Short Communication

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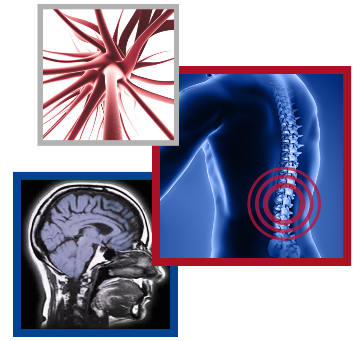
Pain Management



The effect of obesity on pain severity and pain interference

Jade I Basem[1], Robert S White[1], Stephanie A Chen[2], Elizabeth Mauer[3], Michele L Steinkamp[1], Charles E Inturrisi[4] & Lisa R Witkin*,[1]

[1]Department of Anesthesiology, Weill Cornell Medicine, New York, NY 10065, USA
[2]Department of Anesthesiology, Columbia University Medical Center, New York, NY 10032, USA
[3]Department of Healthcare Policy & Research, Weill Cornell Medicine, New York, NY 10065, USA
[4]Department of Pharmacology, Weill Cornell Medicine, New York, NY 10065, USA
*Author for correspondence: lrw9003@med.cornell.edu

Aim: Obesity is one of the most prevalent comorbidities associated with chronic pain, which can severely interfere with daily living and increase utilization of clinical resources. We hypothesized that a higher level of obesity, measured by BMI, would be associated with increased pain severity (intensity) and interference (pain related disability). **Materials & methods:** Participant data was pulled from a multisite chronic pain outpatient database and categorized based on BMI. **Results:** A total of 2509 patients were included in the study. We found significant differences between BMI groups for all pain severity scores (worst, least, average, current) and total pain interference score. Obese patients had significantly higher scores than normal weight patients. **Conclusion:** We found obesity to be associated with increased pain severity and pain interference.

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Keywords: chronic pain • obesity • outcome assessment • pain management • pain medicine

The Institute of Medicine estimates that 100 million US adults are affected by chronic pain, which costs the nation $635 billion yearly in medical treatment and lost productivity [1]. Pain is a common experience for the general population, as 11.2% of adults report daily pain symptoms [2]. Pain is the most common reason patients seek medical attention with approximately one-fifth of ambulatory medical care associated with pain as a primary symptom or diagnosis [3,4]. The experience of pain is complex, as chronic pain is a multidimensional hierarchical construct that consists of both the sensation of pain severity and interference in engagement with activities [5]. In addition, a threshold effect occurs where low levels of pain intensity are not associated with functional interference; however, higher levels of pain intensity increase the probability of interference in a nonlinear fashion [5–7].

One of the prevalent comorbidities that is commonly associated with chronic pain is obesity [8]. Data from the National Health and Nutrition Examination Survey from 2015 to 2016 demonstrates that 39.8% of US adults were obese [9]. The presence of obesity is associated with an increase in self-reported bodily pain measures and pain related disability, a decrease in psychological well-being, and reduced physical functioning [10–12]. The relationship between pain and obesity is likely multidirectional and multifactorial, including central pain and inflammatory pathways [13–15]. Provider prescriptions of nonsteroidal anti-inflammatory agents used to treat pain are higher among patients with obesity [16,17].

Given the prevalence of obesity in the general and chronic pain populations and its effect on clinical outcomes, it is important to understand how obesity affects the validated pain outcomes commonly used in clinical practice, including pain severity and pain interference. Previous research has elucidated higher pain scores in female, osteoarthritic and postoperative patients with obesity. However, these studies are often limited by small or homogeneous cohorts or examine outcomes that are not commonly used by chronic pain providers in a clinical setting [18–22]. No major study to date has analyzed the impact that obesity has on both pain severity and interference scores in a general and diverse chronic pain population. Herein, we seek to further explore the association of obesity as a risk factor for pain related outcomes. Outcomes of interest include pain severity and pain interference. We

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hypothesized that a higher level of obesity, as measured by BMI, would be associated with increased pain severity and pain interference.

