Higher Opioid Doses Predict Poorer Functional Outcome in Patients with Chronic Disabling Occupational Musculoskeletal Disorders

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Background: Opioids are frequently used for the postoperative treatment of chronic disabling occupational musculoskeletal disorders. In many such cases, long-term opioid use persists because of patient requests for ongoing pain relief. Little is known about the relationship between chronic opioid use and functional recovery in these patients.

Methods: A total of 1226 patients with a chronic disabling occupational musculoskeletal disorder were consecutively admitted into an interdisciplinary functional restoration program. They were divided into two groups: 630 patients who reported no opioid use at the time of admission (No group) and 596 patients who reported some opioid use at the time of admission (Yes group). The 516 patients for whom daily opioid doses could be determined were further divided into four subgroups: Low (<30 mg, n = 267), Medium (31 to 60 mg, n = 112), High (61 to 120 mg, n = 78), and Very High (>120 mg, n = 59). During the initial weeks of treatment, patients consented to be weaned from all opioid medications. In addition, the patients were assessed before and after rehabilitation with regard to self-reported measures of pain, function, and depression and were analyzed for change. One year after the termination of treatment, socioeconomic outcomes were assessed to measure work and financial status, healthcare utilization, and recurrent injury-associated pain.

Results: A higher post-injury opioid dose was associated with a greater risk of program noncompletion, which was anticipated because of the requirement that patients taper opioids. High opioid use was significantly related to important socioeconomic outcomes, such as lower rates of return to work and work retention as well as higher healthcare utilization ($p \leq 0.05$ for all). Moreover, at one year after treatment, the group reporting the highest opioid use was 11.6 times as likely to be receiving Social Security Disability Income/Supplemental Security Income as compared with the group reporting no opioid use at the time of admission into the program.

Conclusions: Chronic opioid use beginning after a work-related injury is a predictor of less successful outcomes for patients whose final treatment intervention is an interdisciplinary functional restoration program. Higher dose levels are associated with progressively greater indemnity and medical costs for ongoing disability. Physicians involved in the treatment of chronic disabling occupational musculoskeletal disorders should be aware of problems associated with permitting long-term opioid use in patients with a disabling occupational disorder.

Level of Evidence: Prognostic Level I. See Instructions to Authors for a complete description of levels of evidence.

The costs associated with the diagnosis and care of musculoskeletal disorders amount to tens of billions of dollars each year in the United States¹. Moreover, occupational musculoskeletal disorders are also the leading cause of work disability in the United States. The most prevalent

form of musculoskeletal disorders—disabling occupational spinal disorders—is the primary cause of federally compensated disability and is a leading cause of disability for those over the age of forty-five years²⁻⁴. Opioid medications are often prescribed for such patients with chronic pain⁵. In fact, between

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1980 and 2000, there was an increase from 8% to 10% in the number of patients receiving opioid prescriptions for the treatment of chronic musculoskeletal pain⁶.

There is no question that many individuals with chronic, nonmalignant pain derive some pain reduction from opioid therapy, with the literature suggesting that approximately 50% of patients receiving appropriately managed chronic opioid therapy achieve a 30% to 40% reduction in pain⁷. However, not much is known regarding the rates of improvement in terms of physical and emotional functioning that accompany the analgesic effects derived from opioid therapy⁸. The effective treatment of chronic pain conditions must target a host of complex variables that contribute to the experience of pain^{9,10}. Accordingly, interdisciplinary pain-management programs have been empirically demonstrated to be therapeutic and cost-effective for the treatment of chronic pain^{11,12}. Regardless of the success of these programs, one potential component of interdisciplinary pain management—the use of opioid medications—continues to come under scrutiny. Opioid medications are the most potent and effective analgesics available, and their use for the treatment of acute and malignant pain conditions has long been the accepted standard of care¹³. However, the use of opioids for the treatment of chronic, nonmalignant pain is surrounded by controversy because of concerns about the potential for abuse and addiction, organ damage, demotivation, and questions regarding long-term effectiveness^{13,14}. Additionally, the debate over the use of opioids for the treatment of chronic nonmalignant pain has been heightened by evidence that chronic opioid use alters pain modulatory systems, possibly increasing pain sensitivity (hyperalgesia) and aggravating the underlying pain condition¹⁵⁻¹⁹.

