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Sex Differences in Treatment Response to Standard Interventions for Type 2 Diabetes and Obesity Among Veterans: A Retrospective Cohort Study

ORIGINAL RESEARCH

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ABSTRACT

Type 2 diabetes mellitus (T2DM) and obesity disproportionately affect veterans, yet sex-specific differences in treatment response remain poorly characterized in this population. Prior literature indicates that biological sex influences glucose metabolism, adipose tissue distribution, hormonal regulation, and pharmacotherapy response, but women veterans have been historically underrepresented in VA-based metabolic disease research. This retrospective cohort study examined 4,523 veterans (4,327 male, 195 female) with comorbid T2DM and obesity seen at VA Central California Health Care System from January 2023 through June 2024. Primary outcomes were HbA1c <7% achievement and 12-month percentage weight change. Adjusted analyses used Mantel-Haenszel (MH) stratified estimation and multivariable linear regression. Female veterans were significantly younger (57.8 ± 13.1 vs. 67.2 ± 11.7 years; $p < .001$) with lower baseline HbA1c (7.13% vs. 7.53%; $p = .005$). Unadjusted HbA1c < 7% achievement was significantly higher in females (60.5% vs. 44.9%; $p < .001$). The age-adjusted MH odds ratio for female sex was 2.01 (95% CI [1.08, 3.71]; $p < .001$), consistent across all four age strata. After BMI adjustment, the estimate was attenuated (MH-OR = 1.74; 95% CI [0.83, 3.67]). Baseline BMI was the only significant independent predictor of weight loss ($\beta = -1.44\%$ per SD; $p = .001$). Female sex showed a non-significant trend toward greater weight loss ($\beta = -1.35\%$; $p = .29$) after adjustment. These findings must be interpreted cautiously given the observational design and 22:1 sex imbalance. Prospective, adequately powered studies are warranted to confirm these findings and guide sex-specific veteran care.

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Type 2 diabetes mellitus (T2DM) and obesity represent two of the most prevalent and economically burdensome chronic conditions in the United States (U.S.), affecting approximately 37 million and 100 million Americans, respectively. These conditions frequently co-occur, sharing overlapping pathophysiological mechanisms including insulin resistance, chronic low-grade inflammation, and adipokine dysregulation (Petersen & Shulman, 2018). Veterans represent a population with particularly high prevalence of both conditions, driven by lifestyle, occupational, psychological, and sociodemographic factors associated with military service (Barber et al., 2021).

SEX DIFFERENCES IN METABOLIC DISEASE: WHAT IS KNOWN

A substantial body of literature documents that biological sex shapes both the pathophysiology and clinical course of T2DM and obesity. Kautzky-Willer et al. (2016) established that sex differences in adipose tissue distribution—women having proportionally greater subcutaneous fat and men more visceral fat—translate into distinct metabolic risk profiles and differential response to insulin-sensitizing therapies. Women with T2DM demonstrate different β-cell function trajectories, with some evidence suggesting women lose β-cell reserve more rapidly relative to metabolic load (Gallagher & LeRoith, 2015). Women generally have lower lean body mass, altered drug distribution volumes, and differences in Cytochrome P45(CYP) enzyme activity affecting metabolism of several antidiabetic agents including sulfonylureas and thiazolidinediones (TZDs; Franconi & Campesi, 2014).

Arnetz et al. (2014) found in a systematic review that women with T2DM had worse glycemic control in some cohorts but better adherence to lifestyle interventions. Sex-based differences in GLP-1 receptor agonist response have been observed in pharmacokinetic studies, with women achieving higher plasma concentrations at equivalent doses, potentially contributing to greater glycemic and weight-reduction efficacy (Nauck et al., 2021). For sodium-glucose cotransporter 2 (SGLT2) inhibitors, cardiovascular outcome trial data suggest relative risk reductions are broadly consistent across sexes; though women may have higher rates of genitourinary adverse effects influencing long-term adherence (Zannad et al., 2020).

In the domain of obesity treatment, meta-analyses of behavioral weight loss interventions report that women frequently achieve greater absolute weight loss in structured programs (Pagoto & Appelhans, 2013). Semaglutide trials in the Semaglutide Treatment Effect in People (STEP) program with obesity demonstrated comparable percentage weight loss between sexes, though the proportion achieving ≥10% weight loss tended to be higher in women (Wilding et al., 2021). Hormonal factors, particularly menopausal status, significantly modify weight loss responsiveness: postmenopausal women exhibit attenuated weight-loss response due to estrogen deficiency–driven changes in energy expenditure and fat redistribution (El Khoudary et al., 2020).

SEX DIFFERENCES IN THE VETERAN POPULATION: A SPECIFIC GAP

Despite this broader literature, evidence specifically characterizing sex differences in T2DM and obesity treatment outcomes in the veteran population remains sparse. Female veterans represent a rapidly growing segment of the Department of Veterans Affairs (VA) healthcare users—increasing from approximately 4% to over 10% over the past two decades (Department of Veterans Affairs, 2017). Female veterans face unique challenges including higher rates of military sexual trauma, distinct mental health comorbidity profiles, and stressors associated with female military service (Dichter et al., 2017). Prior VA-focused research has examined sex differences in diabetes care quality broadly (Hofer et al., 1999). Separate bodies of literature address obesity treatment in veterans (Maciejewski et al., 2016) and mental health comorbidities among female veterans (Kimerling et al., 2016), but integrated analyses specifically examining sex-stratified treatment response to concurrent T2DM and obesity interventions are lacking. This study addressed this gap with three objectives: (a) assess sex differences in treatment response using both unadjusted and confounder-adjusted analyses, (b) identify biological, hormonal, behavioral, and psychosocial contributing factors, and (c) provide insights for sex-specific treatment strategies with appropriate acknowledgment of observational limitations.

METHODS

STUDY DESIGN AND SETTING

This retrospective cohort study used data extracted from the Veterans Health Administration (VHA) Corporate Data Warehouse at VA Central California Health Care System spanning January 1, 2023 through June 30, 2024.

STUDY POPULATION AND PARTICIPANTS

A total of 4,523 veterans met eligibility criteria, of whom 4,327 (95.7%) were male and 195 (4.3%) were female. Eligible participants were adult veterans with ICD-10–

coded diagnoses of both T2DM and obesity (or body mass index [BMI] ≥30 kg/m²) seen in Outpatient Primary Care or Women's Health clinics; identified by specified VA stop codes. Patients with type 1 diabetes, gestational diabetes, or incomplete demographic data were excluded.