Materials & methods

Patient population

We collected data from a longitudinal observational cohort of chronic pain outpatients seen in the Weill Cornell Medicine (WCM) pain medicine clinic from 8 July 2011 to 17 October 2016. These patients are part of a larger tri-institutional chronic pain database herein referred to as The Registry, which encompasses Pain Services data from WCM, Hospital for Special Surgery and Memorial Sloan-Kettering Cancer Center (MSKCC), NY, USA. The Registry design, enrollment procedures, data collection and analysis have been previously described [23]. A data sharing agreement exists between WCM and the Health System Innovation and Research Program, University of Utah School of Medicine, UT, USA, who maintain the database and assist with the data analysis. Health System Innovation and Research Program merges the coded Patient Reported Outcomes data in Webcore with data captured in EPIC, our electronic health record system, to form a complete coded limited dataset for The Registry [23]. While patient identifiers are removed, the coded data contains encounter dates, and therefore the data represents a limited dataset according to the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rules. Patient data is collected under standard of care and is part of a quality improvement program.

The inclusion criteria for this study was all chronic pain patients, as defined by at least one clinic attendance. If multiple visits had data recorded, the first entry was the value used in analysis, including BMI. The original exclusion criteria for The Registry was absence of a chronic pain diagnosis, but for this study the exclusion criteria also included patients without BMI data and without a specific type of chronic pain diagnosis for the encounter [23]. The ICD-9 code associated with the first visit was used as the primary diagnosis.

Patient specific factors and process factors were obtained for each patient at each encounter. These factors included: demographics (age, sex, marital status, ethnicity, language, religion and payor), vitals (height, weight, blood pressure, temperature, pulse rate), diagnoses, current procedural terminology (CPT) codes, medications and the survey data which included the pain severity and pain interference scores. BMI was calculated as weight in kilograms divided by the square of height in meters. Participants were categorized into three groups based on BMI: underweight (BMI <18.5), normal weight (BMI = 18.5–24.99), overweight (BMI = 25–29.9) and obese (BMI ≥ 30); the normal weight category was used as the reference in all models.

During each outpatient pain clinic encounter, pain information was collected using the Brief Pain Inventory short form. The Brief Pain Inventory short form is a validated tool that assesses the presence of pain; pain severity, pain interference, percentage of relief provided by pain treatments or medications (0–100%), and the location of pain at 22 prespecified sites assessed over a 24-h recall period [24]. Patients describe their pain severity on a scale from 0 (“No Pain”) to 10 (“Pain as bad as you can imagine”) when their pain is at its worst, least, on average and if they are experiencing pain right now [7]. Pain interference is measured on seven daily functions, including general activity, mood, walking ability, normal work (includes both work outside the house and housework), relations with other people, sleep and enjoyment of life. Each pain interference measure is assessed through a rating scale from 0 (“Does not Interfere”) to 10 (“Completely Interferes”).

Estimating opioid use, dosage & duration

Opioid medications that were being taken and prescribed at each encounter were abstracted from EPIC. For patients included in the Registry, we captured all the opioids recorded for each encounter backward to 1 November 2010 (this date was specified as when clinicians were required to perform medication reconciliation in EPIC and therefore represents the most reliable data). Resultantly, opioid duration was measured from 1 November 2010 to 1 September 2016, including opioid use prior to entry into the Registry. Based on a discussion with the pain clinicians on patient opioid prescription filling practices, we looked back at least 45 days from their clinic visit for a schedule 2 opioid prescription or refill. We excluded patients receiving intrathecal opioids from this analysis.

Statistical analysis

Statistical analyses were performed using R Version 3.5.3 (Vienna, Austria) [25]. Bivariate analyses were performed to compare pain outcomes by demographic/clinical patient characteristics as well as to compare demographic/clinical patient characteristics by BMI groups (underweight, normal, overweight and obese). Bivariate tests included independent two-sample t-tests, Analysis of Variance (ANOVA) or Chi-squared/Fisher's Exact tests, as appropriate. Nonparametric equivalents were used for violations of normality.

