% 55–64: 17.31% ≥65: 18.57%	White: 70.59% AA/B: 11.20% H/L: 10.16% Other/multi: 6.42%
Gorman et al., 2015	United States	2005–2010 BRFSS	To evaluate how health reports and social advantage operate before and after adjustment for established health risk factors by sexual orientation.	BMI calculated from self-reported height and weight. Reported as prevalence of overweight[e] and obesity.[f]	Sexual identity. Reported as H, G, B, and other/don't know	162,475 M 252,798 W	97.20% H 2.09% G 0.72% B	H $\bar{X}$ (*SD*) 43.9 (15.2) G $\bar{X}$ (*SD*) 42.7 (13.5) B $\bar{X}$ (*SD*) 38.0 (13.9)	White: 63.29% AA/B: 4.80% H/L: 20.86% Asian: 8.45% Other: 2.60%
Hatzenbuehler et al., 2013	United States	Wave IV AddHealth	To determine whether sexual orientation disparities in biomarkers of early CVD risk are present among young adults.	BMI calculated from measured height and weight. Reported as $\bar{X}$ (*SD*) BMI.	Sexual identity. Reported as H and GB.	6,438 M 6,013 W	96.69% H 3.31% GB	H $\bar{X}$ (*SD*) 29.03 (0.12) GB $\bar{X}$ (*SD*) 29.04 (0.19)	AA/B: 14.45% Asian: 3.11% H/L: 11.23% Multi, NA, other: 5.56% White 65.64%
Heck & Jacobson, 2006	United States	1997 – 2004 NHIS	To examine ever and current asthma diagnosis among persons in same-sex relationships.	BMI calculated from self-reported height and weight. Reported as prevalence of overweight[e] and obesity.[f]	Partnership or marriage. Reported as same- and opposite-sex partnerships or marriages.	61,298 M 68,196 W	99.30% opposite-sex partnership 0.70% same sex partnership	18–29 11.64% 30–39: 23.08% 40–49: 24.32% ≥50: 41.06%	White: 77.42% AA/B: 8.60% H/L: 10.49% Other: 4.00%
Jackson et al., 2016	United States	2013–2014 NHIS	To investigate the relationship between sexual orientation identity and health among US women and men.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of overweight[e] and obesity.[f]	Sexual identity. Reported as H, G, B, and something else/don't know.	30,961 M 38,309 W	96.79% H 2.02% G 0.52% B 067% something else/don't know	Range 18 to >85	White: 62.55% AA/B: 12.97% H/L: 15.84% NA: 1.31% Asian/PI: 6.19%
Laska et al., 2015	United States	2007–2011 CSHS	To assess disparities in weight and weight-related behaviors among college students by sexual orientation and gender.	BMI calculated from self-reported height and weight. Reported as prevalence of overweight[e] and obesity.[f,g,h]	Combined sexual identity and behavior. Reported as H, discordant H, G, B, and unsure.	12,498 M 21,384 W	93.05% H 0.85% discordant H 2.89% G 1.61% B 1.60% unsure	18–20: 32.83% 21–24: 33.89% ≥25: 33.31%	White: 80.76% AA/B: 4.27% Asian: 7.08% H/L: 2.26% Multi/other: 4.02%
Newlin Lew et al., 2018	United States	2014 BRFSS	To assess the prevalence and related ORs for obesity, prediabetes, and diabetes in sexual minority men compared with straight men.	BMI calculated from self-reported height and weight. Reported as prevalence and likelihood of obesity.[f]	Sexual identity. Reported as H, G, and B.	53,542 M	97.00% H 2.00% G 1.00% B	18–24: 10.87% 25–34: 16.85% 35–44: 16.10% 45–54: 19.51% 55–64: 18.13% ≥65: 18.54%	White: 80.24% AA/B: 11.99% H/L: 7.71%
Nyitray et al., 2019	Brazil, Mexico, and United States	Anal canal specimens from men, ages 18–70 y	To study the association between HPV infection and BMI.	BMI calculated from measured height and weight. Reported as prevalence of overweight[e] and obesity.[f]	Sexual behavior. Reported as MSM and MSW.	1,676 M	80.43% MSW 19.57% MSM	18–24: 25.95% 25–34: 31.92% 35–44: 26.91% 45–70: 15.21%	*Race* White: 46.60% AA/B: 14.44% Other: 37.89% Refuse/missing: 1.07% *Ethnicity* H/L = 46.36% Non-Hispanic: 52.57% Refuse/missing: 1.07%
Rosario et al., 2016	United States	1999–2010 GUTS	To examine sexual-orientation disparities in frequent engagement in cancer-related risk indicators of tobacco, alcohol, diet and physical activity, ultraviolet radiation, and STIs.	BMI calculated from self-reported height and weight.[b] Reported as prevalence and likelihood of elevated BMI.[d]	Combined sexual identity and behavior. Reported as completely H, mostly H, G, and B.	3,797 M 6,161 W	90.25% completely H 6.45% mostly H 2.66% G 0.63% B	NR	Total[f] White: 95.4% Minorities: 4.6%