MEASURES

Extracted data included date of birth, sex, date of first T2DM diagnosis, baseline and serial HbA1c values, serial weights, BMI, and binary medication use indicators for: metformin, sulfonylureas, GLP-1 receptor agonists (diabetes-indicated), Wegovy, Mounjaro, Saxenda, sodium-glucose cotransporter 2 (SGLT2) inhibitors, Dipeptidyl peptidase-4 (DPP-4) inhibitors, insulin, thiazolidinediones (TZDs), phentermine, orlistat, and Qsymia. Care engagement was captured as binary indicators for dietitian visits, MOVE! program participation, and Primary Care Mental Health Integration (PCMHI) visits. Comorbidities were ascertained from international classification of diseases (ICD)-coded records with anxiety, depression, coronary artery disease (CAD), congestive heart failure (CHF), chronic kidney disease (CKD), cerebrovascular disease (CVD), and menopause. For adjusted analyses, composite variables were constructed: any GLP-1 (e.g., diabetes- or obesity-indicated); any obesity medication (e.g., Wegovy, Orlistat, Qsymia, Phentermine); CV disease burden (e.g., CAD or CHF present); and mental health comorbidity (e.g., anxiety or depression present).

OUTCOMES

The primary glycemic outcome was achievement of HbA1c < 7%; consistent with American Diabetes Association (ADA) treatment targets (ADA Professional Practice Committee, 2024). The primary weight outcome was 12-month percentage weight change from baseline. Secondary outcomes included absolute weight change and ≥5% body weight reduction at 12 months.

STATISTICAL ANALYSIS

Unadjusted analyses used independent samples *t*-tests for continuous variables and Pearson chi-square tests for categorical variables; all tests were two-tailed (α = .05). Adjusted analyses for the glycemic outcome used Mantel-Haenszel (MH) stratified estimation, controlling separately for: (a) baseline HbA1c category (< 7%, 7–7.9%, 8–8.9%, ≥ 9%); (b) age category (< 50, 50–59, 60–69, ≥ 70 years); and (c) BMI category (< 30, 30–34.9, 35–39.9, ≥ 40 kg/m²). Mantel-Haenszel odds ratios with 95% confidence intervals (i.e., Woolf method) are reported. Adjusted analyses for weight outcomes used multivariable linear regression including female sex, age (standardized), BMI (standardized), baseline weight (standardized), insulin use, any GLP-1 use, any obesity medication use, CV disease burden, and mental health comorbidity as covariates, restricted to patients with available 12-month weight data. Subgroup analyses examined HbA1c achievement among insulin and GLP-1 users separately, and weight change by BMI stratum. Patient age was calculated as of July 1, 2023 and no imputation was performed for missing data. This study was conducted using de-identified VHA administrative data and IRB approval was not required.

BASELINE CHARACTERISTICS

Female veterans were significantly younger than males (57.8 ± 13.1 vs. 67.2 ± 11.7 years; $p < .001$) and had lower baseline HbA1c (7.13 ± 1.64% vs. 7.53 ± 1.64%; $p = .005$). BMI did not differ significantly (35.5 ± 6.6 vs. 34.8 ± 5.4 kg/m²; $p = .52$), though males were heavier in absolute terms (235.1 ± 41.6 vs. 205.9 ± 40.5 lbs; $p < .001$). Weight follow-up data at 12 months were available for 1,210 males (28.0%) and 54 females (27.7%). Baseline characteristics are presented in Table 1 and illustrated in Figure 1.

MEDICATION USE

Medication use rates are summarized in Table 2 and illustrated in Figure 2. Metformin was the most prescribed agent (58.4% males vs. 53.3% females; $p = .38$). Males were more frequently prescribed SGLT2 inhibitors (32.1% vs. 20.5%; $p = .003$) and insulin (28.9% vs. 20.5%; $p = .040$). Females were more commonly prescribed TZDs (13.8% vs. 5.4%; $p < .001$), Wegovy (5.1% vs. 0.7%; $p < .001$), orlistat (2.6% vs. 0.5%; $p = .001$), and Qsymia (2.6% vs. 0.5%; $p = .002$). GLP-1 agonist use for diabetes trended higher in females (26.7% vs. 20.4%; $p = .11$).

COMORBIDITIES

Comorbidity profiles are shown in Table 2, Figures 3, and 6. Females had significantly higher rates of anxiety (47.2% vs. 25.3%; $p < .001$) and depression (60.0% vs. 38.2%; $p < .001$). Males had significantly greater cardiovascular comorbidity: CAD (31.0% vs. 12.3%; $p < .001$) and CHF (18.3% vs. 7.2%; $p < .001$). CKD was numerically higher in males (20.5% vs. 14.4%; $p = .11$). Menopause was documented in 18.5% of female veterans, consistent with its recognized role as a modifier of insulin resistance and metabolic risk (El Khoudary et al., 2020).

Care Engagement

Female veterans were significantly more likely to participate in MOVE! (Figure 4; 11.8% vs. 4.3%; $p < .001$). Dietitian visit rates (22.1% vs. 18.2%; $p = .40$) and PCMHI engagement (17.4% vs. 12.0%; $p = .08$) trended higher in females but did not reach significance.

CHARACTERISTIC	MALE (*n* = 4,327)	FEMALE (*n* = 195)	*P*
Age, *M* ± *SD* (years)	67.2 ± 11.7	57.8 ± 13.1	<.001*
Baseline HbA1c, *M* ± *SD* (%)	7.53 ± 1.64	7.13 ± 1.64	.005*
Baseline BMI, *M* ± *SD* (kg/m²)[a]	34.8 ± 5.4	35.5 ± 6.6	.52
Baseline weight, *M* ± *SD* (lbs)[a]	235.1 ± 41.6	205.9 ± 40.5	<.001*
HbA1c data available, *n* (%)	4,192 (96.9)	190 (97.4)	–
BMI/Weight data available, *n* (%)	2,812 (65.0)	131 (67.2)	–
12-month weight data available, *n* (%)	1,210 (28.0)	54 (27.7)	–

Table 1 Baseline Clinical Characteristics by Sex.

Note: HbA1c = hemoglobin A1c; BMI = body mass index; *M* = mean; *SD* = standard deviation.a Among participants with available data. * $p < .05$.