To examine the effect of BMI on pain severity and pain interference we fit multivariable linear regression models to our data; regression coefficients along with their 95% CIs were reported. We developed separate models for each of the four pain severity scores (worst, least, average and current) and for total pain interference with the additional inclusion of pain severity as a covariate. All models adjusted for demographic and clinical variables available and considered relevant (age, pain procedure within 45 days prior, opioids prescribed within 45 days prior and diagnosis). All statistical tests were two-sided with statistical significance assigned at an alpha level of 0.05.

Results

A total of 2509 patients were included in the study. The cohort's median age was 59 years, median BMI was 27 kg/m^2, and the most common pain diagnosis category was musculoskeletal pain (77%). About 20% of the patients received a pain procedure within 45 days prior to the pain clinic encounter. Pain procedures could not be further stratified in our dataset, but include the most commonly performed minimally invasive, image-guided injections including epidural steroid injections, facet injections and joint injections, for example. Half of the patients (53%) received an opioid prescription within 45 days prior. Differences between BMI groups are shown in Table 1. Some statistical significance represents underlying differences in the spread of pain scores, as shown through the range. Bivariate tests revealed significant differences between BMI groups for all pain severity scores and for total pain interference score (Table 2). Additional covariates, such as ethnicity, religion and more granular comorbidities were omitted from the data analysis due to the lack of consistent available information in our dataset.

For each multivariable model looking at pain severity (as either the worst, least, average, or current pain within the past 24 h), patients with obesity demonstrated significantly higher scores than normal weight patients after controlling for age, pain procedure within the 45 days prior to the pain clinic encounter, opioid prescription within the 45 days prior, diagnosis category, sex and payor status. Specifically, patients with obesity had an average 0.339 higher severity score at their worst pain within the past 24 h, 0.615 at their least pain within the past 24 h, 0.355 at their average pain in the past 24 h and 0.611 at their current pain than patients within the normal weight range. Similarly, for the multivariable model looking at overall pain interference, patients with obesity demonstrated significantly higher scores than normal weight patients after controlling for the same factors in addition to pain severity (as measured as the worst pain in the past 24 h). Specifically, patients with obesity had an average 0.355 higher overall pain interference score than patients without obesity.

Confirming our assumption, pain severity (as measured as the worst pain in the past 24 h) was significantly associated with overall pain interference; specifically, overall pain interference increased on average by 0.679 points for each additional point higher in worst pain severity.

Underweight patients and overweight patients also showed higher scores for least pain in 24 h (0.760 and 0.434, respectively) that reached significance compared with patients of normal BMI. Additionally, underweight patients trended toward significance for the pain severity model ($p = 0.058$) and overweight patients had a significant difference for the pain interference model ($p = 0.022$), both compared with patients of normal BMI.

Opioid prescription was statistically significant for each pain severity and pain interference outcome used in multivariable modeling ($p < 0.0001$ for all outcomes). 58.3% of patients with obesity and 63.2% of underweight patients were prescribed opioid medications within 45 days prior compared with only 50.7% of normal weight patients ($p = 0.001$), with all BMI groups being more likely to take pain medications than not. Differences between BMI groups also existed when looking specifically at immediate-release (IR) opioid medications and extended-release (ER) opioid medications prescribed. A total of 56.3% of patients with obesity and 61.8% of underweight patients were prescribed IR opioid medications compared with 46.5 and 48.3% of normal and overweight patients ($p < 0.001$), respectively. About 14% of both obese, normal and overweight patients were prescribed ER opioid medications compared with 25% of underweight patients ($p = 0.041$).

Discussion

Pain severity & interference

Our study showed that pain clinic patients with obesity experience higher pain severity and pain interference scores than normal weight patients. Our findings corroborate prior literature that shows that obesity is a risk factor for chronic pain [26–31] and demonstrates that obesity is an independent risk factor for experiencing more pain severity

Table 1. Differences between BMI groups.