(continued)

Table 1. (continued)

Author(s), year	Study site	Data source	Objective	Measure of obesity	Measure of sexual orientation	Gender	Male participants[a]		
							Sexual orientation	Age (y)	Race/ethnicity
Strutz et al., 2015	United States	Wave IV AddHealth 2008	To describe a wide range of health status and healthcare access characteristics of sexual minorities in comparison with those of the majority population.	BMI calculated from measured height and weight. Reported as prevalence and likelihood of overweight[e] and obesity.[f]	Combined sexual attraction, behavior, and identity. Sexual minorities were reported as those having all three indicators, attraction plus any other indicator, and any one indicator of sexual minority status.	6,020 M 7,068 W	90.50% H 9.50% any one indicator 3.32% all three indicators 3.14% attraction plus	24–27: 34.17% 28–29: 33.16% ≥30: 32.66%	White: 67.16% AA/B: 14.60% H/L: 11.98% Other: 6.36%
Stupplebeen et al., 2019	California, United States	2003–2012 CHIS	To examine whether the association between weight status and four chronic diseases (heart disease, hypertension, lifetime asthma, and type 2 diabetes) varied by sexual orientation identity among adult men.	BMI calculated from self-reported height and weight.[b] Reported as $\bar{X}$ (*SD*) BMI and prevalence of overweight[e] and obesity[f,i,k]	Sexual identity. Reported as H and GB.	72,214 M	95.96% H 4.04% GB	$\bar{X}$ (*SE*) 40.66 (0.09)	H/L: 35.51% White: 46.54% AA/B: 5.6% Asian: 12.35%
Trinh et al., 2017	United States	2013–2015 NHIS	To analyze the health behaviors and outcomes and use of health care services by sexual and racial/ethnic minorities compared with white heterosexuals.	BMI calculated from self-reported height and weight.[b] Reported as prevalence of overweight[e] and obesity.[f]	Sexual identity. Reported as H and sexual minority (GB).	41,059 M 50,854 W	97.9% H 2.1% sexual minority	Total[g] $\bar{X}$ (*SD*) 47 (0.14)	White: 68.56% AA/B: 13.35% H/L: 18.09%
Tuthill et al., 2020	United States	2005–2010 BRFSS	To examine how health status and health behavior vary within and across LGB men and women.	BMI calculated from self-reported height and weight.[b] Reported as prevalence of obesity.[f]	Sexual identity. Reported as H, G, B, and other/don't know	223,675 M 334,098 W	97.39% H 1.91% G 0.70% B	NR	White: 81.82% AA/B: 5.91% H/L: 8.38% Asian/PI: 2.10% NA: 1.79%
VanKim et al., 2020	Minnesota, United States	2009–2013 State CSHS	To examine the relationship between the college LGB climate, including campus-based policies and resources, and obesity across sexual orientation groups.	BMI calculated from self-reported height and weight.[b] Reported as prevalence and likelihood of overweight[e] and obesity.[f]	Combined sexual identity and behavior. Reported as H, discordant H, G, B, and unsure.	10,368 M 18,219 W	92.85% H 0.68% discordant H 3.24% G 1.53% B 1.70% unsure	NR	NR
Wolstein et al., 2018[l]	United States	2011–2014 CHIS	To examine differences in health care access, health behaviors, and health outcomes by sexual orientation among California adults.	BMI calculated from self-reported height and weight.[b] Reported as prevalence and likelihood of obesity.[f]	Sexual identity. Reported as H, G, B, and other.	14,489, 000 M 15,344,000 W	93.6% H 3.4% G 2.6% B 0.4% other	Range: 18–70	NR

