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Association Between Obesity and Functional Status in Patients With Spine Disease

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Study Design. A cross-sectional study of 15,974 patients with spine disease from 26 members of the National Spine Network.

Objectives. To use functional status measures and clinical parameters to evaluate the association between obesity and health status among patients with spine conditions.

Summary of Background Data. With 22.5% of Americans overweight, obesity is a significant health concern. However, the functional impact caused by obesity in spine patients remains unknown.

Methods. Functional status was measured on 15,974 patients on an initial visit using a general physical health measure (SF-36 Physical Component Summary score) and a disease-specific measure (Oswestry Disability Index). Obesity was measured using body mass index (kg/m^2). Patients were categorized into four groups according to body mass index: normal range (<25.0 kg/m^2, n = 5732), Grade 1 obesity (25.0–29.9 kg/m^2, n = 5845), Grade 2 obesity (30.0–39.9 kg/m^2, n = 3836), and Grade 3 obesity (≥40.0 kg/m^2, n = 561). The associations between SF-36 Physical Component Summary and Oswestry Disability Index scores and body mass index were evaluated in a multivariate linear regression model. Clinical presentation data were derived from patient and clinician reports and were compared across body mass index categories.

Results. In the four obesity categories, the PCS scores were 32.6 (normal range body mass index), 30.8 (Grade 1), 28.2 (Grade 2), and 25.9 (Grade 3) ($P < 0.001$). The SF-36 Physical Component Summary score of the general U.S. population is 50.0. The Oswestry Disability Index scores across the four body mass index groups were 39.0, 41.6, 46.6, and 52.2, respectively ($P < 0.001$). Compared with nonobese patients, obese patients were more likely to have radicular pain and neurologic signs ($P < 0.01$). Furthermore, obese patients had more comorbidities and were more likely to be receiving worker's compensation. After adjusting for clinical and demographic factors, each increased level of obesity was associated with a 1–1.5-point worsening in both the SF-36 Physical Component Summary and Oswestry Disability Index scales ($P < 0.05$).

Conclusions. General and disease-specific functional health status was significantly worse for patients with a higher body mass index. Obese patients also displayed more severe pain symptoms than nonobese spine patients. [Key words: body mass index, functional status, National Spine Network, obesity, Oswestry Disability Index, Physical Component Summary score, SF-36, spinal condition] **Spine 2002;27:306–312**

Over the past two decades, the prevalence of obesity (body mass index [BMI] ≥ 30 kg/m^2) in the United States has dramatically increased, rising from 14.5% of the population in 1980 to 22.5% in 1994.[11] This epidemic has a far-reaching public health impact because obesity has been identified as a strong risk factor for cardiovascular disease, cancer, stroke, and endocrine disorders.[27] Furthermore, obese patients have significantly lower functional status than nonobese patients; that is, the obese have more physical morbidity than their normal weight counterparts.[12,32]

In addition to cardiovascular and malignant diseases, some chronic and high-morbidity spine conditions have been linked to obesity. Specifically, low back pain has been correlated with obesity in many studies.[3,5,16,17,20,21,22,24,30] Some theorize that the abnormal mechanical loads placed on the spine of the obese patient cause back disorders.[5,16,17] Others suspect that a spine condition is the initial injury and that the resultant sedentary lifestyle leads to obesity.[15,20] Although the association between low back pain and body weight has been well studied, little is known about how obesity affects functional status in spine patients. The authors hypothesize that increased BMI in the spine patient is coupled with lower functional status and worse disease-specific measures. This present study of a large population of spine patients examines the associations between obesity and functional status in spine patients. The study uses well-accepted and validated measures of functional status (SF-36 Physical Component Summary [PCS] score and Oswestry Disability Index [ODI]) and standard clinical parameters to examine patients across all levels of BMI (kg/m^2) in an effort to understand how obesity is related to the health status of spine patients.