	BMI <18.5	18.5–24.99	BMI 25–29.99	BMI ≥30	p-value	n
Weight	106 (98.8; 118)	136 (122; 153)	171 (155; 190)	215 (190; 243)	0	2509
Height	65.3 (63.7; 69.0)	65.5 (63.0; 68.7)	66.1 (63.0; 70.0)	65.5 (63.9; 69.0)	<0.001	2509
Age (continuous)	52.2 (36.8; 69.5)	58.2 (42.2; 72.2)	60.7 (49.7; 71.3)	59.1 (49.4; 68.6)	0.003	2509
Age (categorical)					<0.001	2509
18–44	25 (36.8%)	249 (28.8%)	152 (18.1%)	120 (16.3%)		
45–64	23 (33.8%)	283 (32.7%)	362 (43.0%)	364 (49.6%)		
65+	20 (29.4%)	334 (38.6%)	327 (38.9%)	250 (34.1%)		
Sex					<0.001	2509
Female	57 (83.8%)	561 (64.8%)	417 (49.6%)	452 (61.6%)		
Male	11 (16.2%)	305 (35.2%)	424 (50.4%)	282 (38.4%)		
Payor					<0.001	2373
Medicare	20 (31.2%)	303 (36.8%)	307 (38.6%)	254 (36.9%)		
Medicaid	7 (10.9%)	105 (12.7%)	134 (16.8%)	168 (24.4%)		
Commercial	37 (57.8%)	416 (50.5%)	355 (44.6%)	267 (38.8%)		
Ethnic group						2509
African American	0 (0.00%)	1 (0.12%)	0 (0.00%)	1 (0.14%)		
Asian/PA	0 (0.00%)	1 (0.12%)	0 (0.00%)	0 (0.00%)		
Caucasian	0 (0.00%)	1 (0.12%)	1 (0.12%)	0 (0.00%)		
Declined	26 (38.2%)	334 (38.6%)	329 (39.1%)	220 (30.0%)		
Hispanic	2 (2.94%)	54 (6.24%)	85 (10.1%)	113 (15.4%)		
Multiracial	0 (0.00%)	2 (0.23%)	1 (0.12%)	0 (0.00%)		
Not Hispanic	38 (55.9%)	427 (49.3%)	391 (46.5%)	357 (48.6%)		
Null	0 (0.00%)	1 (0.12%)	0 (0.00%)	0 (0.00%)		
Unknown	2 (2.94%)	45 (5.20%)	34 (4.04%)	43 (5.86%)		
Pain procedure with 45 days prior					0.884	2509
No	57 (83.8%)	691 (79.8%)	675 (80.3%)	588 (80.1%)		
Yes	11 (16.2%)	175 (20.2%)	166 (19.7%)	146 (19.9%)		
Pain procedure with 45 days after					0.804	2509
No	56 (82.4%)	680 (78.5%)	652 (77.5%)	576 (78.5%)		
Yes	12 (17.6%)	186 (21.5%)	189 (22.5%)	158 (21.5%)		
Opioid medication within 45 days prior					0.002	2509
No	25 (36.8%)	431 (49.8%)	410 (48.8%)	306 (41.7%)		
Yes	43 (63.2%)	435 (50.2%)	431 (51.2%)	428 (58.3%)		
IR opioid medications within 45 days prior					<0.001	2509
No	26 (38.2%)	463 (53.5%)	435 (51.7%)	321 (43.7%)		
Yes	42 (61.8%)	403 (46.5%)	406 (48.3%)	413 (56.3%)		
ER opioid medications within 45 days prior					0.064	2509
No	51 (75.0%)	738 (85.2%)	730 (86.8%)	627 (85.4%)		
Yes	17 (25.0%)	128 (14.8%)	111 (13.2%)	107 (14.6%)		
Pain severity and interference						
Worst pain, 24 h	8.00 (6.00; 9.00)	7.00 (5.00; 9.00)	8.00 (6.00; 9.00)	8.00 (6.00; 9.00)	<0.001	2425
Least pain, 24 h	5.00 (3.00; 7.00)	4.00 (2.00; 6.00)	4.00 (2.00; 7.00)	5.00 (2.00; 7.00)	<0.001	2415
Average pain, 24 h	6.00 (4.25; 8.00)	6.00 (4.00; 7.00)	6.00 (4.00; 8.00)	6.00 (5.00; 8.00)	<0.001	2371
Pain now-current	6.50 (4.00; 8.00)	5.00 (3.00; 7.00)	6.00 (3.00; 8.00)	6.00 (4.00; 8.00)	<0.001	2370
General activity	7.00 (5.00; 9.00)	6.00 (4.00; 8.00)	6.00 (4.00; 8.00)	7.00 (5.00; 9.00)	<0.001	2345
Mood	7.00 (4.00; 9.00)	6.00 (2.00; 8.00)	5.00 (3.00; 8.00)	6.00 (3.00; 8.00)	0.003	2330
Walking	6.00 (3.00; 9.00)	5.00 (2.00; 8.00)	6.00 (3.00; 8.00)	7.00 (4.00; 9.00)	<0.001	2339
Normal work	7.00 (5.00; 9.00)	6.00 (4.00; 8.00)	7.00 (4.00; 9.00)	7.00 (5.00; 9.00)	<0.001	2315
Relations with others	5.00 (1.25; 7.00)	4.00 (0.00; 7.00)	4.00 (0.00; 7.00)	5.00 (0.00; 7.00)	0.035	2294