Setting aside concerns of iatrogenic addiction, the literature remains unclear in terms of whether opioids are effective for the treatment of chronic nonmalignant pain, especially over the long term. Also, whether or not treatment is deemed successful depends largely on one's definition of success. At the center of this dispute is whether the appropriate goal of treatment is active rehabilitation to improve function or simply passive palliation¹⁵ designed only to manage or reduce pain. While the field of orthopaedic surgery generally supports the importance of function, the literature on pharmacological interventions for chronic pain has focused on pain relief and adverse events, to the near exclusion of functional outcomes⁷. Clinical reports have supported the possibility that long-term opioid use diminishes an individual's natural physiological capacities to modulate pain²⁰⁻²². Evidence is mounting that long-term use leads to changes in opioid receptors as well as in the serotonin, norepinephrine, dopamine, and GABA (gamma-aminobutyric acid) neurotransmitter systems^{23,24}. More recent research has indicated that these changes lead to opioid tolerance and opioid-induced hyperalgesia^{16,17,25}. Furthermore, previous exposure to opioids might lead to long-term, cumulative decreases in their efficacy. Research has suggested that the risk of hyperalgesia might have serious implications for, and limit the clinical utility of, opioid therapy for the treatment of chronic pain^{25,26}.

Functional restoration is a type of interdisciplinary chronic pain management emphasizing the objective measurement of function, measurement-directed exercise progression, multimodal disability management, and multidisciplinary medical oversight²⁷. While only 5% to 15% of occupational musculoskeletal injury claims result in chronic pain and disability, these interdisciplinary programs are frequently the last major medical intervention prior to reaching maximum medical improvement, and they cost the most, with estimated costs of as high as \$200 billion a year²⁸. It is the 5% to 15% of patients with chronic conditions who account for 80% of these costs¹⁴. Therefore, post-rehabilitation socioeconomic outcomes (work status, ongoing financial disability benefits, healthcare utilization, and recurrent injury) may be a reliable measure of the effectiveness of achieving societally important goals for an entire course of treatment for a work-related injury claim. Such outcomes have been demonstrated for spinal disorders, upper extremity disorders, and a range of mixed musculoskeletal disorders²⁹⁻³⁸.

The purpose of the present study was to examine the post-injury, pre-rehabilitation level of opioid use as a predictor of treatment outcome for a cohort of subjects with a chronic disabling occupational musculoskeletal disorder who were participating in a functional restoration program. These patients had all completed a course of musculoskeletal rehabilitation care (including diagnostic testing, early nonoperative care, and surgical treatment whenever warranted) but had not improved and had had development of chronic disability. They entered functional restoration as the terminal medical event. In the present study, subjects were divided into groups, on the basis of their pre-rehabilitation level of opioid use, to determine if the pre-rehabilitation level of opioid use is associated with the response to treatment as measured by socioeconomic outcomes, the pain reported, depressive symptomatology, and physical functioning at the time of program completion and at the time of the one-year follow-up.

Materials and Methods

Subjects

The subjects included 1226 consecutive, prospectively assessed patients with a chronic disabling occupational musculoskeletal disorder who consented to, and began, a prescribed course of functional restoration for the treatment of disabling chronic pain over a four-year period of time at a regional rehabilitation facility for the functional restoration of qualified candidates. All patients had received previous treatment for a work-related-injury claim but had not yet been able to return to work. All patients had involvement of at least one extremity bone/joint or spinal region and an injury that was deemed to be compensable (i.e., deemed to be work-related according to the rules of the jurisdiction). The mechanisms of injury ran the gamut from slips, falls, and overexertion or lifting claims to repetitive-motion claims, with the majority of subjects having sustained soft-tissue injuries described as "sprains/strains." There were no cases of what generally would be considered major multiple-site trauma. Patients were eli-

gible to participate in the study if they had (1) disability that had lasted for more than four months after an injury, (2) a lack of responsiveness to previous surgical or nonoperative treatments, (3) severe impairment of physical functioning, (4) the ability to speak English or Spanish, and (5) an opioid status that could be determined at the time of admission.