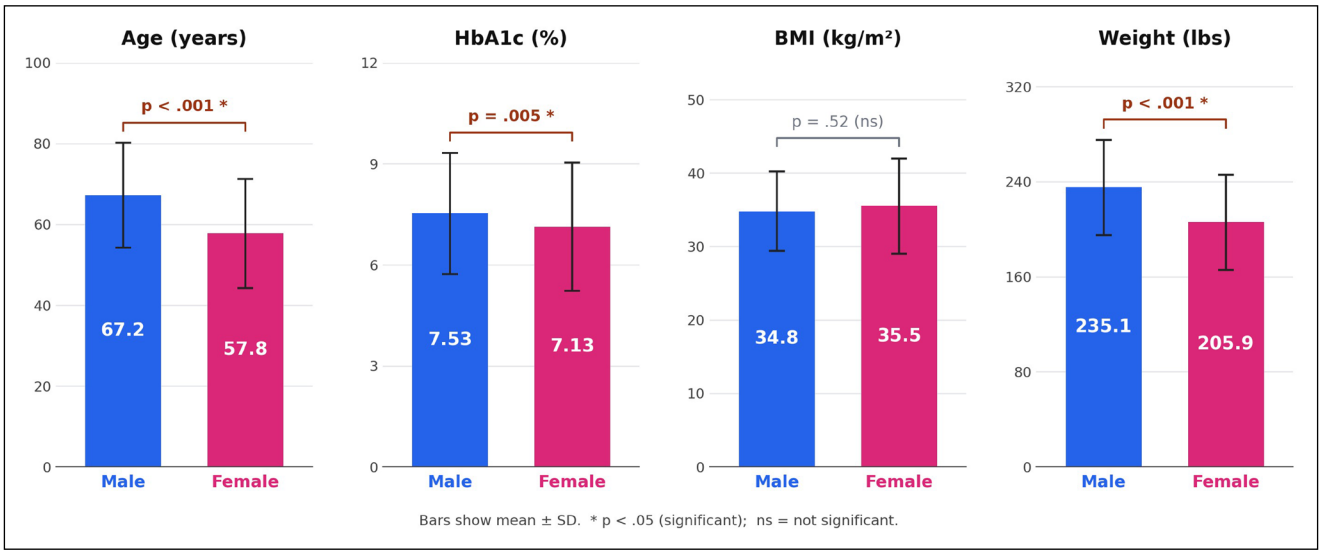


Figure 1 Baseline Clinical Characteristics by Sex.

Note: Mean values with ±1 *SD* error bars. BMI = body mass index; HbA1c = hemoglobin A1c; *SD* = standard deviation. * $p < .05$.

Unadjusted Treatment Outcomes

Females achieved HbA1c < 7% at a significantly higher rate than males (60.5% vs. 44.9%; $\chi^2 = 17.98$; $p < .001$), a 34.7% relative difference. These unadjusted results must be interpreted in light of significant baseline differences, particularly age and baseline HbA1c. Mean 12-month weight loss was −2.10 ± 9.12% in females versus −0.84 ± 8.58% in males ($p = .61$), and ≥5% weight loss was achieved by 29.6% versus 21.8% ($p = .40$). Unadjusted outcomes are presented in Table 3 and Figure 5.

ADJUSTED ANALYSES—WEIGHT OUTCOME

In multivariable linear regression ($n = 1,264$), female sex was associated with a non-significant trend toward greater weight loss (β = −1.35%; 95% CI [−3.87, 1.17]; $p = .29$) after adjustment. Higher baseline BMI was the only statistically significant independent predictor of weight loss (β = −1.44% per *SD*; $p = .001$; Apovian et al., 2015). In BMI-stratified analyses, females showed directionally greater weight loss at higher BMI categories (BMI ≥40: −7.19% vs. −3.01%), though female sample sizes were very small ($n = 9$). Longitudinal weight trajectories are shown in Figure 6.

ADJUSTED ANALYSES—GLYCEMIC OUTCOME

Results of Mantel-Haenszel stratified analyses are presented in Table 4 and the forest plot in Figure 7. Mantel-Haenszel stratification by baseline HbA1c yielded degenerate strata, confirming that baseline HbA1c is a powerful determinant of target achievement and an important confounder of the unadjusted sex comparison. After controlling for age, females retained significantly higher odds of HbA1c target attainment (MH-OR = 2.01; 95% CI [1.08, 3.71]; $p < .001$). Stratum-specific ORs were consistent across all age groups (range: 1.36–2.55). Females outperformed males in all four age strata (< 50 years: 60.0% vs. 41.7%; 50–59: 47.5% vs. 39.9%; 60–69: 64.1% vs. 41.2%; ≥ 70: 59.3% vs. 45.8%). After controlling for BMI, the sex effect was attenuated but directionally preserved (MH-OR = 1.74; 95% CI [0.83, 3.67]; $p = .002$). The CI crossed 1.0, reflecting reduced precision due to the small female sample size rather than absence of a true effect.

VARIABLE	MALE *n* = 4,327 (%)	FEMALE *n* = 195 (%)	*p*
Antidiabetic Medications			
Metformin	58.4	53.3	.38
Sulfonylurea	19.0	17.4	.87
GLP-1 agonist (diabetes-indicated)	20.4	26.7	.11
SGLT2 inhibitor	32.1	20.5	.003*
DPP-4 inhibitor	15.7	12.8	.55
Insulin	28.9	20.5	.040*
TZD	5.4	13.8	<.001*
Obesity-Targeted Medications			
Wegovy (semaglutide)	0.7	5.1	<.001*
Orlistat	0.5	2.6	.001*
Qsymia	0.5	2.6	.002*
Comorbidities			
Anxiety	25.3	47.2	<.001*
Depression	38.2	60.0	<.001*
Coronary artery disease	31.0	12.3	<.001*
Congestive heart failure	18.3	7.2	<.001*
Chronic kidney disease	20.5	14.4	.11
Cerebrovascular disease	9.3	4.6	.08
Menopause	0.0	18.5	<.001*
Care Engagement			
Dietitian visit	18.2	22.1	.40
MOVE! program	4.3	11.8	<.001*
PCMHI visit	12.0	17.4	.08

Table 2 Medication Use, Comorbidity Prevalence, and Care Engagement by Sex.

Note: GLP-1 = glucagon-like peptide-1; SGLT2 = sodium-glucose cotransporter-2; TZD = thiazolidinedione; DPP-4 = dipeptidyl peptidase-4; PCMHI = Primary Care Mental Health Integration; MOVE! = Managing Overweight/Obesity for Veterans Everywhere. * $p < .05$.