Materials and Methods

Study Design. This study is a cross-sectional observational study of 15,974 patients from the National Spine Network

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(NSN). The NSN is a consortium of 26 spine centers nationwide, including academic institutions, hospitals, private practices, and individual physicians, which treat spine conditions and collaborate in collecting outcomes data on their patients. Most member centers are specialty clinics dedicated to spine care, and all centers espouse a multidisciplinary philosophy of spine treatment and are affiliated with an accredited hospital or academic medical center. The majority of participating physicians are orthopedic surgeons, neurosurgeons, neurologists, physiatrists, and anesthesiologists; however, there are a limited number of internists and family practitioners involved in the network. The NSN protocol states that each participating physician should administer the NSN Health Status Survey to each of their spine patients. The network's patient population is composed primarily of patients with the most common spine diagnoses (herniated disc, spinal stenosis, spondylosis, sprain/stains, and chronic pain syndrome) and includes a smaller number patients with scoliosis, spinal tumors, kyphosis, trauma, infection/inflammation, and osteoporosis.

Measures

NSN Health Status Survey. The data used in this study are from the initial visit NSN Health Survey Questionnaire. This survey is completed by both the clinician and the patient. The patient enters information about demographics, functional health status, spine symptoms, comorbidities, medications, and work status. The clinician enters information about pain symptoms, neurologic signs, surgical history, diagnoses, diagnostic studies, consultations, and treatment plan.[9]

Short-Form 36 Health Status Questionnaire. Functional health status is assessed using the Medical Outcomes Trust Short Form 36 (SF-36) Health Status Questionnaire, which is integrated into the NSN Health Status Survey.[36] The SF-36 survey measures functional status in eight categories: general health perceptions (GH), physical function (PF), general mental health (MH), role function as limited by physical problems (RP), role function as limited by mental problems (RE), bodily pain (BP), vitality (VT), and social function (SF). Two summary scales are also available: the PCS, an overall summary of physical well being, and the Mental Component Summary, an overall summary of mental health. Both summary scales are normalized to a score of 50, which represents the "average" health status of the general U.S. population, and the populations' standard deviation is 10 (see Appendix).[9,35]

Using the PCS scale alone enables more user-friendly interpretation of a patient's functional status than if all eight SF-36 scores are interpreted separately. Also, the number of statistical analyses is significantly reduced when using one score instead of eight. Compared with the eight SF-36 subscales, PCS scores have greater or equal reliability and have many more scale levels, creating more statistical power to detect differences in physical health.[35] The possible range of PCS scores is from 2 (complete disability) to 76 (no disability).[35]

ODI. The Oswestry Low Back Pain Disability Questionnaire is a 10-question, low back-specific survey, which generally takes 3–5 minutes to complete.[7] The NSN questionnaire uses 9 of the 10 items (items 2–10) from the American version of the questionnaire developed by the American Academy of Orthopedic Surgeons for the MODEMS project. Each question has six possible responses that are scored from 0 to 5. All scores are summed and divided into the highest possible score of 45, producing a 0–100% scale, with 0 representing no disability and 100 representing complete disability. For missing responses the total possible score is reduced (*e.g.*, the highest possible score for 8 responses would be 40). This scale is referred to as the ODI. The ODI is a popular disease-specific outcome measure for studies of patients with low back pain.[8]

BMI. Various techniques are available for measuring obesity including skinfold thickness, bioelectrical impedance, and dual energy radiograph absorptiometry.[27] A standardized, less expensive, less time-consuming, and more accurate method of assessing body fat is by BMI.[27] BMI is calculated as weight in kilograms divided by the square of the height in meters (kg/m^2). A BMI of 30.0 is equivalent to 186 lb in a 5 ft 6 in. person and 221 lb in a 6 ft 0 in. person. The World Health Organization international classification of obesity defines four levels of severity: normal range BMI (<25.0 kg/m^2), Grade 1 (moderate) obesity (25.0–29.9 kg/m^2), Grade 2 (severe) obesity (30.0–39.9 kg/m^2), and Grade 3 (morbid) obesity (≥40.0 kg/m^2).[27]

Statistical Analyses

Patients. Of the original data set of 18,389 patients, 1399 patients did not enter their height and/or their weight on the questionnaire. Thus, BMI could be calculated on 16,990 patients. PCS scores cannot be calculated if a patient answered less than half of the questions in one or more of the eight SF-36 subscales. This was the case for 1016 patients. Thus, PCS and BMI could be calculated on 15,974 patients, approximately 87% of the original data set. The 13% of NSN baseline patients who were excluded from the analysis tended to be older, more often female, less often working, and have worse physical and mental health status by all scales of the SF-36. Therefore, this study's estimates of overall functional status, as measured by the PCS and ODI, will tend to overestimate the health status

