4-1997

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Senior Honors Project
April 17, 1997

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Objective: To determine factors which can serve as predictors of success in recovery from spinal surgery for patients who receive Workers' Compensation.

Study Design: A retrospective study was performed to determine functional and pain status in Workers' Compensation patients receiving lumbar fusion or microdiskectomies.

Summary of Background Data: 55 patients receiving spinal fusion (53%) or microdiskectomies (47%) performed by physicians in an Orthopaedic Surgery group practice setting were assessed.

Methods: Subjects were evaluated pre-surgically and post-surgically using the Oswestry disability score and Visual Analogue Scale as outcome measures. Gender, smoking, type of surgery, litigation pending, age, and time elapsed between onset of injury and surgery were compared between subjects as predictors of outcome.

Results: Gender and the type of surgery were found to have a significant effect in reducing the pain level, while smoking and litigation were found to be insignificant. Patients undergoing microdiskectomies have a greater reduction in pain than patients undergoing fusions. Male patients have greater reduction in pain level after spinal surgery than females. The quantitative factors of age and time elapsed between injury and surgery were found to be unrelated to changes in Oswestry scores.

Conclusion: Surgery type and gender can serve as outcome predictors for successful recovery from spinal surgery. However, there are many other factors which should be examined by larger, prospective studies using multiple outcome measures.

INTRODUCTION

Much research has been conducted which seems to suggest that Workers' Compensation has a negative effect on the recovery of patients from work-sustained injuries. It is commonly assumed that patients who are compensated for work-related injury have little incentive to return to their previous level of functioning. The term "compensation neurosis" was coined by Rigler in 1879 to describe the increased rate of disability following railway accidents due to previous introduction of compensation legislation (Greenough and Fraser 1989). Back pain is a prominent offender, as it is the third leading cause of total work disability (Krousel-Wood et al. 1994). Studies by Greenough and Fraser concluded that payment of compensation delays recovery from low-back injury (1989). Frederickson et al. (1987), Franklin et al. (1994), and Leavitt (1992) found similar results. 68% of Workers' Compensation patients in Washington State were still totally-work disabled two years after spinal fusion. (Franklin et al. 1994). Although Leavitt tried to ascertain whether the level of physical exertion, rather than compensation itself, accounted for disability status, his research determined that on-the-job injury does lead to prolonged disability time, irrespective of the type of job performed. Carpenter et al. (1996) and Pihlajamäki et al. (1996) found that clinical outcome did not correspond to radiographically-determined repair success.

However, such results make it possible to oversimplify the problem and to blame poor recovery from workplace injuries on compensation alone. Although compensation may play a notable role, there are other nonorganic or demographic factors which may be more indicative of surgical success.

The patient's gender may be a differential for assessing successful recovery from spinal injury. Krousel-Wood et al. (1994) determined that significantly more men than women were classified as unfit for work. Settlement of compensation claims was found to result in reduced Oswestry disability scores in women, but not in men (Greenough and Fraser 1989). However, Little et al. (1994) reported that female patients had worse post-surgical results than males

Clinical observations have indicated that smoking contributes to degenerative disc disease; the rate of post-fusion pseudoarthrosis in smokers is reportedly to be 3 to 4 times higher than that of nonsmokers (Brown et al. 1983). Silcox et al. (1995) established a direct relationship between non-union of the spine following fusion and the presence of systemic nicotine. Fifty-six percent of control animals were determined to have solidly fused lumbar spines at a critical post-surgical time; however, those animals receiving nicotine exhibited no solid fusions. This model suggests smoking as an important outcome predictor.

Differences in the type of surgery used may affect outcome results. Fusion (with diskectomy) has demonstrated a wide range of successful outcomes in differing studies, from 11-95% (Pihlajamäki et al. 1996). Postoperative failure may occur in 30-40% of cases (Kant et al. 1995). Microdiskectomies appear to be successful in as many as 91% (Williams 1978) and 96% of cases (Goald 1978). Chatterjee et al. (1995) found a higher percentage of satisfactory outcome in microdiskectomy patients as compared to diskectomy patients.