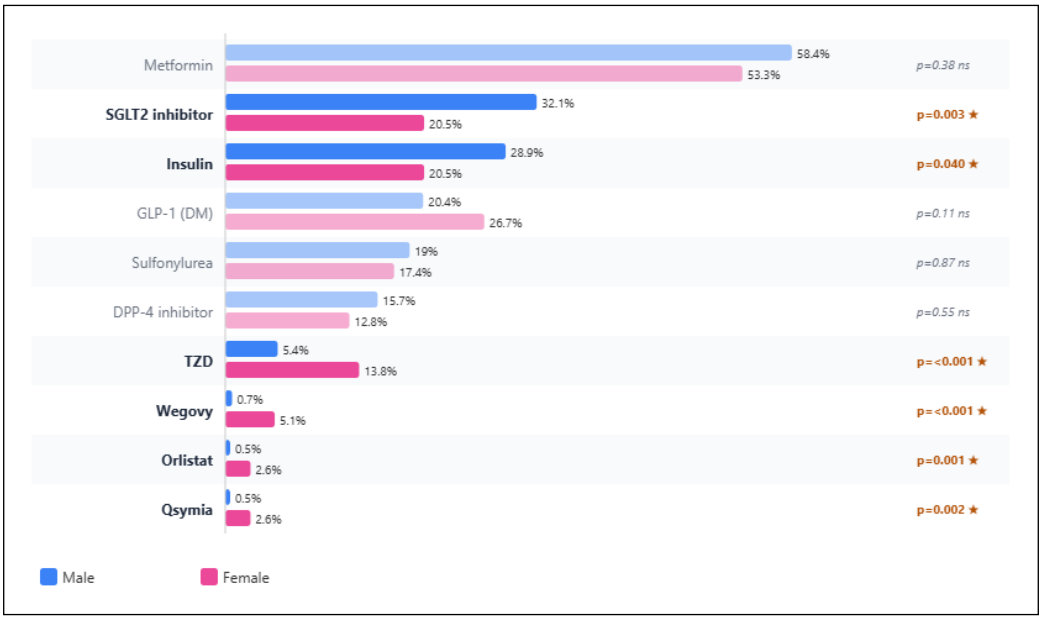


Figure 2 Medication Prescribing Rates by Sex (%).

Note: Fully opaque bars indicate statistically significant sex differences ($p < .05$); semi-transparent bars indicate non-significant differences. GLP-1 = glucagon-like peptide-1; SGLT2 = sodium-glucose cotransporter-2; TZD = thiazolidinedione; DPP-4 = dipeptidyl peptidase-4.

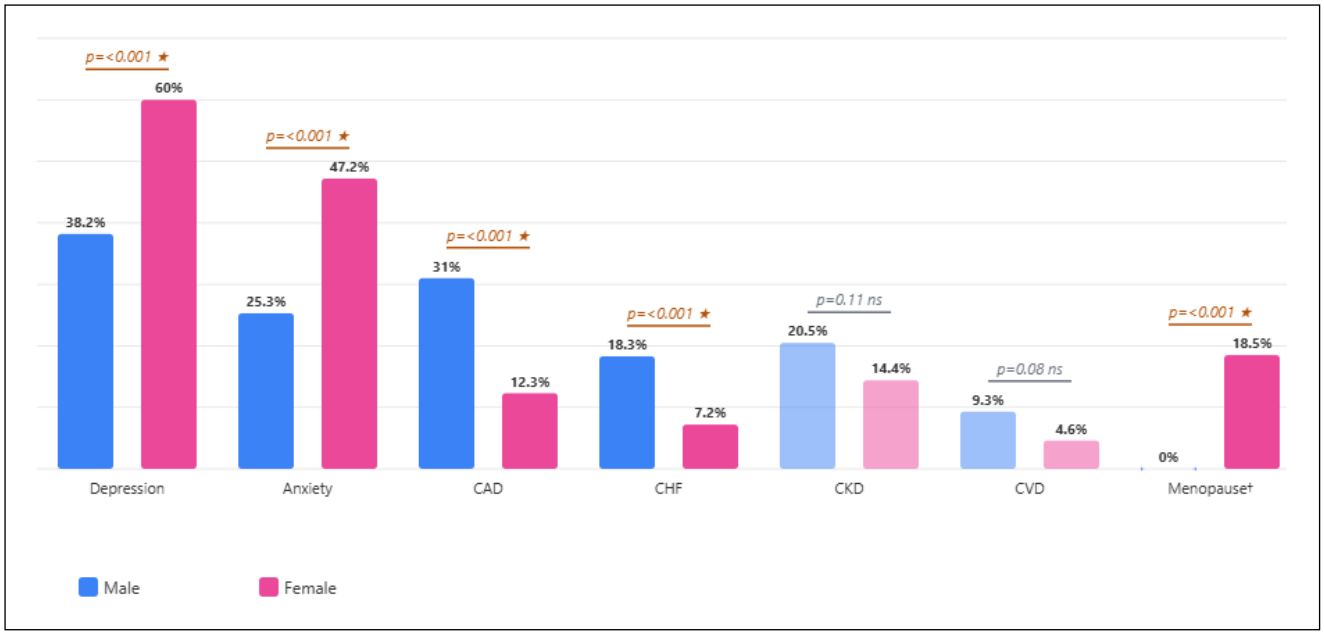


Figure 3 Comorbidity Prevalence by Sex (%).

Note: Fully opaque bars indicate statistically significant differences ($p < .05$); semi-transparent bars indicate non-significant differences. CAD = coronary artery disease; CHF = congestive heart failure; CKD = chronic kidney disease; CVD = cerebrovascular disease. †Menopause reported in female veterans only by definition.