ER: Extended release; IR: Immediate release.

Table 1. Differences between BMI groups (cont.).

	BMI <18.5	18.5–24.99	BMI 25–29.99	BMI ≥30	p-value	n
Sleep	6.50 (3.00; 8.00)	5.00 (1.00; 8.00)	5.00 (2.00; 8.00)	6.00 (3.00; 9.00)	0.003	2318
Enjoyment of life	8.00 (5.00; 9.00)	6.00 (3.00; 8.00)	7.00 (4.00; 8.00)	7.00 (5.00; 9.00)	<0.001	2297
Interference total score	6.29 (5.00; 7.71)	5.43 (3.14; 7.43)	5.71 (3.71; 7.43)	6.46 (4.14; 8.00)	<0.001	2359
Diagnosis category						2509
Back pain	14 (20.6%)	238 (27.5%)	268 (31.9%)	218 (29.7%)		
Extremity pain	12 (17.6%)	102 (11.8%)	102 (12.1%)	105 (14.3%)		
Head-mouth pain	2 (2.94%)	17 (1.96%)	16 (1.90%)	8 (1.09%)		
Inflammatory pain	2 (2.94%)	6 (0.69%)	5 (0.59%)	6 (0.82%)		
Myofascial pain	5 (7.35%)	75 (8.66%)	36 (4.28%)	39 (5.31%)		
Neuropathic	8 (11.8%)	98 (11.3%)	109 (13.0%)	90 (12.3%)		
Osteoarthrosis pain	5 (7.35%)	55 (6.35%)	64 (7.61%)	63 (8.58%)		
Pelvic-abdominal pain	9 (13.2%)	57 (6.58%)	45 (5.35%)	21 (2.86%)		
Radicular pain	6 (8.82%)	181 (20.9%)	166 (19.7%)	147 (20.0%)		
Unclear/unknown	5 (7.35%)	37 (4.27%)	30 (3.57%)	27 (5.04%)		
Diagnosis category					0.001	2509
Musculoskeletal	44 (64.7%)	657 (75.9%)	641 (76.2%)	578 (78.7%)		
Neuropathic	8 (11.8%)	98 (11.3%)	109 (13.0%)	90 (12.3%)		
Other	11 (16.2%)	74 (8.55%)	61 (7.25%)	29 (3.95%)		
Unclear/unknown	5 (7.35%)	37 (4.27%)	30 (3.57%)	37 (5.04%)		

ER: Extended release; IR: Immediate release.

and pain that may interfere with patients' daily function. Heim *et al.* reported that in a population of older adults, patients with obesity were more likely to develop pain, and that the frequency of pain increased more drastically with increased BMI, especially for women [32]. Their study found that, regardless of weight changes, someone with a higher BMI is more likely to longitudinally develop chronic pain [32].

Pain severity

Our study found that obesity was related to pain severity. Patients' rating of worst pain in the last 24 h was statistically significant, with increased pain severity found in patients with obesity compared with the normal patients. Overweight and underweight patients did not have a statistically significant difference compared with normal patients in multivariable modeling of worst pain in the last 24 h. Obesity as a risk factor for pain severity has been found in many other studies, ranging from adolescents to geriatric populations [30,31,33,34]. Chronic pain development in an obese population, particularly morbidly obese (BMI >35), after a motor vehicle accident had a significant effect on increasing pain severity during multiple follow-up visits within a year [22].