Table 1. Demographics

Characteristic	All Patients	Normal Range	Grade 1 Obesity	Grade 2 Obesity	Grade 3 Obesity
No. of patients	15,974	5732	5845	3836	561
Age (yr) [mean (±SD); range: 18–98]	48.9 (±15.1)	46.9 (±16.1)	50.5 (±14.8)	49.8 (±13.9)	47.7 (±12.3)
Body mass index range (kg/m^2)	17.0–68.4	<25.0	25.0–29.9	30.0–39.9	≥40.0
Female (%)	51.4 (n = 8203)	62.1	40.2	49.9	67.7
White (%)	89.6 (n = 13,568)	90.8	90.5	87.2	84.1
College education or beyond (%)	61.2 (n = 9287)	66.7	60.7	54.7	55.6
Married (%)	69.9 (n = 10,569)	65.5	73.3	72.0	64.3
Receiving worker compensation (%)	8.4 (n = 1343)	6.7	8.2	11.2	9.3

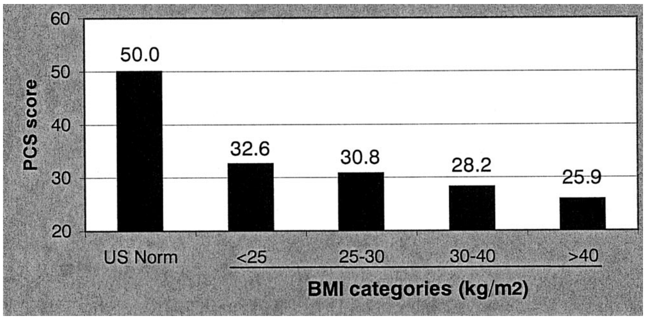

Figure 1. Average PCS scores for each BMI category ($P<0.001$).

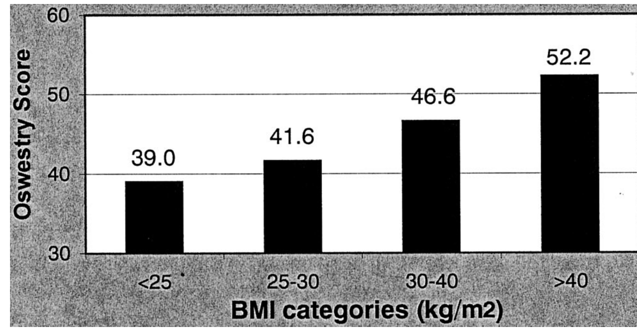

Figure 2. Average Oswestry scores for each BMI category ($P<0.001$).

of this population and likely represent a conservative estimate of the burden of spine disease and obesity.

Analyses. χ^2 tests and analysis of variance were used to assess differences in patient characteristics between BMI groups. Multivariate linear regression analyses were performed to isolate the independent association between BMI and functional status (PCS and ODI). Potentially confounding variables included in the models were age, gender, education level, worker's compensation, current smoker, chronicity of symptoms, radicular pain, previous surgery, comorbidity frequency, and location of spinal condition. All statistical analyses were performed using Stata 6.0 statistical software (Stata Corp., College Station, TX).

■ Results

Demographic

Obese patients tended to be nonwhite, less educated, and more likely to be receiving Workers' Compensation (Table 1). Normal range BMI patients and Grade 3 obese patients tended to be female, whereas Grade 1 patients tended to be male.