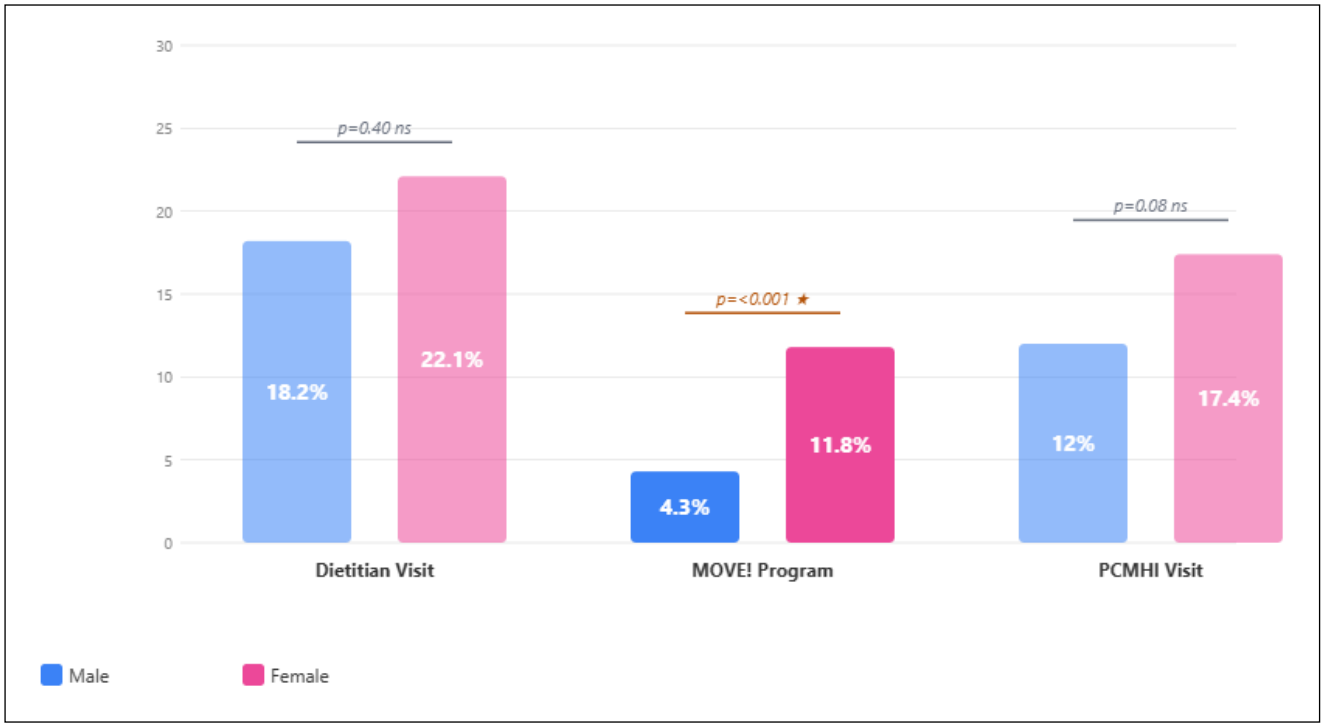


Figure 4 Behavioral Care Engagement Rates by Sex (%).

Note: Only MOVE! program participation showed a statistically significant sex difference ($p < .001$). MOVE! = Managing Overweight/Obesity for Veterans Everywhere; PCMHI = Primary Care Mental Health Integration.

Subgroup Analyses

Among insulin users, females achieved HbA1c < 7% at a higher rate (27.5% vs. 20.2%). Among GLP-1 users, the difference was more pronounced (40.7% vs. 26.4%), consistent with pharmacokinetic data indicating higher GLP-1 plasma concentrations in women at equivalent doses (Nauck et al., 2021), suggesting the sex advantage in glycemic control may be amplified with GLP-1 receptor agonist therapy.

OUTCOME	MALE	FEMALE	STATISTIC	*p*
HbA1c <7% achieved, *n/N* (%)	1,882/4,195 (44.9)	115/190 (60.5)	$\chi^2 = 17.98$	<.001*
12-month weight change, *M* ± *SD* (lbs)[a]	−2.64 ± 18.38	−4.86 ± 19.90	$t = 0.81$	.61
12-month weight change, *M* ± *SD* (%)[a]	−0.84 ± 8.58	−2.10 ± 9.12	$t = 1.00$	.61
≥5% weight loss at 12 months, *n/N* (%)[a]	264/1,210 (21.8)	16/54 (29.6)	$\chi^2 = 1.83$	.40

Table 3 Unadjusted Treatment Outcomes by Sex.

Note: HbA1c = hemoglobin A1c; *M* = mean; *SD* = standard deviation.a Among participants with available 12-month weight data: male *n* = 1,210; female n = 54. * *p* < .05.

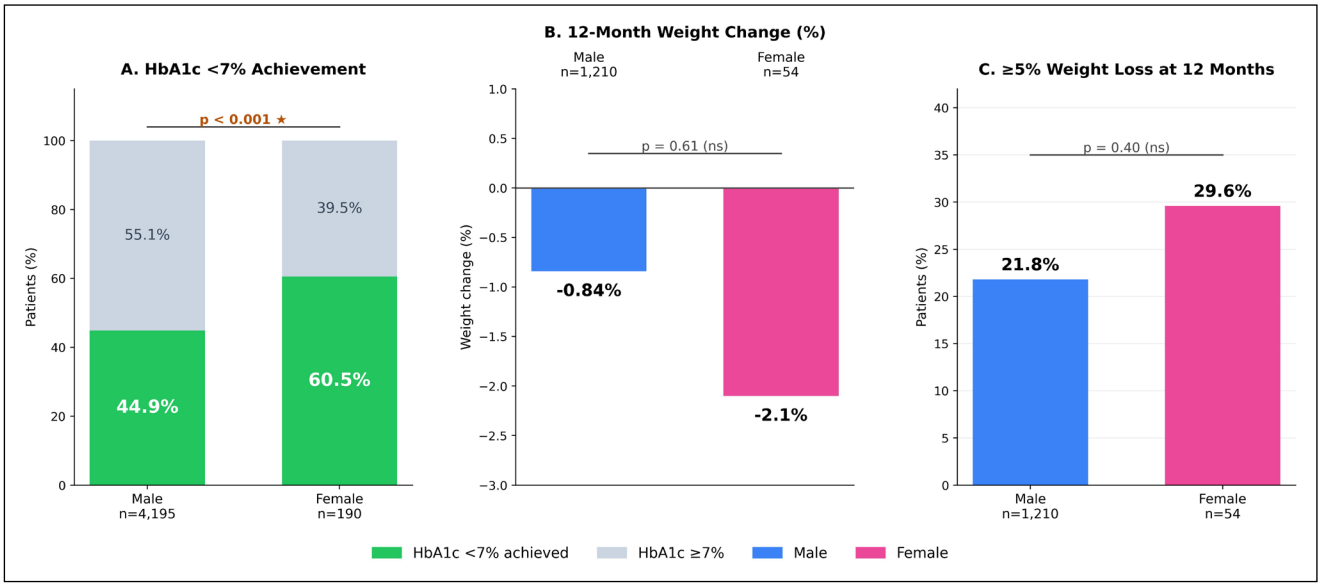


Figure 5 Primary Treatment Outcomes by Sex.

Note: Panel A: Proportion achieving HbA1c < 7% (*p* < .001). Panel B: Mean 12-month percentage weight change (*p* = .61). Panel C: Proportion achieving ≥5% body weight reduction at 12 months (*p* = .40). †Among participants with available 12-month weight data (male *n* = 1,210; female *n* = 54).