The 1226 patients were divided into two groups. The “No” group (n = 630) consisted of all patients who were not taking any opioid medication at the time of admission to the functional restoration program. These patients may have used opioids following the injury but discontinued them before admission to the program or they may never have used opioids during the course of treatment for their claim. The “Yes” group (n = 596) consisted of those who were utilizing opioids at the time of admission to the program. Subgroups of the Yes group were formed on the basis of the daily use of opioid medications, classified as morphine-equivalent doses. An average daily dosage could be determined for 516 of the 596 patients in the Yes group. The remaining eighty patients in the Yes group reported taking opioid medications, but the exact dosage could not be determined on the basis of the information recorded in the medical chart. For example, these patients reported “prn” (i.e., “as needed”) or “occasional” use but reported neither a dose nor a number of tablets. Because the dosage level could not be determined, these patients were excluded from the statistical analyses that were performed for opioid subgroups. The remaining 516 subjects were divided into four subgroups on the basis of opioid use in morphine equivalents: (1) the Low subgroup (≤ 30 mg; n = 267), (2) the Medium subgroup (31 to 60 mg; n = 112), (3) the High subgroup (61 to 120 mg; n = 78), and (4) the Very High subgroup (>120 mg; n = 59).

Data on Pre-Rehabilitation Opioid Use

Information regarding the average daily dosages of opioid medication being taken at the time of admission was gathered from multiple locations in the patients’ medical records. In order to standardize the collection of this information and to control for the accuracy of patient reports, a specific procedure was followed. First, information regarding opioid use was gathered from the initial physician note. This information was compared with the data gathered by staff psychologists during the mental health evaluation. All opioid medications reported by patients during the initial physician visit and the mental health evaluation were included in the study. If discrepancies in the quantity of medications being taken were noted, the higher dose was used for purposes of the study. In addition, almost all patients in the Medium, High, and Very High opioid subgroups were referred to the staff psychiatrist for an organized weaning process. Additional medications were reported in the staff psychiatrist’s note.

Procedure

All patients received an initial evaluation before beginning treatment, which included a physical examination, a medical history, a medical case management disability assessment interview, a quantitative functional capacity evaluation, and a

psychological intake interview. The functional restoration program consisted of a quantitatively-directed exercise program supervised by both physical and occupational therapists in conjunction with a multimodal disability management component that included individual counseling, group therapy, stress-management training, vocational reintegration, and future fitness management^{27,30,39,40}.

Demographic data on the patients were collected as part of the intake interview noted above, at the end of which the patient was asked to complete a series of physical and functional capacity measures normalized to age, sex, and body weight. On the first day of the intensive treatment phase of the rehabilitation program, patients were asked to complete the five instruments: (1) the Beck Depression Inventory (BDI)⁴¹; (2) the Million Visual Analog Scale (MVAS)⁴², a questionnaire used to assess disability; (3) the Oswestry Disability Index (ODI); (4) the Short Form-36 Health Survey (SF-36); and (5) the quantified Pain Drawing (PD)⁴³, an analog self-reported measure of perceived pain intensity. The BDI, MVAS, ODI, SF-36, and PD were repeated at the time of program completion in order to evaluate the response to treatment. Additionally, one year after program completion, a structured interview was conducted with the subjects to evaluate socioeconomic outcomes, including work status, healthcare utilization, recurrent surgery involving the same body part, recurrent injury claims related to the same body part, and case settlement status⁴⁴. Subjects were interviewed either in person or over the telephone. The reliability of this structured interview has been documented in previous studies⁴⁴.