However, some studies have disputed the relationship between pain severity and obesity [19,35]. Taspinar *et al.* did not find obesity to influence pain severity for university students with nonspecific back pain. However, this study included only university students, which limits its generalizability to the wider chronic pain population, which includes patients of a larger age range.

Looking at the underweight population, the literature agrees with our finding of a trend toward increased current pain severity in the underweight population compared with the normal group [36]. Previously, this has also influenced the prescription of opioid medications for pain relief, specifically in cancer populations, but the true clinical relevance has yet to be determined. A recent study found a j-curve with BMI for pain presence and pain intensity, so this could be the phenomenon observed in our results as well [37].

Pain interference

Pain severity is related to pain interference, as it is not unexpected that higher levels of pain intensity would have more drastic effects on functioning [5]. In our study, pain interference scores increased with increased ratings of worst pain in the last 24 h. Pain severity and frequency has been shown to directly predict pain interference and quality of life [38–40]. Of note, our findings contradict with several studies that did not find an association between pain severity and pain interference [19]. This finding could be due to a threshold effect that occurs where low levels

Table 2. Multivariable model results.

		Pain severity (worst 24 h)		Pain severity (least 24 h)		Pain severity (average 24 h)		Pain severity (current)		Pain interference	
		Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Sex	Sex (male)	-0.578 (-0.782, -0.373)	0.000	-0.621 (-0.861, -0.382)	0.000	-0.619 (-0.819, -0.420)	0.000	-0.678 (-0.913, -0.442)	0.000	-0.212 (-0.379, -0.046)	0.013
Payor status	Medicaid	0.541 (0.227, 0.856)	0.001	1.390 (1.021, 1.759)	0.000	0.736 (0.428, 1.044)	0.000	0.896 (0.533, 1.259)	0.000	0.113 (-0.143, 0.369)	0.388
	Commercial	-0.438 (-0.700, -0.178)	0.001	-0.339 (-0.646, -0.033)	0.030	-0.476 (-0.731, -0.221)	0.000	-0.418 (-0.719, -0.117)	0.007	-0.179 (-0.390, 0.033)	0.098
BMI	Underweight	0.296 (-0.328, 0.919)	0.353	0.760 (0.025, 1.495)	0.043	0.406 (-0.196, 1.009)	0.186	0.689 (-0.023, 1.401)	0.058	0.304 (-0.201, 0.810)	0.238
	Ref = normal weight	–	–	–	–	–	–	–	–	–	–
	Overweight	0.198 (-0.043, 0.439)	0.108	0.434 (0.151, 0.718)	0.003	0.189 (-0.047, 0.426)	0.117	0.170 (-0.108, 0.449)	0.231	0.229 (0.033, 0.425)	0.022
	Obese	0.339 (0.088, 0.589)	0.008	0.615 (0.321, 0.908)	0.000	0.355 (0.111, 0.599)	0.004	0.611 (0.322, 0.900)	0.000	0.355 (0.152, 0.558)	0.001
Age		-0.004 (-0.011, 0.004)	0.304	-0.001 (-0.010, 0.008)	0.809	-0.001 (-0.008, 0.007)	0.887	-0.011 (-0.019, -0.002)	0.014	-0.020 (-0.026, -0.014)	0.000
Pain procedure within 45 days prior		0.064 (-0.181, 0.309)	0.609	-0.083 (-0.370, 0.205)	0.573	-0.084 (-0.324, 0.156)	0.492	-0.041 (-0.324, 0.242)	0.775	-0.027 (-0.225, 0.171)	0.787
Opioid prescription within 45 days prior		0.661 (0.459, 0.863)	0.000	0.580 (0.343, 0.817)	0.000	0.523 (0.326, 0.721)	0.000	0.676 (0.443, 0.909)	0.000	0.418 (0.253, 0.584)	0.000
Diagnosis	Ref = musculoskeletal	–	–	–	–	–	–	–	–	–	–
	Neuropathic	0.108 (-0.201, 0.416)	0.494	0.058 (-0.304, 0.420)	0.754	0.076 (-0.224, 0.376)	0.619	0.097 (-0.259, 0.453)	0.593	-0.158 (-0.408, 0.092)	0.217
	Other	0.161 (-0.230, 0.551)	0.420	-0.318 (-0.775, 0.139)	0.172	-0.045 (-0.427, 0.337)	0.818	-0.343 (-0.793, 0.107)	0.135	-0.295 (-0.609, -0.018)	0.065
	Unclear/unknown	-0.172 (-0.653, 0.309)	0.483	-0.192 (-0.754, 0.371)	0.504	-0.061 (-0.526, 0.404)	0.797	-0.188 (-0.739, 0.363)	0.504	0.350 (-0.039, 0.739)	0.078
	Worst pain	–	–	–	–	–	–	–	–	0.679 (0.646, 0.712)[1]	0.000