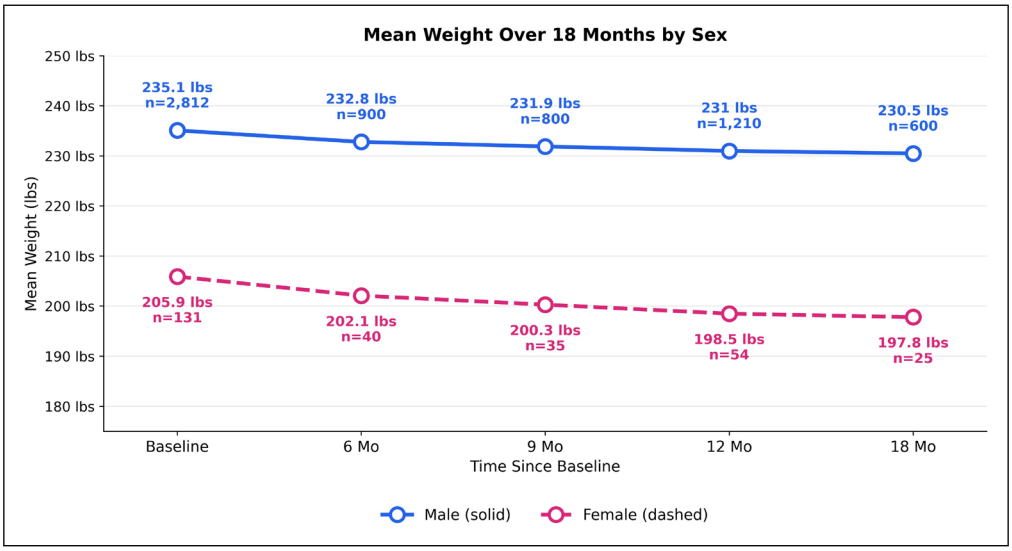


Figure 6 Longitudinal Weight Trajectory by Sex From Baseline to 18 Months.

Note: Solid blue line = male; dashed pink line = female. Weight follow-up data were available for approximately 28% of the cohort. Values at intermediate time points represent available-case means. Sample sizes (*n*) at each time point reflect available-case data.

ANALYSIS	ESTIMATE	95% CI	*p*
HbA1c < 7% Achievement — MH Pooled ORs (Female vs. Male)			
Adjusted for age category	MH-OR = 2.01	[1.08, 3.71]	<.001*
Adjusted for BMI category	MH-OR = 1.74	[0.83, 3.67][a]	.002
HbA1c Achievement by Age Stratum — Male (%) vs. Female (%)			
Age <50 years (male *n* = 415, female *n* = 50)	41.7 vs. 60.0	Stratum OR = 2.10	—
Age 50–59 years (male *n* = 602, female *n* = 40)	39.9 vs. 47.5	Stratum OR = 1.36	—
Age 60–69 years (male *n* = 1,031, female *n* = 78)	41.2 vs. 64.1	Stratum OR = 2.55	—
Age ≥70 years (male *n* = 2,279, female *n* = 27)	45.8 vs. 59.3	Stratum OR = 1.72	—
Subgroup Analyses			
HbA1c <7%: insulin users only	Male 20.2% (*n* = 1,251) vs. Female 27.5% (*n* = 40)	—	—
HbA1c <7%: GLP-1 users only	Male 26.4% (*n* = 913) vs. Female 40.7% (*n* = 59)	—	—
12-Month % Weight Change by BMI Stratum — Male vs. Female			
BMI 30–34.9 kg/m²	−1.15% vs. +1.04%	—	—
BMI 35–39.9 kg/m²	−1.51% vs. −3.24%	—	—
BMI ≥40 kg/m²	−3.01% vs. −7.19%	—	—
Multivariable Linear Regression: 12-Month % Weight Change			
Female sex	β = −1.35 (*SE* = 1.29)	[−3.87, 1.17]	.29
BMI (per *SD*)[b]	β = −1.44 (*SE* = 0.43)	[−2.28, −0.60]	.001*

Table 4 Adjusted Analyses: Mantel-Haenszel Stratified Odds Ratios, Subgroup Results, and Multivariable Regression for Weight Change.

Note: MH = Mantel-Haenszel; OR = odds ratio; CI = confidence interval; BMI = body mass index; GLP-1 = glucagon-like peptide-1; *SE* = standard error; *SD* = standard deviation.a CI crosses 1.0; point estimate directionally preserved but precision limited by small female sample.b Only statistically significant independent predictor of weight loss in multivariable model. * $p < .05$.

DISCUSSION

PRINCIPAL FINDINGS

This study identified a consistent pattern of superior glycemic control in female veterans, both in unadjusted analyses and after stratification for age (MH-OR = 2.01), consistent across all four age strata. After BMI adjustment, the point estimate remained directionally consistent (MH-OR = 1.74) but with wider confidence intervals, reflecting reduced precision due to the limited female sample size. Baseline BMI was the dominant predictor of weight loss, with female sex showing a non-significant trend toward greater weight reduction after adjustment (Apovian et al., 2015). These findings support the conclusion that sex-associated differences in glycemic treatment response are clinically meaningful in this veteran cohort, though their precise magnitude after full confounder adjustment cannot be established with certainty given the observational design and the 22:1 male-to-female ratio.

INTERPRETATION IN LIGHT OF THE LITERATURE

The superior glycemic outcomes in females are consistent with emerging literature on sex-based treatment response in T2DM (Arnetz et al., 2014). The pronounced female advantage among GLP-1 users (40.7% vs. 26.4%) is consistent with pharmacokinetic data showing higher drug exposure in women at equivalent doses (Nauck et al., 2021). Higher TZD prescribing in females (13.8% vs. 5.4%) may further contribute to glycemic outcomes, as females may derive greater insulin-sensitizing benefit from TZD therapy (Gouni-Berthold & Berthold, 2020). Mental health comorbidities are well-established barriers to diabetes self-management and medication adherence (Gonzalez et al., 2008), yet females achieved better glycemic outcomes, suggesting that VA-integrated mental health services may partially mitigate these barriers. The critical role of baseline BMI as the dominant predictor of weight loss is consistent with the broader obesity treatment literature (Apovian et al., 2015).