Statistical Methods

It should be noted that, prior to data collection, a power analysis was conducted to determine an appropriate sample size. In order to detect a medium effect size of 0.5 (on the basis of Cohen’s d) with a power of 0.80 and an alpha of 0.05 for five levels (k = 5), a total of 480 subjects were required. Thus, we had more than an ample sample size. Subsequently, statistical analyses of group and subgroup differences involving continuous variables were performed with use of analysis of variance. In order to control for any potential variation in the severity of disability between the opioid groups, the pretreatment length of disability was used as a covariate in all of the analyses. Post-rehabilitation, when appropriate, analysis of covariance was also used to control for pre-rehabilitation differences. Chi-square and Mantel-Haenszel chi-square analyses were used for dichotomous and categorical variables. Finally, linear regression analyses were performed to determine if the pre-rehabilitation level of opioid use was predictive of the post-rehabilitation physical and psychological scores, and logistic regression analyses were performed to determine if the pre-rehabilitation level of opioid use was predictive of one-year socioeconomic and health outcomes.

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Results**Comparisons of No and Yes Groups****Demographic Variables**

The demographic variables for the opioid groups are presented in Table I. The rate of program completion differed significantly between the two groups ($p = 0.002$), with the Yes group being more than 1.5 times as likely as the No group to discontinue treatment prematurely (odds ratio, 1.54; 95% confidence interval, 1.18 to 2.02). This was an expected finding because weaning from opioid medications was a requirement for program completion, with some opioid users initially refusing to consider medication tapering or subsequently failing to comply. It is noteworthy that the No group included a higher percentage of patients with upper extremity disorders, whereas thoracolumbar disorders were more common in the Yes group. Patients with multiple-site involvement were equally distributed. The Yes group had a significantly longer length of disability ($p < 0.001$), a higher rate of previous work-related injury claims ($p = 0.012$), a higher rate of pre-rehabilitation orthopaedic surgery ($p < 0.001$), and a greater likelihood of pre-rehabilitation qualification for Social Security Disability payments ($p < 0.001$) relative to the No group. Whites were proportionally over-represented and Hispanics were under-represented in the Yes group ($p < 0.001$).

Pre-Rehabilitation and Post-Rehabilitation Self-Reported Measures

Pre-rehabilitation and post-rehabilitation self-reported measures for the opioid groups are presented in Table II. Interestingly, and perhaps counterintuitively, at the time of program admission, despite the use of opioid medication to ameliorate pain, the Yes group uniformly demonstrated higher pre-rehabilitation ratings of pain, disability, and depression on the majority of the commonly used self-reported measures that were employed in the present study. After rehabilitation, these self-reported measures were collected only from those who had completed the program. It is important to be aware that opioid detoxification was a necessary requirement for completion of the program so that post-rehabilitation self-reported scores all reflected patients no longer taking opioids, irrespective of their pre-rehabilitation status. In that regard, program discharge differences between the No and Yes groups were now nonsignificant for all measures except the ODI and the measure for pain intensity, with these differences being relatively minor.

One-Year Post-Rehabilitation Socioeconomic and Health Outcomes

The one-year post-rehabilitation socioeconomic and health outcomes for the groups are presented in Table III. The data in that table pertain only to those patients from the two groups who completed the functional restoration program. For those

TABLE I Demographic Variables

Variable	No (N = 630)	Yes (N = 596)	Odds Ratio (95% Confidence Interval)*	P Value*
Percentage of total (n = 1226)	51.4	48.6		
Sex (% male)	50.0	48.2	NS	NS
Age† (yr)	43.4 ± 1.0	44.1 ± 9.3	NA	NS
Program completion (%)	81.4	74.0	1.54 (1.18 to 2.02)	0.002
Injured regions (%)				
Cervical	4.0	5.5		
Thoracic/lumbar	33.9	46.3		
Upper extremity	22.2	10.4		
Lower extremity	7.7	4.8		
Multiple musculoskeletal	32.1	33.0		
Race (%)			NA	<0.001
White	49.4	58.0		
Black	23.9	25.4		
Hispanic	24.5	15.9		
Other	2.3	0.7		
Length of disability† (mo)	11.1 ± 10.8	15.6 ± 17.3	NA	<0.001
Prior work-related injury (%)	35.8	43.5	1.38 (1.07 to 1.7)	0.012
Pre-rehabilitation surgery (%)	37.6	49.5	1.63 (1.28 to 2.08)	<0.001
Attorney retained (%)	18.1	21.0	NS	NS
Pre-rehabilitation SSDI/SSI‡ (%)	0.6	2.6	4.07 (1.34 to 12.34)	<0.001

*NS = not significant; NA = not applicable. †The values are given as the mean and the standard deviation. ‡SSDI = Social Security Disability Income, SSI = Supplemental Security Income.