Functional Status

The PCS score, in which higher values indicate better functioning, was negatively correlated with BMI (Figure 1). That is, the group with the lowest BMI had the highest functional status (PCS = 32.6 for nonobese *vs.* 25.9 for morbidly obese, $P < 0.001$). A similar trend was found with the ODI, in which higher values indicate more disability (ODI = 39.0 for nonobese *vs.* 52.2 for morbidly obese, $P < 0.001$) (Figure 2). This indicates that patients who had the least physical morbidity were in the normal range of BMI. This was found in both the general (PCS) and spine-specific (ODI) measures. Importantly, with a PCS of 32.6 (± 10.1 SD), even the highest functioning group was nearly 2 standard deviations below the U.S. general population norm of 50.0 (± 10.0 SD).[35]

Clinical Status

There were significant trends across the four BMI categories for neurologic symptoms and signs (Table 2). Compared with normal range BMI patients, Grade 3 obese patients had more radicular pain (33.6% [nonobese] *vs.* 47.2% [morbidly obese], $P < 0.001$) and more neurologic signs (26.4% [nonobese] *vs.* 32.7% [morbidly obese], $P < 0.01$). The data in Table 2 also show that obese patients were more likely to have chronic symptoms (total duration of spine disease of at least 3 months) and more likely to have lumbosacral disease (as opposed to cervical or thoracic disease). Spinal stenosis was the most common diagnosis in all four BMI categories (Table 3).

Comorbidities

Morbidly obese spine patients had, on average, almost twice as many comorbidities as nonobese spine patients (2.6 comorbidities per morbidly obese patient *vs.* 1.4 comorbidities per nonobese patient, $P < 0.001$) (Figure 3). Furthermore, more cardiac disease, hypertension, pulmonary disease, diabetes mellitus, gastrointestinal ulcers, depression, frequent headaches, and arthritis (osteoarthritis and rheumatoid arthritis) were reported among the obese (all P values < 0.001) (Table 4). Compared with nonobese patients, obese patients were more likely to have more than one comorbidity (38.3% [nonobese] *versus* 68.1% [morbidly obese], $P < 0.001$). Nonobese patients were more likely to have no comorbidites (34.7% [nonobese] *versus* 12.8% [morbidly obese], $P < 0.001$).

Table 2. Clinical Profile

Characteristic	Normal Range BMI [% (n)]	Grade 1 Obesity [% (n)]	Grade 2 Obesity [% (n)]	Grade 3 Obesity [% (n)]	*P* Value
Lumbosacral diagnosis	56.2 (3221)	63.4 (3706)	64.7 (2480)	65.4 (367)	<0.01
Radicular pain	33.6 (1925)	40.2 (2350)	42.2 (1617)	47.2 (265)	<0.001
Neurologic signs	26.4 (1486)	31.7 (1826)	32.0 (1200)	32.7 (181)	<0.01
≥3 months of symptoms	85.9 (4598)	87.0 (4776)	88.2 (3162)	89.0 (468)	<0.01

Table 3. Five Most Common Diagnoses

Diagnosis	Normal Range BMI [% (n)]	Grade 1 Obesity [% (n)]	Grade 2 Obesity [% (n)]	Grade 3 Obesity [% (n)]
Spinal stenosis	30.5 (1748)	37.0 (2164)	37.1 (1423)	35.1 (197)
Herniated disc	18.7 (1073)	20.8 (1216)	19.7 (756)	17.8 (100)
Chronic pain syndrome	8.9 (510)	8.1 (471)	9.7 (372)	14.4 (81)
Sprain	8.7 (500)	6.2 (361)	6.0 (231)	6.1 (34)
Spondylolisthesis	3.7 (213)	5.2 (303)	5.5 (211)	5.5 (31)

Regression

After adjusting for potentially confounding factors (age, gender, education level, Workers' Compensation, smoking, chronicity of symptoms, radicular pain, previous surgery, comorbidity frequency, and location of spinal condition), BMI was significantly associated with functional health status (PCS and ODI) ($P < 0.05$). For PCS, regression results indicated that each higher level of obesity was associated with an approximately 1.2-point drop in PCS score. The adjusted PCS score for morbidly obese spine patients was 3.7 points below the average PCS score for normal weight spine patients. For ODI, regression showed that each higher level of obesity was associated with a 1.5-point increase in ODI score, except for morbid obesity (Grade 3), which added 3.3 points to the Grade 2 obesity score. The adjusted ODI score for morbidly obese spine patients was 6.3 points above the average ODI score for normal weight spine patients.