Age is another possible predictor. Fredrickson et al. (1987) found that patients over the age of 50 return to work less frequently than those under the age of 50. Franklin et al. (1994) concluded that poor outcome risk increases by 37% for each 10 year increase in age. However, Lancourt and Kettelhut (1992) studied 92 non-organic predictors, and although age was defined, results were not reported or described as statistically significant. Carpenter et al. (1996) determined that outcome score and rate of fusion are not significantly affected by age.

The objective of this study was to examine various demographical and surgical factors which may contribute to successful recovery from spinal surgery, namely spinal fusion and microdiskectomy. These factors were used to determine functional and pain outcome predictors for Workers' Compensation patients, independent from the actual receipt of compensation.

METHODS

Information was collected from 55 Workers' Compensation patients who underwent either fusion or microdiskectomy between 11/93 and 12/97. All procedures were performed by physicians in one Orthopaedic Surgery group practice. 53 percent of the patients received fusion and diskectomy or fusion alone, and 47 percent of the patients had received microdiskectomy. Procedures were not of uniform approach. Information was collected pre-operatively and post-operatively at either 3 months, 6 months, or 12 months and later. The most recent available post-operative data was used for each patient and the differences in time were separately adjusted for. Post-operative data was available for 40 of the 55 patients (73%).

Demographic, personal and physical, and surgical data were collected. The Oswestry Low Back Pain Questionnaire (OSW) was used to assess functional capacity. This questionnaire, which is completed by the patient, is divided into ten sections dealing with various aspects of functioning (Fairbanck et al. 1980). The absolute change in this disability score from pre- to post-surgery was used as an outcome measure. The Visual Analogue Score (VAS) was used to evaluate pain. The VAS allows the patient to rate their own perception of their pain on a scale from 0 to 10. A post-operative score of 5 or above was used as a negative outcome measure.

Factors independently evaluated included gender, smoking, litigation pending, and surgery method (fusion vs. microdiskectomy). The quantitative factors of age and time elapsed between injury and surgery were simultaneously measured.

When comparing pre-operative with post-operative Oswestry and VAS scores, the standard paired two-sample t-test was performed to determine statistically significant improvement in scores, using the calculation shown in Table 1 (Equation 1). This test was done for OSW and VAS scores separately. The differences in pre- and post-operation scores were calculated and the Pearson correlation was determined. Simple linear regression was performed, and the slope coefficient was found. Missing values of OSW and VAS (specifically, six missing values of pre-op OSW, one missing value of post-op OSW, and one missing value of post-op VAS) were approximated using simple linear regression (Table 1, Equation 2). In the subsequent analysis, only OSW scores were used.

To determine which factors (gender, smoking, surgery method, and litigation pending) are indicative of successful recovery from spinal surgery, the data were grouped according to factor levels and checked for statistically significant differences in the average measure of success among the groups. Standard, unpaired, two-sample t-tests were used for each factor tested. The hypothesis shown in Table 1 (Equation 3) was used for the factors to determine population means of Δ_{OSW}.

The effects of age and time lapsed from injury to surgery on OSW change were calculated simultaneously using the linear regression shown in Table 1 (Equation 4). The standard F test was performed to test the significance of the values of the coefficients β_1 and β_2 (Equation 5).

***Table 1.* Statistical Formulas Used in the Analysis of Worker's Compensation Data**

1. $t = \dfrac{d}{s_d / \sqrt{n_d}}$, where d, s_d, and n_d are the sample mean, sample standard deviation, and sample size of the vector of difference

2. $\Delta_{OSW} = \alpha\Delta_{VAS} + \epsilon$

3. $H_o : \mu_X = 0$ vs. $H_1: \mu_Y \neq 0$, where μ_X and μ_Y are population means

4. $\mu_Y = \beta_o + \beta_1 X_1 + \beta_2 X_2$, where Y is the change in OSW score, and X_1 and X_2 are age and the time from injury to surgery, respectively.

5. $H_o : \beta_1 = \beta_2 = 0$ vs. $\beta_1 \neq 0$ or $\beta_2 \neq 0$

RESULTS

All tabular and graphical results are summarized at the conclusion of this section. Demographic and surgical statistics are shown in Table 2.