TABLE II Pre-Rehabilitation and Post-Rehabilitation Self-Reported Variables, Controlled for Pre-Rehabilitation Length of Disability

Variable*	No	Yes	F†	P Value‡
Pre-admission (n = 1226)				
Number of patients (% of total)	630 (51.4)	596 (48.6)		
Beck Depression Inventory§	13.6 ± 9.2	16.4 ± 10.3		NA
Million Visual Analog Scale§	84.1 ± 25.9	95.3 ± 20.0		NA
Oswestry Disability Index§	36.6 ± 21.0	41.9 ± 15.3	13.6	<0.001
SF-36 MHS§	40.0 ± 9.4	37.9 ± 9.6	8.2	0.004
SF-36 PHS§	31.1 ± 5.8	29.7 ± 5.9	10.9	0.001
Pain intensity§	6.2 ± 2.0	6.6 ± 1.7		NA
Post-discharge (n = 954)				
Number of patients (% of total)	513 (53.8)	441 (46.2)		
Beck Depression Inventory§	8.0 ± 6.7	9.7 ± 7.9		NA
Million Visual Analog Scale§	59.1 ± 27.5	70.7 ± 28.1		NA
Oswestry Disability Index§	20.4 ± 7.0	23.6 ± 7.6	7.3	0.008
SF-36 MHS§	46.8 ± 8.2	46.2 ± 9.6	0.4	NS
SF-36 PHS§	36.7 ± 7.1	34.9 ± 6.4	2.2	NS
Pain intensity§	4.4 ± 2.1	4.9 ± 2.1	9.6	0.002

*SF-36 MHS = Short Form-36 mental health summary; SF-36 PHS = Short Form-36 physical health summary; Pain intensity = visual analog score on 11-point scale. †Analysis of covariance. ‡NA = not applicable; NS = not significant. §The values are given as the mean and the standard deviation.

patients, there were significant differences in terms of the percentage who returned to work at some time during the post-treatment year as well as remarkable differences in terms of the percentage who were still at work (work retention) at the time of the one-year post-rehabilitation interview. While there was no significant difference in the rate of new surgery at the original injury site or recurrent injury claims, the patients in the Yes group had more than double the rate of seeking healthcare from new providers. Interestingly, during the process of seeking information on cost factors from insurance carriers on this group of patients, it was revealed that much of the healthcare-seeking behavior for the Yes group was related to finding providers who would agree to restart the prescrip-

tion opioid medication. Therefore, a substantial number of patients in the Yes group found new providers to prescribe opioids, suggesting that there may be a link between unsuccessful work retention and resurgent opioid-seeking behaviors.

Comparisons of Opioid Subgroups

Demographic Variables

Demographic variables for the opioid subgroups are presented in Table IV. Racial representation varied significantly among the subgroups ($p = 0.001$). The proportion of white individuals in each subgroup increased linearly as dosage level increased, from 48.6% in the Low subgroup to 80.0% in the Very High subgroup. Conversely, the proportion of Hispanic indi-

TABLE III One-Year Post-Rehabilitation Socioeconomic Outcomes, Controlled for Pre-Rehabilitation Length of Disability (Completers Only)

Variable	No	Yes	Wald Statistic	P Value*	R ²
Number of patients (% of total) (n = 954)	513 (53.8)	441 (46.2)			
Work return	93.7%	88.1%	6.55	0.01	0.089
Work retention	85.3%	68.8%	21.73	<0.001	0.103
New surgery to the original site of injury	2.1%	4.4%	1.41	NS	
Seeking treatment from new provider	14.0%	29.9%	18.17	<0.001	0.046
Recurrent injury to same body part	4.4%	6.8%	1.96	NS	
Workers' Compensation case settlement	97.2%	98.0%	0.094	NS	
Post-rehabilitation SSDI or SSI†	1.9%	5.2%	1.23	NS	

*NS = not significant. †SSDI = Social Security Disability Income, SSI = Supplemental Security Income.