THE CONFOUNDER QUESTION

The age-adjusted MH-OR of 2.01 demonstrates that the major demographic confounder does not eliminate the sex difference. Attenuation to MH-OR = 1.74 after BMI adjustment, with a CI crossing 1.0, indicates BMI contributes to the association but that limited female sample size constrains precision. A fully specified

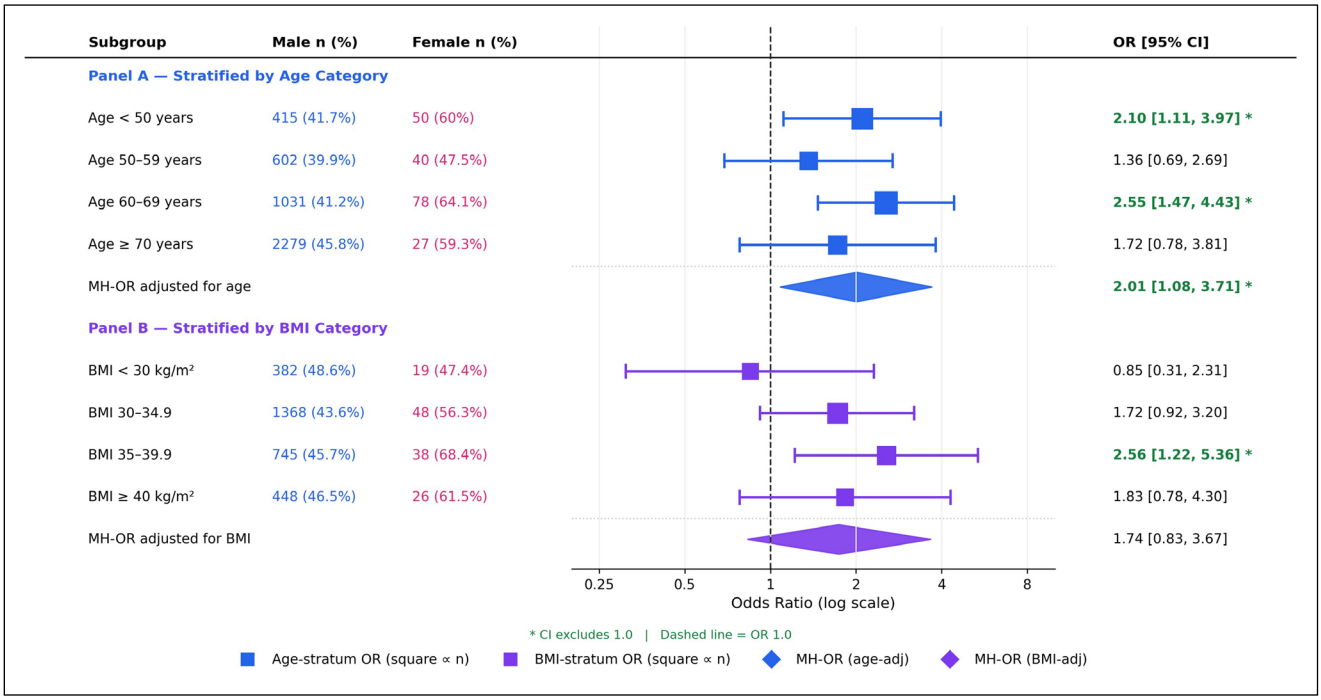


Figure 7 Forest Plot of Sex-Stratified Odds Ratios for HbA1c < 7% Achievement (Female vs. Male veterans).

Note: Panel A: Stratified by age category. Panel B: Stratified by BMI category. Squares represent stratum-specific odds ratios; size is proportional to sample size. Diamonds represent Mantel-Haenszel pooled estimates. Dashed vertical line indicates OR = 1.0 (null). MH = Mantel-Haenszel; CI = confidence interval; BMI = body mass index. * CI excludes 1.0 ($p < .05$).

multivariable logistic regression model was not achievable due to the highly imbalanced sample (195 females vs. 4,327 males) and resulting sparse-data constraints.

CARDIOVASCULAR AND MENTAL HEALTH CONSIDERATIONS

Male veterans' greater cardiovascular burden (CAD 31.0%, CHF 18.3%) appropriately drove higher SGLT2 inhibitor prescribing, consistent with robust cardiovascular outcome data (Zannad et al., 2020). Female veterans' substantially higher rates of depression (60.0%) and anxiety (47.2%) reflect the well-documented mental health burden in this population, attributable in part to military sexual trauma (Kimerling et al., 2016). Menopause documentation in 18.5% of female veterans highlights estrogen deficiency as a key metabolic modifier warranting systematic assessment (El Khoudary et al., 2020).

CLINICAL IMPLICATIONS

For female veterans with comorbid T2DM and obesity: (a) systematic mental health screening and integration into metabolic disease management (Gonzalez et al., 2008), (b) routine menopausal status assessment (El Khoudary et al., 2020), (c) proactive prescribing of obesity-targeted pharmacotherapy, particularly GLP-1 receptor agonists where females may derive amplified benefit (Nauck et al., 2021), and (d) continued behavioral program referrals. For male veterans: (a) substantially increased MOVE! program referral—only 4.3% enrolled despite high metabolic and cardiovascular disease burden; (b) guideline-concordant SGLT2 inhibitor use (Zannad et al., 2020); and (c) depression screening and treatment (Gonzalez et al., 2008). For both sexes, longitudinal weight documentation must be improved; weight follow-up data were available for fewer than 30% of patients.

LIMITATIONS

Several limitations warrant consideration. First, the observational design precludes causal inference; residual confounding by unmeasured factors (e.g., adherence, diabetes duration, race/ethnicity, socioeconomic status) cannot be excluded. Second, the 22:1 male-to-female ratio substantially limits statistical power and precision of adjusted estimates; the MH-adjusted CI crossing 1.0 after BMI stratification reflects this directly. Third, the single-site design may limit generalizability to other VA facilities or geographic regions. Fourth, because post-treatment HbA1c achievement is inherently influenced by baseline

HbA1c, and females had lower baseline HbA1c, the true sex-specific treatment effect on glycemic improvement could not be fully disentangled; longitudinal HbA1c change data were not available in a time-linked fashion. Fifth, weight follow-up data were available for only approximately 28% of the cohort, potentially introducing selection bias. Sixth, sparse female data (n = 195, with some comorbidity cells as small as n = 7) precluded a fully specified multivariable logistic regression with simultaneous covariate adjustment. Seventh, prescription data reflect dispensing rather than confirmed adherence.

FUTURE RESEARCH

Future research should include: (a) multi-site VA data linkage to increase female sample size (target $n \geq 500$) for adequately powered multivariable regression; (b) longitudinal HbA1c change analysis rather than cross-sectional target achievement; (c) propensity score–matched analysis pairing veterans on age, baseline HbA1c, BMI, and comorbidity burden; (d) pharmacokinetic sub-studies examining sex differences in GLP-1 receptor agonist response (Nauck et al., 2021); and (e) qualitative research on barriers to MOVE! program engagement in male veterans.