■ Discussion

This study targeted two major public health concerns: obesity and spinal conditions. Obesity is a rapidly increasing and serious medical problem that affects millions of Americans across geographic location, age group, race, education level, and sex.[25] Also afflicting millions of Americans, spinal conditions are widespread and often very disabling, although such conditions usually are not fatal.[14]

The present study investigated the authors' hypothesis that increased obesity in the spine patient is associated with lower health status and worse disease-specific measures.

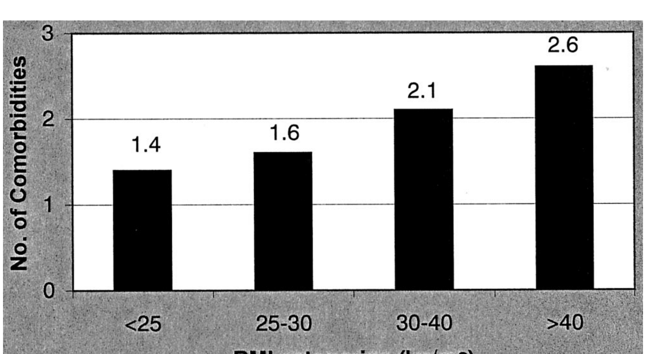

Figure 3. Mean number of comorbidities for each BMI category ($P<0.001$).

Our results indicate an association between BMI and functional status, as measured by the SF-36 PCS and the ODI. That is, in spine patients those with higher BMI exhibited significantly worse functional status. To our knowledge, there is no corresponding literature of spine patients available for comparison. However, studies of general populations have shown similar findings: significant functional impairment in obese patients.[6,12,29,32,34,37–39]

Importantly, the spine patients' PCS scores, even among the nonobese patients, represent severe physical morbidity. Figure 4 compares the PCS scores of our spine patients with patients with other diseases. Like the spine patients in the present study, these comparison studies from the literature were performed at specialist clinics. The mean PCS of our morbidly obese spine patients ($BMI \geq 40.0$ kg/m^2) was 25.9 *versus* 32.6 for our nonobese patients ($BMI < 25.0$ kg/m^2) ($P < 0.001$). The mean PCS score was 29.0 before surgery for primary hip arthroplasty patients, 30.4 for the initial visit surveys from a large spine patient population, 32.6 before surgery for primary knee arthroplasty patients, and 35.2 before surgery for primary shoulder arthroplasty patients.[2,9,19,31] Among nonorthopedic conditions, the average PCS score was 33.9 for patients with chronic obstructive pulmonary disease, 37.1 for patients with systemic lupus erythematosus, and 38.4 for patients with various forms of cancer.[1,23,33] The PCS scores for a general U.S. population of nonspine obese patients ($BMI \geq 40.0$ kg/m^2) was 40.6.[6] These data indicate that obese spine patients are among the most functionally impaired patient groups, and they are significantly more impaired than obese patients without spine disease. It is important to note the PCS values in these cited studies are not adjusted for age. This makes comparing age-unadjusted PCS values across studies potentially difficult and thus should be done with caution.

Although the inverse association of BMI and functional status is interesting and clinically relevant, it cannot necessarily be concluded that obesity worsens spine symptoms, which, in turn, lower PCS scores. Because PCS is a general measure of physical morbidity, obesity may decrease PCS scores independently of affecting the spine condition. We thus examined spine-specific measures of disease. In general, obese patients were more likely than the nonobese to have radicular pain distribution and neurologic signs. Furthermore, obese patients had more comorbidities than nonobese patients. This

Table 4. Comorbidity Frequency

Comorbidity	Normal Range BMI [% (n)]	Grade 1 Obesity [% (n)]	Grade 2 Obesity [% (n)]	Grade 3 Obesity [% (n)]	*P* Value
Smoker (current or former)	56.9 (3097)	57.9 (3201)	58.6 (2141)	53.5 (292)	0.079
Depression	21.0 (1206)	21.2 (1236)	27.2 (1042)	36.9 (207)	<0.001
Arthritis (osteo or rheumatoid)	16.4 (942)	16.7 (977)	19.4 (746)	26.0 (146)	<0.001
Frequent headaches	14.7 (842)	13.3 (779)	16.9 (649)	20.0 (112)	<0.001
Cardiac disease	9.1 (519)	11.3 (660)	13.6 (520)	13.7 (77)	<0.001
Hypertension	8.5 (486)	16.3 (953)	26.0 (997)	33.2 (186)	<0.001
Gastrointestinal ulcer	8.3 (477)	10.4 (605)	13.4 (513)	13.7 (77)	<0.001
Pulmonary disease	6.1 (347)	6.4 (375)	7.3 (281)	11.9 (67)	<0.001
Diabetes mellitus	2.4 (139)	5.8 (338)	11.0 (420)	19.8 (111)	<0.001
More than one comorbidity	38.3 (2193)	43.3 (2529)	54.5 (2092)	68.1 (382)	<0.001
No comorbidities	34.7 (1987)	29.9 (1750)	22.0 (843)	12.8 (83)	<0.001