TABLE IV Demographic Variables: Opioid Subgroups

Variable	No	Low	Medium	High	Very High	P Value*
Number of patients (% of total) (n = 1146)	630 (55.0)	267 (23.3)	112 (9.8)	78 (6.8)	59 (5.1)	
Sex (% male)	50.0	50.0	39.4	47.2	52.9	NS
Age† (yr)	43.3 ± 9.9	44.7 ± 9.5	43.4 ± 9.3	42.9 ± 9.6	44.8 ± 8.9	NS
Program completion (%)	81.5	76.0	68.7	68.1	70.6	0.003
Injured regions (%)						<0.001
Cervical	4.0	3.9	6.6	9.6	5.4	
Thoracic/lumbar	33.9	46.5	56.6	50.7	37.5	
Upper extremity	22.2	11.8	6.6	8.2	8.9	
Lower extremity	7.7	3.9	2.8	2.7	12.5	
Multiple	32.1	33.9	27.4	28.8	35.7	
Race (%)						0.001
White	49.2	48.6	59.2	63.2	80.0	
Black	23.9	30.0	27.6	22.1	12.0	
Hispanic	24.6	20.2	12.2	14.7	8.0	
Other	2.3	1.2	1.0	0.0	0.0	
Length of disability† (mo)	11.1 ± 10.8	15.2 ± 17.9	18.7 ± 19.7	13.0 ± 9.1	15.7 ± 11.3	<0.001
Prior work-related injury (%)	35.8	45.5	41.8	48.3	43.9	0.012
Pre-rehabilitation surgery (%)	37.7	43.1	58.1	52.3	64.4	<0.001

*NS = not significant. †The values are given as the mean and the standard deviation.

viduals decreased as dosage level increased, from 20.2% in the Low subgroup to 8.0% in the Very High subgroup.

The length of disability (in months) differed significantly among the subgroups ($p < 0.001$). Post hoc analyses revealed that the No, Low, and Medium subgroups all differed significantly from each another. The Medium subgroup also differed from the High subgroup. The proportions of patients with pre-rehabilitation surgical procedures also differed significantly

($p < 0.001$), with a linear increase in opioid dose as surgery rates increased. Similarly, the proportion of patients reporting previous work-related injury differed significantly ($p = 0.012$).

One-Year Post-Rehabilitation Socioeconomic and Health Outcomes

Table V presents the one-year post-rehabilitation socioeconomic and health outcomes for the opioid subgroups. The percentage of patients reporting return to work ranged from 93.7% in the

TABLE V One-Year Post-Rehabilitation Socioeconomic Outcomes: Opioid Subgroups Controlled for Pre-Rehabilitation Length of Disability (Completers Only)

Variable	No	Low	Medium	High	Very High	P Value*	R ²
Number of patients (% of total) (n = 887)	513 (57.8)	205 (23.1)	75 (8.5)	53 (6.0)	41 (4.6)		
Work return (%)	93.7	88.7	89.5	90.7	75.9	0.05	0.107
Work retention (%)	85.2	70.1	63.0	69.0	55.2	<0.001	0.132
Surgery to same body part (%)	2.1	5.5	2.1	7.7	7.4	NS	
Seeking treatment from new provider (%)	14.0	28.8	36.7	28.2	29.6	0.001	0.052
New injury to same body part (%)	4.4	3.8	13.0	6.3	4.2	NS	
Workers' Compensation case settlement (%)	97.2	98.6	98.0	95.0	100.0	NS	
SSDI or SSI† (%)	1.9	5.7	3.9	4.5	18.5	0.03	0.176

*NS = not significant. †SSDI = Social Security Disability Income, SSI = Supplemental Security Income.