Because the two measures of improvement, Δ_{OSW} and Δ_{VAS}, were found to be positively associated, as shown in Figure 1, only the Oswestry scores were used in subsequent analysis. However, there were 14 missing values of post-operative Oswestry scores, reducing the data from 55 to 41 observations (a 75% rate of response). Spinal surgery was found to have a significant effect in reducing the patient's level of pain and increasing his functioning, as measured by the Oswestry and VAS scores.

Because the percentage change in Oswestry Score did not seem to be normally distributed, the absolute change in this score was used in the analyses. A normal QQ-Plot (Quantile plot) and a histogram of Δ_{OSW} are shown in Figures 2 and 3, respectively, and show the adequacy of the normality assumption for this data.

There seems to be a significant difference between male and female patients in the average reduction of pain level, as shown by the p-value in Table 3. According to the mean values in Table 3 and the distributions of Δ_{OSW} for males and females shown in Figure 5, male patients appear to have greater reduction in pain level after spinal surgery than do females. Figure 4 shows a straight-line pattern which further demonstrates that the corresponding samples were taken from normal distributions.

Smoking was not found to be a significant outcome predictor in this study. The high p-value shown in Table 3 indicates that there is not a statistically significant difference between smoking and non-smoking patients in the average reduction of pain. Figure 6 does not illustrate a straight-line pattern; thus the corresponding samples may not have been taken from the same distribution type. Figure 7 shows the distribution of change in Oswestry score for smokers and non-smokers. Figure 8 shows that the data for this factor deviated from required normality assumptions.

Surgery type was found to serve as a possible outcome predictor. There is a difference shown between patients undergoing microdiskectomies versus those undergoing fusions in the average reduction of pain, as calculated by the low p-value shown in Table 3 and by the straight-line plot in Figure 9. Mean values (Table 3) and the distribution plot (Figure 10) further indicate that there is a much greater reduction in pain level after surgery for patients undergoing microdiskectomies as compared to patients receiving fusions.

Pending litigation did not appear to be a significant outcome predictor. The large p-value (Table 3) suggests an insignificant relationship between litigation and outcome. In the average reduction of pain, there was no difference between patients with pending and non-pending litigation. Figure 11 shows the plot of the data sets and Figure 12 shows the distributions of change in Oswestry score between the two litigation statuses.

Age and time elapsed from injury to surgery were not found to have a significant effect on changes in Oswestry score. The p-value was not significant at the 5% level (Table 3b). Regression was also shown to be insignificant according to the multiple R^2 data. Furthermore, the scatter plots in Figures 13-14 do not show any relation of Δ_{OSW} to age and time between injury and surgery, respectively.

	Table 2. **Summary of Demographic and Surgical Data**	
GENDER	***Male:*** 65% (36/55)	***Female:*** 35% (19/55)
AGE	*Average:* 41.8 years	*Range:* 24-65 years
SMOKING	***Smoker:*** 55% (30/55)	***Nonsmoker:*** 45% (25/55)
LITIGATION PENDING	***Litigation:*** 38% (21/55)	***No Litigation:*** 62% (34/55)
SURGERY	***Fusion:*** 53% (29/55)	***Microdiskectomy:*** 47% (26/55)
TIME FROM INJURY TO SURGERY	*Average:* 12.3 months	*Range:* 1-108 months
TIME POST-SURGERY	*Average:* 12.1 months	*Range:* 3-27 months

Table 3a. **Statistical Data for Determination of Outcome Predictors**

	t-statistic	**p-value**	μ_X	μ_Y
FACTORS				
Male vs. Female	2.399	0.0213	14.4	-1.25
Smokers vs. Non-smokers	-0.5681	0.5732	6.5	10.37
Microdiskectomies vs. Fusions	-3.1549	0.0031	1	20.9
Pending vs. Non-pending Litigation	-0.3359	0.7388	7	9.3

Table 3b. **Statistical Data for Determining the Effect of Age & Time Elapsed from Injury to Surgery**