higher frequency of comorbidities is supported by findings in general populations.[6,21,26,27] Our results suggest that obese spine patients are 1) more disabled overall, 2) have more severe back pain symptoms, and 3) have more comorbidities than nonobese patients. Finally, BMI was a significant predictor of functional health status (PCS), when controlled for age, gender, education level, Workers' Compensation, current smoker, symptom chronicity, radicular pain, previous surgery, comorbidity frequency, and location of spinal condition.

A major limitation of our study is that it is a cross-sectional case study. Although 87% of our patients have chronic symptoms of >3 months (78% had symptoms of >6 months), spine conditions can follow a waxing and waning pattern. Thus, a cross-sectional study would not capture the temporal nature of back disease. Furthermore, this study was not able to test the causality of patients' spine condition and their obesity. As discussed in the introduction, some hypothesize that spine conditions predate obesity, whereas others argue that it is the obesity that predisposes patients to spinal pathology. If the initial injury was spine disease, which then prevented exercise and thus led to increased adiposity, it would logically follow that those with chronic back symptoms would have a higher BMI than those with acute disease. However, in our sample, patients with symptoms of <1 year (BMI = 27.4 kg/m^2) had levels of obesity similar to patients with symptoms >1 year (mean BMI = 27.7 kg/m^2). This slight difference is likely not enough to support the contention that spine symptoms increase BMI. However, a more precise longitudinal study would be required to draw such a conclusion.

A third possible causal pathway was not measurable in this cross-sectional analysis. Both obesity and low back pain are associated with depression and psychosocial distress; therefore, obesity and low back pain may not be directly related to one another but rather may each result from depression, anxiety, and/or distress. The high prevalence of depression among obese patients in these data (Table 4) highlights this possibility.

Another limitation was that the BMI data were patient reported. It has been suggested that patients often overestimate their height and underestimate their weight.[28] Indeed, if this is the case here, then the BMI values would be underestimated, making our results conservative. And although our patients are from 26 centers nationwide, they are all from specialty clinics. Thus, our sampling is representative of specialists' patients but may not be representative of the average U.S. population with spine conditions.

A fourth limitation of this study is in the PCS data presented in Figure 4. We have presented available com-

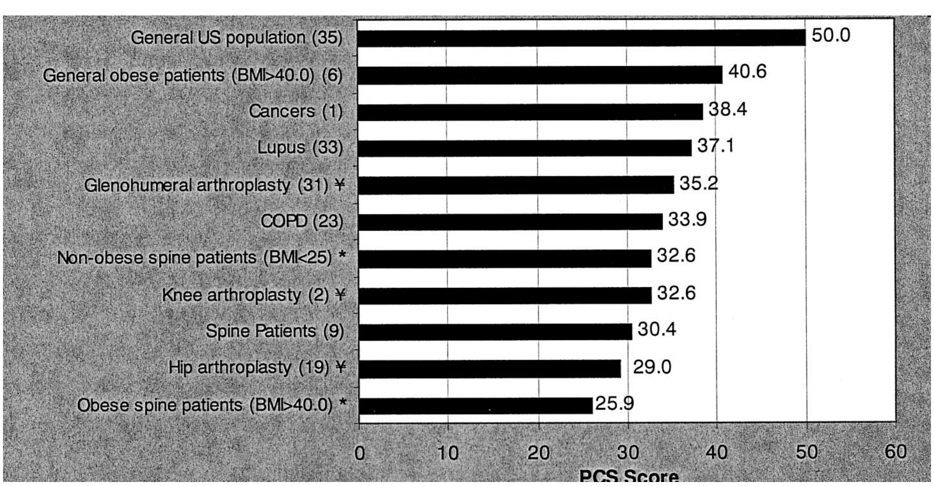

Figure 4. Comparison of PCS scores across a variety of medical conditions (references in parentheses). *, patients from present study; ¥, preoperative score.