No subgroup to 75.9% in the Very High subgroup ($p = 0.05$). The percentage of patients reporting work retention ranged from 85.2% in the No subgroup to 55.2% in the Very High subgroup ($p < 0.001$). The proportion of patients seeking treatment from a new provider was 14.0% in the No subgroup and ranged from 28.2% to 29.6% in the Low, High, and Very High subgroups ($p < 0.001$). The proportions of patients reporting receiving SSDI/SSI (Social Security Disability Income/Supplemental Security Income) benefits ranged from 1.9% in the No subgroup to 18.5% in the Very High subgroup ($p < 0.03$). Thus, the Very High subgroup was 11.6 times as likely as the No subgroup to be receiving SSDI or SSI benefits at the time of the one-year follow-up (odds ratio, 11.62; 95% confidence interval, 3.51 to 38.46). Receiving SSDI/SSI benefits (generally a lifelong welfare payment once instituted) occurred at a time when the vast majority of patients in both groups had settled their Workers' Compensation claims (i.e., were no longer receiving Workers' Compensation financial benefits). It is important to note that the transition to Social Security Disability payments requires patients to demonstrate "inability to work" to the satisfaction of the Social Security Administration and is therefore incompatible with the work retention outcome.

Discussion

The present investigation revealed a number of important findings. The pre-rehabilitation level of opioid use was found to be associated with the rate of completion of the functional restoration program, such that patients reporting higher levels of pre-rehabilitation opioid use were at greater risk of program noncompletion. The subgroups with higher opioid use had lower rates of completion of the functional restoration program (range, 68% to 71%) as compared with the Low subgroup (76%) and the No group (82%) ($p = 0.003$). Patients who participate in this specific treatment must agree to wean from opioid medications at the onset of treatment and subsequently must follow through. Not surprisingly, patients who are receiving opioids and who also report greater pain and disability may decide to drop out of rehabilitation programs when they are required to wean from their pain medications. This is a challenge faced everyday in the clinical setting. Other reports have described a similar relationship between the level of pre-rehabilitation opioid use and program completion⁴⁵.

Pre-rehabilitation opioid use also was found to be associated with a number of important socioeconomic variables. The Yes group was more likely to report a previous work-related injury as well as to report a pre-rehabilitation surgical procedure than the No group was. The Very High subgroup was more than three times as likely as the No group to report a pre-rehabilitation surgical procedure.

On the basis of these data, one could speculate that individuals taking higher levels of opioids may be suffering from more severe injuries that are less amenable to treatment. However, no patients were disabled by multiple-site major trauma. Most had sustained soft-tissue injuries, including a few fractures and dislocations. The most frequent surgical procedures were lumbar discectomy, lumbar/cervical fusion, upper

limb nerve decompression, and soft-tissue joint procedures (shoulder decompression or knee internal derangement repair). Orthopaedic surgeons are likely to agree that the majority of patients undergoing such procedures are unlikely to have sufficient permanent tissue damage to warrant extended periods of chronic opioid use. Indeed, the now widely accepted and heuristic biopsychosocial model of chronic pain (pain lasting more than six months) emphasizes the importance of psychosocial factors that interact with the initial injury-induced nociception^{10,46,47}. Normally, by six months after the injury (well past the normal healing period expected for the protective biological function of nociception), the resulting psychosocial factors play a major role in the maintenance of pain and disability, with the original nociception playing a more subordinate role. Thus, the biopsychosocial model views the severity of the initial injury as only tangentially related to chronic pain and disability issues that develop several months later.

There were many self-reported differences found for depression (as measured with the Beck Depression Inventory), pain and disability (as measured with the Million Visual Analog Scale, Oswestry Disability Index, and quantified Pain Drawing), and general health-related quality of life (as assessed with the SF-36). As a whole, these biopsychosocial data clearly indicate that, before rehabilitation, patients taking opioids have a greater symptom burden (i.e., self-reported pain, disability, and depression) that needs to be addressed, relative to patients not taking opioids, in order for successful intervention to occur. Such patients are especially in need of a comprehensive interdisciplinary pain-management program, such as functional restoration, in order to have therapeutic gains⁹. Interestingly, just as patients receiving pre-rehabilitation opioids demonstrate higher self-reported pain in general, previous studies from our group have demonstrated that the relatively small percentage of patients with persistent high self-reported pain and disability after rehabilitation tend to have less successful outcomes^{38,48,49}. As noted earlier, research has suggested that chronic opioid use alters pain modulatory systems, possibly increasing pain sensitivity (hyperalgesia) and thus aggravating the underlying pain condition¹⁵⁻¹⁹. This helps to explain the results of the present study.