Note. GUTS = growing up today study; BMI = body mass index; H = heterosexual; B = bisexual; G = gay; M = men; W = women; NR = not reported; BRFSS = behavioral risk factor surveillance system; H/L = Hispanic/latinx; AA/B = African American/black; GfK = growth from knowledge; $\bar{X}$ = mean; *SD* = standard deviation; min = minimum; max = maximum; MEPS = medical expenditure panel survey; CHIS = California health interview survey; CCHS = Canadian community health survey; CI = confidence intervals; NHANES = national health and nutrition examination survey; CVD = cardiovascular disease; MSM = men who have sex with men; ALSPC = Avon longitudinal study of parents and children; NA = native American; SES = socioeconomic status; AddHealth, The National Longitudinal Study of Adolescent to Adult Health; NHIS = national health interview survey; CSHS = college student health survey; OR = odds ratio; HPV = human papillomavirus; MSW = men who have sex with women; STIs = sexually transmitted infections; *SE* = standard error; CDC = centers for disease control and prevention; FPL = federal poverty level; L = lesbian; Multi = multiracial; PI = pacific islander; y = years.

[a]Percentages with one decimal place were directly reported in the study, while percentages with two decimal places were calculated from data reported in the study. [b]All numbers reported correspond to observations from repeated-measures longitudinal data. [c]For participants 12–20 y, BMI was converted to age- and sex-specific BMI *Z*-scores using CDC standards. [d]Defined as BMI ≥25 kg/m^2. [e]Defined as BMI ≥25 kg/m^2 but <30 kg/m^2. [f]Defined as BMI ≥30 kg/m^2. [g]Combined for men and women. [h]For valid data points reporting BMI; the forest plot in Supplementary Figure 1 only includes the comparisons for 57 H vs. 34 G men reported, and excludes 26 H White and 23 H Black men whose. [i] Obesity was subclassified as Grade 1 (BMI≥30 kg/m^2 but <35 kg/m^2), Grade 2 (BMI≥35 kg/m^2 but <40 kg/m^2), or Grade 3 (BMI≥40 kg/m^2). [j]The 2011 Money, Sex, and Love Survey (Study 5) does not report measures relevant to this meta-analysis and, thus, was excluded. [k]Grade 2 and Grade 3 obesity were combined as a single category. [l] Authors were contacted to verify the absolute numbers of M and W participants.