CONCLUSIONS

In this retrospective cohort of 4,523 veterans with comorbid T2DM and obesity, female veterans achieved significantly better glycemic control than males in unadjusted analyses. Mantel-Haenszel stratified analysis demonstrated this association persisted after age adjustment (MH-OR = 2.01; 95% CI [1.08, 3.71]) and was directionally preserved after BMI adjustment (MH-OR = 1.74; 95% CI [0.83, 3.67]). Baseline BMI was the strongest independent predictor of weight loss after multivariable adjustment (Apovian et al., 2015), with female sex showing a non-significant trend toward greater weight reduction. These findings must be interpreted with appropriate caution given the observational design and pronounced sex imbalance. Nonetheless, sex is a clinically relevant modifier of metabolic treatment outcomes in veterans, and sex-specific strategies—encompassing mental health integration (Gonzalez et al., 2008), hormonal status assessment (El Khoudary et al., 2020), and targeted pharmacotherapy (Nauck et al., 2021; Wilding et al., 2021)—warrant systematic implementation and prospective evaluation.

COMPETING INTERESTS

The authors have no competing interests to declare.

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REFERENCES

ADA Professional Practice Committee. (2024). Standards of medical care in diabetes—2024. *Diabetes Care, 47*(Suppl. 1), S1–S321. https://doi.org/10.2337/dc24-SINT

Apovian, C. M., Aronne, L. J., Bessesen, D. H., McDonnell, M. E., Murad, M. H., Powell, A. G., Rubino, D. M., Sahebkar, A., & **Still, C. D.** (2015). Pharmacological management of obesity: An Endocrine Society clinical practice guideline. *Journal of Clinical Endocrinology & Metabolism, 100*(2), 342–362. https://doi.org/10.1210/jc.2014-3415

Arnetz, L., Ekberg, N. R., & **Alvarsson, M.** (2014). Sex differences in type 2 diabetes: Focus on disease course and outcomes. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy, 7*, 409–420. https://doi.org/10.2147/DMSO.S51301

Barber, K. J., Quiñones, A. R., & **Pantell, M. S.** (2021). Obesity prevalence and correlates in the Veterans Health Administration. *Obesity, 29*(3), 547–555. https://doi.org/10.1002/oby.23109

Department of Veterans Affairs. (2017). *Women veterans report: The past, present, and future of women veterans*. National Center for Veterans Analysis and Statistics. https://www.va.gov/vetdata

Dichter, M. E., Sorrentino, A., Bellamy, S., Medvedeva, E., Roberts, C. B., & **Iverson, K. M.** (2017). Disproportionate mental health burden associated with past-year intimate partner violence among women Veterans. *Journal of Traumatic Stress, 30*(6), 555–563. https://doi.org/10.1002/jts.22241

El Khoudary, S. R., Aggarwal, B., Beckie, T. M., Hodis, H. N., Johnson, A. E., Langer, R. D., Limacher, M. C., Manson, J. E., Stefanick, M. L., & **Allison, M. A.** (2020). Menopause transition and cardiovascular disease risk: Implications for timing of early prevention. *Circulation, 142*(25), e506–e532. https://doi.org/10.1161/CIR.0000000000000912

Franconi, F., & **Campesi, I.** (2014). Pharmacogenomics, pharmacokinetics and pharmacodynamics: Interaction with biological differences between men and women. *British Journal of Pharmacology, 171*(3), 580–594. https://doi.org/10.1111/bph.12362

Gallagher, E. J., & **LeRoith, D.** (2015). Obesity and diabetes: The increased risk of cancer and cancer-related mortality. *Physiological Reviews, 95*(3), 727–748. https://doi.org/10.1152/physrev.00030.2014

Gonzalez, J. S., Peyrot, M., McCarl, L. A., Collins, E. M., Serpa, L., Mimiaga, M. J., & **Safren, S. A.** (2008). Depression and diabetes treatment nonadherence: A meta-analysis. *Diabetes Care, 31*(12), 2398–2403. https://doi.org/10.2337/dc08-1341

Gouni-Berthold, I., & **Berthold, H. K.** (2020). Sex differences in the treatment of type 2 diabetes. *Current Diabetes Reports, 20*(7), 28. https://doi.org/10.1007/s11892-020-01316-y

Hofer, T. P., Hayward, R. A., Greenfield, S., Wagner, E. H., Kaplan, S. H., & **Manning, W. G.** (1999). The unreliability of individual physician "report cards" for assessing the costs and quality of care of a chronic disease. *JAMA, 281*(22), 2098–2105. https://doi.org/10.1001/jama.281.22.2098

Kautzky-Willer, A., Harreiter, J., & **Pacini, G.** (2016). Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. *Endocrine Reviews, 37*(3), 278–316. https://doi.org/10.1210/er.2015-1137

Kimerling, R., Pavao, J., & **Valdez-Colon, A.** (2016). Relationship between military sexual trauma and veteran suicide risk. *Journal of Traumatic Stress, 29*(5), 397–404. https://doi.org/10.1002/jts.22118

Maciejewski, M. L., Arterburn, D. E., Van Scoyoc, L., Smith, V. A., Yancy, W. S. Jr., Weidenbacher, H. J., Livingston, E. H., & **Olsen, M. K.** (2016). Bariatric surgery and long-term durability of weight loss. *JAMA Surgery, 151*(11), 1046–1055. https://doi.org/10.1001/jamasurg.2016.2317

Nauck, M. A., Quast, D. R., Wefers, J., & **Meier, J. J.** (2021). GLP-1 receptor agonists in the treatment of type 2 diabetes—State-of-the-art. *Molecular Metabolism, 46*, Article 101102. https://doi.org/10.1016/j.molmet.2020.101102

Pagoto, S. L., & **Appelhans, B. M.** (2013). A call for an end to the diet debates. *JAMA, 310*(7), 687–688. https://doi.org/10.1001/jama.2013.8601

Petersen, M. C., & **Shulman, G. I.** (2018). Mechanisms of insulin action and insulin resistance. *Physiological Reviews, 98*(4), 2133–2223. https://doi.org/10.1152/physrev.00063.2017

Wilding, J. P. H., Batterham, R. L., Calanna, S., Davies, M., Van Gaal, L. F., Lingvay, I., McGowan, B. M., Rosenstock, J., Tran, M. T. D., Wadden, T. A., Wharton, S., Yokote, K., Zeuthen, N., & **Kushner, R. F.** (2021). Once-weekly semaglutide in adults with overweight or obesity. *New England Journal of Medicine, 384*(11), 989–1002. https://doi.org/10.1056/NEJMoa2032183

Zannad, F., Ferreira, J. P., Pocock, S. J., Anker, S. D., Butler, J., Filippatos, G., Brueckmann, M., Ofstad, A. P., Pfarr, E., Jamal, W., & **Packer, M.** (2020). SGLT2 inhibitors in patients with heart failure with reduced ejection fraction: A meta-analysis of the EMPEROR-Reduced and DAPA-HF trials. *Lancet, 396*(10254), 819–829. https://doi.org/10.1016/S0140-6736(20)31824-9

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