–: No data.

of pain intensity are not associated with functional interference and where higher levels of pain intensity increase the probability of higher levels of pain interference in a nonlinear fashion [5–7].

In our study, patients with obesity had higher pain interference than normal weight patients. This follows previous trends finding that patients with obesity have a higher frequency of pain interference and more severe disability from pain [19,29,34,39]. Our finding of overweight patients also being statistically significantly higher for values of their pain interference further supports our hypothesis of weight influencing pain interference. Only one study found obesity to be independent of pain interference scores [18].

Sex

Females had consistently worse pain for all pain severity categories and pain interference totals both in the bivariate analyses and multivariable models, which is consistent with prior literature findings [32,34,41]. Sensitivity analyses showed that sex did not impact the relationship between BMI and pain severity or pain interference.

Payor group

Pain severity and pain interference was also impacted by payor status, such that these scores were worse for Medicare and Medicaid patients compared with commercially insured patients. While the observed scores were higher for Medicaid patients compared with Medicare, these differences were not statistically significant. This finding is not surprising, as Medicare patients may be older or have more significant health conditions compared with commercially insured patients; however, the finding regarding Medicaid patients may be due to those patients receiving specialty care later in their diseases progression and presenting with more severe underlying disease, or suggest a health disparity that warrants further investigation. As with sex, these payor differences did not change the relationship of BMI with pain severity and pain interference in multivariable modeling.

Limitations

Our study is limited by the retrospective, multi-institutional data collected primarily from tertiary care centers, and the high prevalence of musculoskeletal pain in our population. Seventy-seven percent of all participants in this study had a diagnosis of musculoskeletal pain, and 79% of patients with obesity diagnosed with that as well, being only slightly higher than the normal (75.9%) and overweight category (76.2%) and significantly higher than the underweight group (64.7%). The data did not include information about the distribution of fat. Previous literature often restricted cohort populations to those with specific types of pain, like musculoskeletal pain, since its development has been more easily associated with obesity [33,34,37,41]. Musculoskeletal pain has also been connected with more pain locations, which is further increased within an obese population [34,41]. Back pain specifically was the most frequent diagnosis within our population, which has previously been linked to obesity as well [30]. Osteoarthritis, however, was less common in this population and that has previously been associated with significant increased pain in obesity studies [37]. While a diagnosis of musculoskeletal pain may influence obesity and pain severity scores, it is an extremely prevalent pain diagnosis with clinical implications in both our population and the general population, and thus could not be ignored. Our data suggests that even with chronic pain diagnoses not related to musculoskeletal pain, the same trends with obesity and increased pain and pain interference are found.