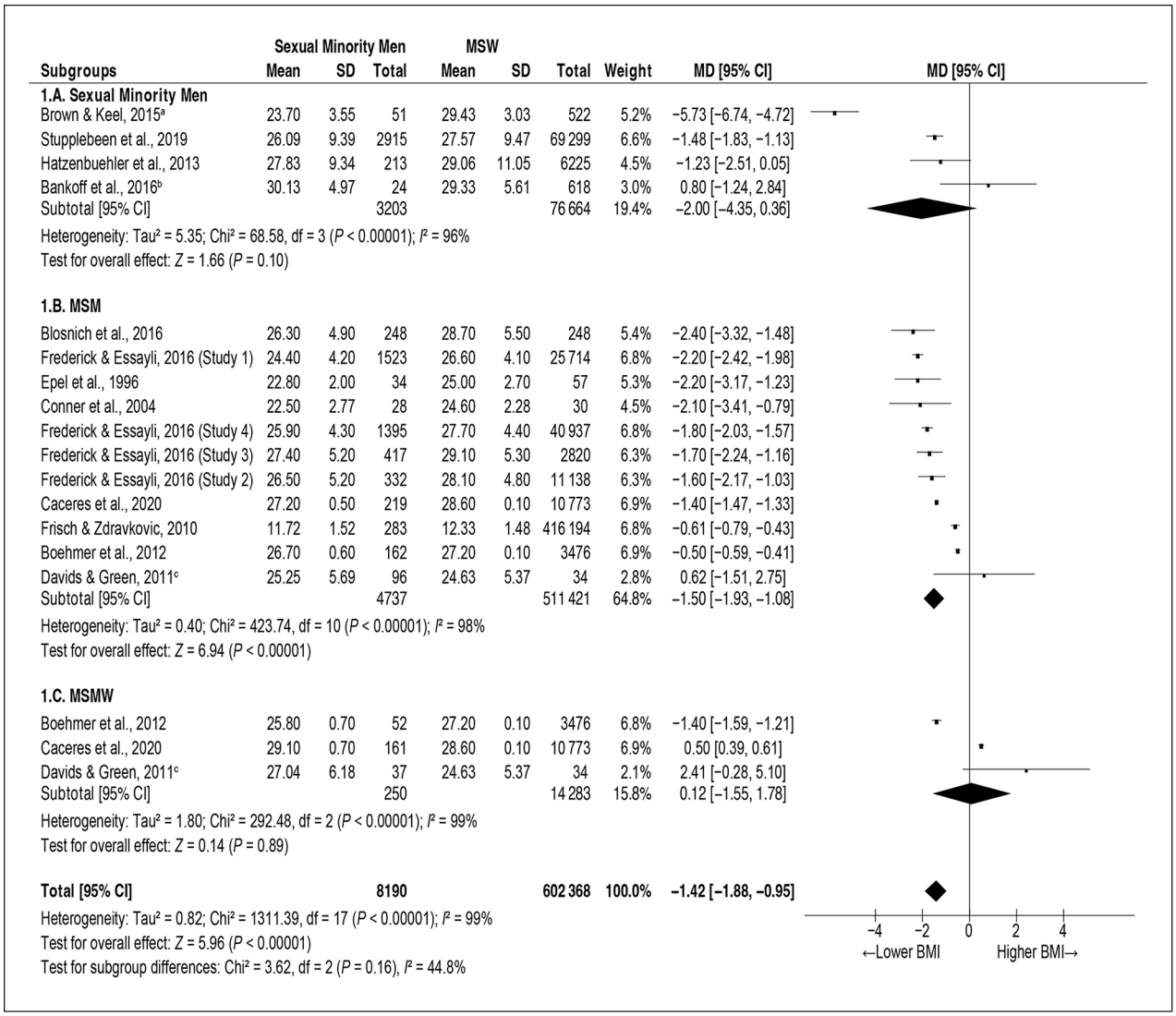

Figure 1. Forest Plot of Studies Reporting Mean Values of BMI Among Sexual Minority Men.
Note. BMI = body mass index; CI = confidence interval; *df* = degrees of freedom; MD = mean difference; MSM = men who have sex with men; MSMW = men who have sex with men and women; MSW = men who have sex with women; *SD* = standard deviation.
[a]Participants were diagnosed with eating disorders. [b]Unweighted means. [c]Participants were diagnosed with body dissatisfaction disorder.

observed for age on the respective prevalence rates of overweight (R^2 analog = .27) and elevated BMI (R^2 analog = .42). It must be noted, however, that only a small proportion of studies reported age as a mean value that could be incorporated in the meta-regression.

Likelihood Estimates

Table 4 presents the summary of the likelihood estimates for overweight, obesity, and elevated BMI by sexual orientation. The respective forest and funnel plots can be found in Supplementary Figures S4 and S5, respectively.

Seven studies presented data on the likelihood of being overweight, either as crude or as adjusted ORs or PRs. The meta-analysis shows that two of the sexual minority men subgroups were significantly less likely to be overweight, namely all sexual minority men (32% less likely) and MSM (37% less likely), while MSMW were not significantly different from MSW in their likelihood of being overweight (OR 0.75, 95% CI [0.52, 1.08]). Overall, all subgroups of sexual minority men were significantly less likely to be overweight (OR 0.68; 95% CI [0.58, 0.80]). Heterogeneity for studies on overweight was variable and most effects operated in the same direction.

Fourteen studies presented data on the likelihood of obesity, either as crude or adjusted ORs (Table 4). Again, sexual minority men and MSM were 33% and

Table 2. Prevalence Estimates of Overweight, Obesity, and Elevated BMI by Sexual Orientation.

Subgroups analyzed	Studies[a] (*n*)	Prevalence estimate	95% Confidence interval		*Z*	*P*
			Lower bound	Upper bound		
Overweight (*N* = 16)						
All sexual minority men	4	34.13%	27.61%	41.32%	−4.2039	<.001
MSM	15	35.64%	32.13%	39.31%	−7.3903	<.001
MSMW	8	33.46%	28.66%	38.62%	−6.0053	<.001
MSW	19	44.00%	40.75%	47.31%	−3.5405	<.001
Obesity (*N* = 26)						
All sexual minority men	6	20.65%	17.82%	0.2379	−14.4861	<.001
MSM	23	20.01%	18.55%	0.2156	−28.8903	<.001
MSMW	16	26.60%	24.38%	0.2895	−16.9734	<.001
MSW	29	25.73%	24.32%	0.2720	−27.6044	<.001
Elevated BMI (*N* = 5)						
MSM	5	38.80%	23.60%	56.55%	−1.2420	.21
MSMW	5	46.71%	29.52%	64.72%	−0.3493	.73
MSW	5	54.75%	37.31%	71.09%	0.5261	.60