parable PCS data from the literature from studies, which, like our spine patients, were from specialist clinics. However, the inclusion criteria for each study were obviously different. Furthermore, the size of each of these comparative study populations was smaller than ours, which questions the sampling equality across these seven studies.

A fifth limitation in this study concerns the fact that our sample does not include patients from the full age range of the U.S. population. Therefore, the possibility that our scores should be adjusted for age must be addressed. This study population is, on average, 9 years younger than the general U.S. population sample used in the Medical Outcomes Study (49 years *vs.* 58 years).[35] One might therefore expect PCS scores in this population to be slightly elevated simply because of the youthful nature of the group. However, when adjusted for age, the mean PCS score for the present spine group is 30.1, less than half a point away from the unadjusted value of 30.5. Similarly, small differences between age-adjusted and unadjusted PCS scores are found across the obesity subgroups. Because age adjustment produces minimal differences in our results and because age-adjustment methods for the PCS have not been formalized, our tabulated results are not age adjusted. Nevertheless, age adjustment may be an important issue when comparing health status across patient populations.

Determining how BMI affects spinal conditions has important consequences. Our data quantify how functionally impaired obese spine patients are. It is important to recognize that the functional status of the average obese spine patient in this population is more than 2 standard deviations below the average of the U.S. population. Because their baseline functioning is so much worse than the U.S. norm, obese spine patients and their clinicians must consider this when establishing goals for treatment plans and adjust their expectations accordingly. Furthermore, patients and clinicians must also recognize that obesity is a chronic disease. Without treatment of the obesity, increased BMI will likely impair the patient's functioning even after a successful spine intervention.

Obesity has been associated with increased mortality and increased prevalence of many conditions, including coronary artery disease, hypertension, stroke, and cancer. Our data suggest that obesity in spine patients is also associated with worse spine-related symptoms. But identifying risk factors is most clinically relevant if the risk is modifiable and if modification results in improved health. Certain factors have been demonstrated to worsen spinal conditions, but many of these are not modifiable (*e.g.*, age, gender, and height). Conversely, BMI potentially can be changed through diet, exercise, behavioral therapy, surgery, and pharmacotherapy.[27] Although our cross-sectional study was unable to look at how changes in BMI affect spine conditions, it is conceivable that as a patient's obesity improved, functioning and symptoms would also improve. This theory is supported in the literature of general obese patients in whom various treatment methods have resulted both in weight loss and in significant improvement in functional status.[4,10,13,18] This is a key area for future spine research. Another next step in investigating this field may focus on how obese spine patients respond to treatment. That is, examining outcomes from various spine treatment methods as a function of BMI would help clinicians understand better and, ideally, treat more successfully their obese spine patients.

■ Appendix

Formula for computing the PCS scale from the 8 SF-36 health status scales. Each scale is standardized (z-score) and placed into this equation, which calculates PCS as a weighted average of all eight standardized scales. The Mental Component Summary is calculated similarly.[35]

$$\begin{aligned} PCS = \{[&PF\_Z \times 0.42402) \\ &+ (RP\_Z \times 0.35119) \\ &+ (BP\_Z \times 0.31754) \\ &+ (GH\_Z \times 0.24954) \\ &+ (VT\_Z \times 0.02877) \\ &+ (SF\_Z \times -0.00753) \\ &+ (RE\_Z \times -0.19206) \\ &+ (MH\_Z \times -0.22069)] \times 10\} + 50 \end{aligned}$$

Acknowledgments

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■ Key Points

- General and disease-specific functional status was significantly worse in patients with a higher BMI.
- Patients with higher BMI had more severe pain symptoms and more comorbidities than patients with lower BMI.
- Morbidly obese spine patients have worse physical functioning than patients with most other disease conditions.

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