When post-rehabilitation biopsychosocial functioning was assessed relative to pre-rehabilitation functioning, both the Yes and No opioid groups showed comparable improvements in terms of decreasing the substantial symptom burden (although differences between the groups were still evident on some measures). Overall, however, the improvements were in keeping with the findings of previous research that clearly documented the therapeutic effectiveness of such comprehensive care for the treatment of chronic pain and disability¹¹. Moreover, such gains translated to some positive post-rehabilitation socioeconomic and health outcomes at the time of the one-year follow-up. For example, no associations were found between initial opioid use and outcomes such as case settlement, attorney retention, or Workers' Compensation benefits. However, the overall outcomes were not as clinically important for the opioid group on many other important indices. Thus, for example, the

High and Very High opioid subgroups were nearly four times more likely than the No opioid subgroup to have reported post-rehabilitation surgery involving the same body part at the time of the one-year follow-up. The opioid-use group also had more healthcare visits. One possible explanation for these findings is that patients who discontinued opioid medications at the time of admission subsequently sought new providers in order to return to using opioids after completing the functional restoration program.

Another important socioeconomic measure was work status. Work-return rates ranged from nearly 94% in the No subgroup to approximately 76% (extremely poor for a functional restoration program) in the Very High opioid subgroup. Work-retention rates ranged from 85% in the No subgroup to 55% (also extremely poor for a functional restoration program) in the Very High opioid subgroup. Thus, based on odds ratios, among those who completed the program, the Yes group was twice as likely as the No group to have not returned to work during the year after treatment and was more than 2.6 times as likely as the No group to not be working at the time of the one-year follow-up.

In conclusion, the findings of the present study further support the effectiveness of functional restoration in the treatment of a chronic disabling occupational musculoskeletal disorder. They also suggest that patients who discontinue opioid medications demonstrate similar benefits in terms of depressive symptoms, pain, disability, and quality of life following the completion of functional restoration relative to patients who do not report pre-rehabilitation opioid use. Perhaps this finding will help to improve clinicians' attitudes toward the potential for functional recovery in patients with chronic pain who are taking opioid medications and will help to ameliorate "opiophobia" (the fear of prescribing opiates because of possible government audits and malpractice lawsuits)¹⁵. Thus, the present study provides no support for the concept that opioid use should persist indefinitely in patients with functionally unacceptable results following the treatment of chronic disabling occupational musculoskeletal disorders. An independent confirmation of these conclusions was recently reported by Lawrence et al.⁵⁰ in a study of patients managed with anterior cervical arthrodesis. Those investigators found that chronic narcotic use prior to cervical arthrodesis was associated with continued narcotic use after surgery and worse functional outcomes. Taken together, such results clearly indicate that treating clinicians will need to modify interventions to more closely address the difficulties that these opioid-using patients have in

terms of returning to, and retaining, work. The pre-rehabilitation level of opioid use, as described in the present study, therefore can be a useful guide for identifying patients who are at increased risk for poorer socioeconomic outcomes and for targeting treatment interventions to improve the likelihood of program completion and positive long-term treatment outcomes for these patients.

Finally, it should be noted that in a large clinical study such as the present one, numerous statistical analyses were conducted, which may have inflated the rate of type-I errors (i.e., accepting the significance of a result when it is not truly significant). However, this was judged to be preferable to risking analyses that were too conservative and that might have failed to capture important effects. Indeed, as Aickin and Gensler pointed out⁵¹, there is still substantial debate in the biostatistical and epidemiologic literature concerning whether such adjustments for multiple tests are warranted, especially when novel or preliminary analyses of a phenomenon are being conducted. In fact, the Holm procedure may be more appropriate because it maximizes statistical power while being less stringent. However, many biostatisticians view even the Holm procedure as too conservative. For example, Perneger⁵² argued that the use of such corrections creates more problems than it solves, such as increasing the likelihood of type-II errors (i.e., not accepting the result as significant [when it is]) in important studies of new phenomena, like the ones evaluated in the present investigation. Of course, future replications of these findings will be needed. ■

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