Note. BMI = body mass index; MSM = men who have sex with men; MSMW = men who have sex with men and women; MSW = men who have sex with women.
[a]Frederick and Essayli (2016) is a single report on four independent studies (denoted as Studies 1-4 in **Supplementary Figure S2, Panel B**), and thus, the number of data points is greater than the number of studies for the categories where this study is included.

Table 3. Meta-Regression Models of Prevalence Rates of Overweight, Obesity, and Elevated BMI Regressed on Mean Age.

Subgroups analyzed	Coefficient	Standard error	95% CI		*Z*	*P*
			Lower bound	Upper bound		
Overweight						
Intercept	−1.6847	0.7295	−3.1145	−0.2550	−2.31	.02
Mean age	0.0297	0.0174	−0.0044	0.0639	1.71	.09
Model fit	$\tau^2 = 0.0614$, $\tau = 0.2477$, $I^2 = 99.92\%$, $Q = 19342.82$, $df = 15$, $p < .001$, R^2 analog = .00					
Obesity						
Intercept	−2.2538	0.4719	−3.1788	−1.3288	−4.78	<.001
Mean age	0.0227	0.0106	0.0019	0.0435	2.13	.03
Model fit	$\tau^2 = 0.1322$, $\tau = 0.3635$, $I^2 = 99.84\%$, $Q = 10760.39$, $df = 17$, $p < .001$, R^2 analog = .27					
Elevated BMI						
Intercept	−1.9249	0.8333	−3.5581	−0.2916	−2.31	.02
Mean age	0.0424	0.0171	0.0088	0.0760	2.48	.01
Model fit	$\tau^2 = 0.1686$, $\tau = 0.4106$, $I^2 = 98.42\%$, $Q = 316.53$, $df = 5$, $p < .001$, R^2 analog = .42					

Note. BMI = body mass index; CI = confidence interval.

21% less likely to be obese, while MSMW did not reach statistical significance for this comparison. Two were identified as significant outliers (Azagba et al., 2019; Caceres et al., 2018). After removal, the analysis reached statistical significance for the MSM (OR 0.79, 95% CI [0.71, 0.88]) subgroup but not for the MSMW subgroup (OR 0.98, 95% CI [0.92, 1.04]). Removal of outliers yielded an overall lower likelihood of obesity among all sexual minority subgroups pooled (OR 0.84, 95% CI [0.78, 0.90]), not shown in Table 4.

Seven studies presented data on the likelihood of elevated BMI. None of the subgroup comparisons reached statistical significance. Funnel plot analyses did not identify studies that would operate as outliers among these subgroups. Pooled analyses did not reach statistical significance and heterogeneity between studies was important ($I^2 = 96\%$).

Risk of bias

Supplementary Table S1 summarizes the bias assessment for the 43 studies included. Most showed a very low risk

Table 4. Prevalence Estimates of Overweight, Obesity, and Elevated BMI by Sexual Orientation.

Subgroups analyzed	Studies (*n*)	OR[b]	95% CI		χ^2	*df*	*P*	I^2
			Lower Bound	Upper Bound				
Overweight		0.68	0.58	0.80	89.56	12	<.001	87%
All sexual minority men	2	0.68	0.55	0.83	0.13	1	.72	0%
MSM[b]	6	0.63	0.50	0.79	49.92	5	<.001	90%
MSMW[b]	5	0.75	0.52	1.08	31.92	4	<.001	87%
Obesity		0.84	0.78	0.90	87.58	22	<.001	75%
All sexual minority men	3	0.67	0.57	0.80	1.77	2	.41	0%
MSM[b]	11	0.79	0.71	0.88	50.32	10	<.001	80%
MSMW[b]	9	0.98	0.92	1.04	9.27	8	.32	14%
Elevated BMI		0.84	0.56	1.25	332.10	12	<.001	96%
MSM	7	0.88	0.53	1.48	237.01	6	<.001	97%
MSMW	6	0.72	0.53	0.98	9.56	5	.09	48%