Our study was also limited by the categorization of weight. For our study, obesity was defined as anyone with a BMI greater than or equal to 30. Further stratification of this obese category has shown trends that indicate greater pain in the severely obese. For McCarthy *et al.,* the severely obese, or those with a BMI of at least 35, were associated with four-times the probability of having chronic pain compared with normal patients, whereas those with BMI = 30–34.99 were only twice as likely [34]. This stratification more drastically shows the impact that obesity poses on the experience of chronic pain. Deyo *et al.* also showed that for those in the top 20%, the prevalence of pain has been found to be significantly higher than those in the bottom 20% of the obese category [28]. While we did not stratify further our obese category, our separation of overweight and obese from normal weight patients does show that patients with obesity had consistently higher pain severity and interference scores than overweight patients. In addition, our study highlights that underweight patients, even with a smaller percentage of musculoskeletal pain diagnoses, similarly have increased pain severity and pain interference, highlighting the importance of BMI in both directions.

Our study only included patients that visited the outpatient pain clinics included in The Registry at least once and who had BMI data and a diagnosis for the encounter. The survey data analyzed was that of the first survey in the registry for each patient. While the first available BMI value was used as well, this did not consistently align with the first full survey dataset since patients often had multiple pain clinic encounters. The inconsistency of complete data sets also meant that we could not compare baseline visits to follow-up visits. By identifying patients retrospectively, we could not follow their progress over more visits longitudinally. Information such as BMI changes and prospective associations were thus unable to be calculated. A recent systematic review suggests that patients with chronic pain and obesity have worse pain management results, which could be implicated in our findings of pain prevalence, severity and interference [30]. In addition, while The Registry is a multisite database, it gathers information solely from New York City-based sites, which could limit the generalizability of our results.

In addition, The Registry database was limited by missing information regarding some sociodemographic data (i.e., language, marital status, religion and ethnic group), occupation information, and by the categorization of comorbidities within the electronic medical record making it difficult to analyze. Specifically, our study was not able to capture the prevalence of psychiatric comorbidities within our chronic pain population. Many other studies have found that this dramatically impacts both obesity and pain, often increasing the likelihood or severity of both [9–11,26,27,34,42,43]. Further research is warranted to assess the role of psychiatric comorbidities and occupation, as well as sociodemographic difference, on pain interference and severity within a chronic pain population.

Conclusion

Our study demonstrated that BMI is associated with statistically significant changes in pain severity and interference as well as opioid prescriptions from real-world data in a large academic pain center that includes not just musculoskeletal pain, but a diverse number of pain conditions receiving multimodal treatments, including interventions. The management of chronic pain is multifaceted and complex, particularly in the obese chronic pain population. Our study suggests that these patients' chronic pain is characterized not only by higher pain severity, but also greater interference with activities of daily living. While these findings are statistically significant, the clinical significance and implication for patient care remains to be seen, but suggests that BMI has a significant effect and could highlight the need for improved individualized treatment strategies, including counseling patients about their BMI, health maintenance, and setting reasonable expectations regarding physical functioning and prognosis. Further prospective research is warranted to understand the relationship between reducing BMI and pain interference scores, as well as understanding the impact in the underweight population, and the influence of sociodemographic factors.

Future perspective

In the field of pain medicine, we speculate that treatment options will continue to become more individualized, particularly in recognizing and treating obesity as a comorbidity of chronic pain. Current research, including our own, demonstrates that obesity is a risk factor for increased pain severity and pain interference on quality of life metrics. Incorporating obesity status and other individualized concerns into a patient's medical history and plan could greatly influence clinical prognosis and chosen pain management treatments.

Summary points

- Pain severity and pain interference has a statistically significant association with BMI, specifically obesity as well as opioid prescriptions.
- The management of chronic pain is multifaceted and complex, particularly in the obese chronic pain population.
- Our study suggests that these patients' chronic pain is characterized not only by higher pain severity, but also greater pain interference, including with activities of daily living.
- We believe that this relationship is multifactorial and bidirectional, and that pain physicians should consider the impact of obesity when developing an individualized pain management treatment strategy.
- Further prospective research is warranted to understand the relationship between BMI and pain severity as well as pain interference.

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Ethical conduct of research

The authors state that they have obtained appropriate institutional review board approval or have followed the principles outlined in the Declaration of Helsinki for all human or animal experimental investigations. In addition, for investigations involving human subjects, informed consent has been obtained from the participants involved. This study was approved by the Institutional Review Board and Clinical Study Evaluation Committee of Weill Cornell Medicine.

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