Note. BMI = body mass index; *df* = degrees of freedom; CI = confidence interval; MSM = men who have sex with men; MSMW = men who have sex with men and women; MSW = men who have sex with women; OR = odds ratio.
[a]The reference group is MSW. [b]Deputy and Boehmer (2014) reported four unadjusted ORs by race/ethnicity for MSM and MSW, which were weighted and averaged as a single estimate using the same meta-analytic assumptions in this study.

of participant selection or response biases ($n = 40$ [93%] and $n = 35$ [81%], respectively). The risk of information or misclassification biases was less clear, with most studies assessed as uncertain ($n = 33$ [77%]). While almost half of the studies presented a low risk of confounding by income ($n = 19$), education ($n = 21$), or age ($n = 26$), only three studies included information on HIV serostatus of participants (Blosnich et al., 2014, 2016; Nyitray et al., 2019).

Discussion

The purpose of this meta-analysis was to examine disparities in the prevalence and likelihood of obesity and overweight among sexual minority men. Based on the extensive review employed, it is believed this is the first study to use meta-analytic techniques to achieve this goal, although a narrative systematic review with comparable findings has been published (Caceres et al., 2017). Forty-three studies, mostly conducted in the United States between 1996 and 2020, were included, although representation from other countries must be noted.

This meta-analysis demonstrated a consistently lower mean BMI among all analytic subgroups of sexual minority men compared with MSW, which was also replicated when analyzing crude prevalence rates and the adjusted likelihood of obesity, overweight, and elevated BMI ($\geq$25 kg/m^2) overall and across most analytic subgroups.

Various explanations have been posited for the BMI disparities observed among sexual minority men. First, compared with heterosexual men, sexual minority men have more awareness of their body image and watch their weight more closely (Warren et al., 2016). Recent studies suggest sexual minority men and heterosexual women are significantly more prone to body dissatisfaction, which may be due to sustained and pervasive social pressure on body image (Conner et al., 2004; Meneguzzo et al., 2021). Besides awareness of body image, obesity-related stigma and the underlying psychological conditions—such as depression, anxiety, and stress—have been demonstrated as important predictors of obesity among gay men (Conner et al., 2004; Fulton & Srinivasan, 2021; Meneguzzo et al., 2021; Warren et al., 2016). These conditions may ultimately be a result of nonconformity stress—a key element within the Minority Stress Theory (Frost et al., 2015; Meyer, 2003). Although the studies included did not specifically assess for psychological conditions, the significantly lower prevalence rates of obesity among sexual minority men are in agreement with this first explanation.

Although weight status can be evaluated via several methods, all the studies included in this meta-analysis used BMI to determine weight status. Thus, a second plausible explanation for the disparities observed is BMI's lower predictive value for cardiovascular disease, especially when compared with other anthropometric measures alone or in combination with imaging techniques that have validated cutoff values for men (e.g., waist circumference, waist-to-hip ratio, waist-to-height ratio, sagittal abdominal diameter, or body fat percentage; (Antonopoulos & Tousoulis, 2017). This lower predictive value derives from the fact that BMI does not measure body fat distribution, which in turn varies by sex, age, and race and ethnicity (Deurenberg et al., 2002; Flegal et al., 2013; Jackson et al., 2002). BMI does not

accurately distinguish body composition of lean and fat mass, and individuals classified as overweight or obese may indeed have increased muscle mass (Jackson et al., 2002; Oreopoulos et al., 2010), which does not necessarily translate into increased risk of CVD. Studies examining obesity could triangulate multiple assessments of body weight and composition to improve analytic accuracy. In addition, biomarkers associated with obesity, such as markers of chronic low-grade inflammation (e.g., cortisol and high-sensitivity C-reactive protein), markers in the insulin/insulin-like growth factor axis, and certain adipokines (e.g., leptin, adiponectin, and resistin), can also be incorporated to better understand the context of CVD risk (Nimptsch et al., 2019).

While most studies included a reported demographic status of the participants, the intersectional effect of sexual minorities and other statuses on weight cannot be estimated. Thus, the third explanation of weight disparities observed arises from an intersectional framework with other demographic variables. In their systematic review on health outcomes within the Minority Stress Theory, VanKim et al. (2020) identified studies demonstrating plausible interaction effects of sexual minority status with race, ethnicity, age, and educational attainment. These effects were consistent across most health outcomes, including BMI differences when compared with heterosexual populations.

A fourth hypothesis for the weight disparities observed in this study is based on the population study design. All studies included in this meta-analysis used survey data, and most participants self-reported weight and height. Therefore, self-report biases (i.e., recall bias and social desirability bias) cannot be ruled out (Althubaiti, 2016). Two systematic literature reviews analyzed the accuracy of self-reported weight, height, and BMI derived from self-reported measures in studies published between 1982–2005 and 2005–2017 (Connor Gorber et al., 2007; Maukonen et al., 2018). Both reviews concluded that both men and women underestimate self-reported weight and overestimate self-reported height, with the ultimate effect of underestimating BMI calculations. Thus, data collection efforts at the population level should rely only on anthropometry rather than self-report to avoid underestimation of weight and BMI and overestimation of height.

Last, and perhaps most importantly, a lower prevalence of obesity and overweight among sexual minority men may not necessarily translate into a healthier cardiovascular status. The obesity paradox in CVD asserts that overweight or class I obese persons may have a better prognosis after CVD ensues (Antonopoulos & Tousoulis, 2017; Carbone et al., 2019), while individuals presenting with normal weight or underweight have a poorer prognosis from CVD as a result of a progressive and sustained catabolic state with loss of lean mass (Elagizi et al., 2018). A meta-analysis reported that, compared with people having normal BMIs, people with obesity presented with significantly higher all-cause mortality, while people with overweight presented lower all-cause mortality (Flegal et al., 2013). Although the obesity paradox in CVD has been studied in the general population, the current study is the first quantitative study demonstrating the plausibility of this phenomenon among sexual minority men.

We assessed the risk of selection, information or misclassification, and response biases. Misclassification bias is always a possibility given the lack of standardization in research measuring the sexual orientation of participants. Biases associated with self-reported data, such as height and weight, are also potential threats to study validity. Among the four potential confounders included in this study, the role of HIV serostatus is by far the most uncertain, followed by the risk of confounding by education level.

Limitations

This study has some limitations worth noting. First, as it has been stated, several studies relied on self-reported height and weight to estimate BMI, which may drive over- or underestimation of key variables due to social desirability and to idealized body image—especially among sexual minority populations. Second, there are two possible sources of misclassification in the studies included. On the one hand, while population representative samples accurately represent sexual minorities (Grasso et al., 2019), scholarly inquiries are limited due to a recognized lack of clarity and consistency in defining specific sexual minority groups (Legate & Rogge, 2019; Wolff et al., 2017). Studies reported either well-known sexual orientation measures of behavioral, identity, or attraction items or reported new measures, such as same-sex partnership. This heterogeneity introduces the possibility of misclassification bias. On the contrary, some studies estimated the likelihood of elevated BMI, combining overweight and obesity as a single measure. This may partially explain the nonsignificant findings in this comparison. Third, while other potential confounders—such as educational attainment and HIV serostatus—were reported among the publications assessed, only a handful of studies indeed controlled for these differences. It must also be noted that only a small number of studies reports age as a mean value that can be incorporated in meta-regression analyses to understand the effect of sampling distribution by age on the BMI estimates.

Limitations aside, this study has important strengths worth mentioning. Our analyses demonstrated that, compared with heterosexual men, sexual minority men present

with a significantly lower prevalence of overweight, obesity, and elevated BMI. This finding has important implications for CVD prevention, which should encourage a healthy control of body weight and composition as one of the American Heart Association's Life Simple Seven. This study also provides plausible evidence for the presence of the obesity paradox in CVD among sexual minority men, warranting further research efforts to understand CVD outcomes among sexual minorities across diverse BMI statuses.

Conclusion

Compared with heterosexual men, sexual minority men present a significantly lower prevalence of obesity and overweight, as measured by BMI. Several plausible explanations exist for this phenomenon, including increased awareness of body image, predictive limitations of BMI as the only measure of weight-to-height, interaction effects with other demographic minority status, and the obesity paradox of cardiovascular disease. Future studies should address the fact this apparently better cardiovascular health status in sexual minority men may actually be driven by a sustained catabolic state that presents with lower BMI than in MSW but may result in poorer CVD outcomes in the long term. The role of proposed biobehavioral markers, such as cortisol, should be explored among sexual minority populations presenting with the obesity paradox.

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