F-statistic	**p-value**	β_1	β_2
1.3661	0.2673	0.33	0.53

FIGURE 1: The relationship between VAS and Oswestry scores

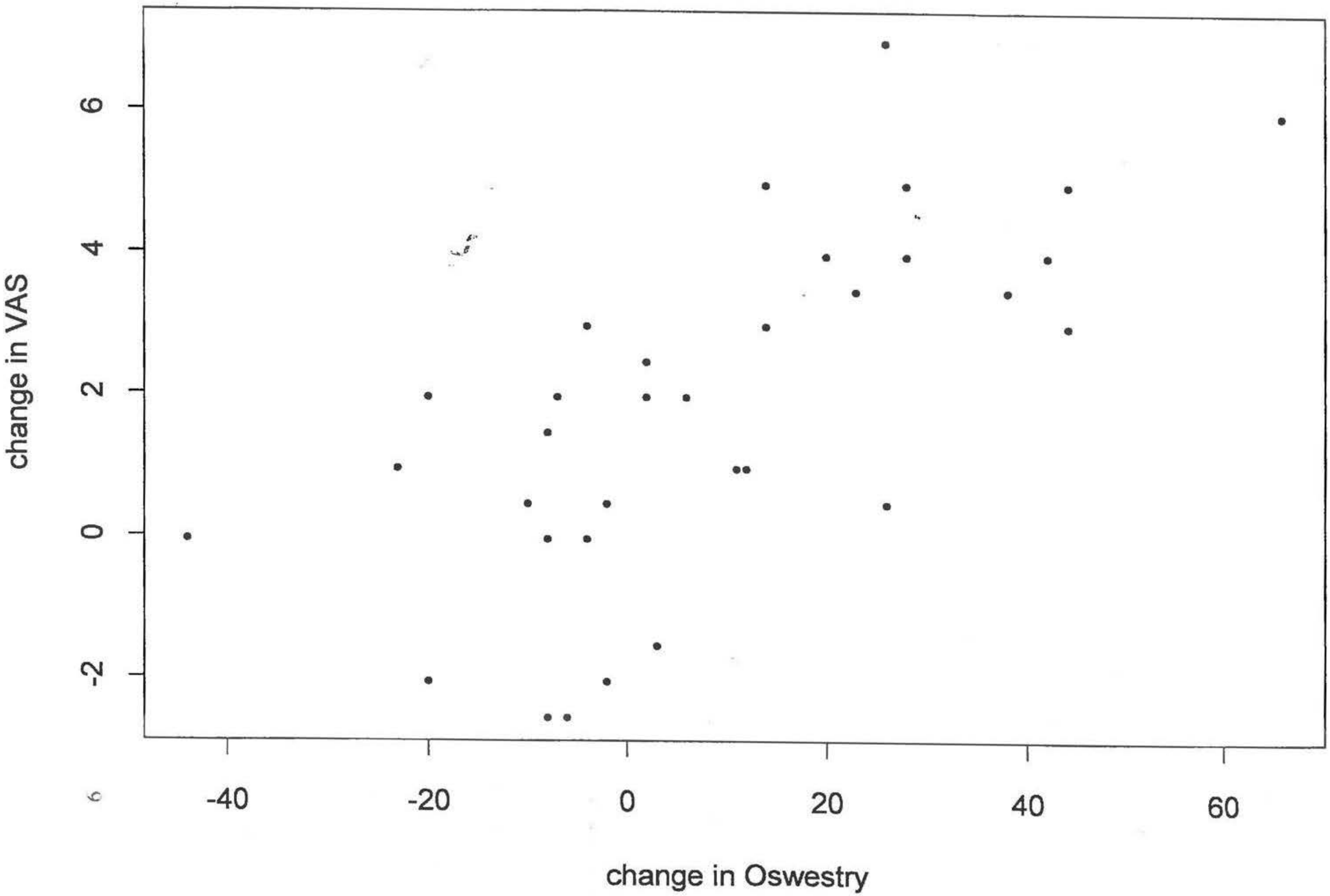


FIGURE 2: The relationship between the change in Oswestry score and the standard normal

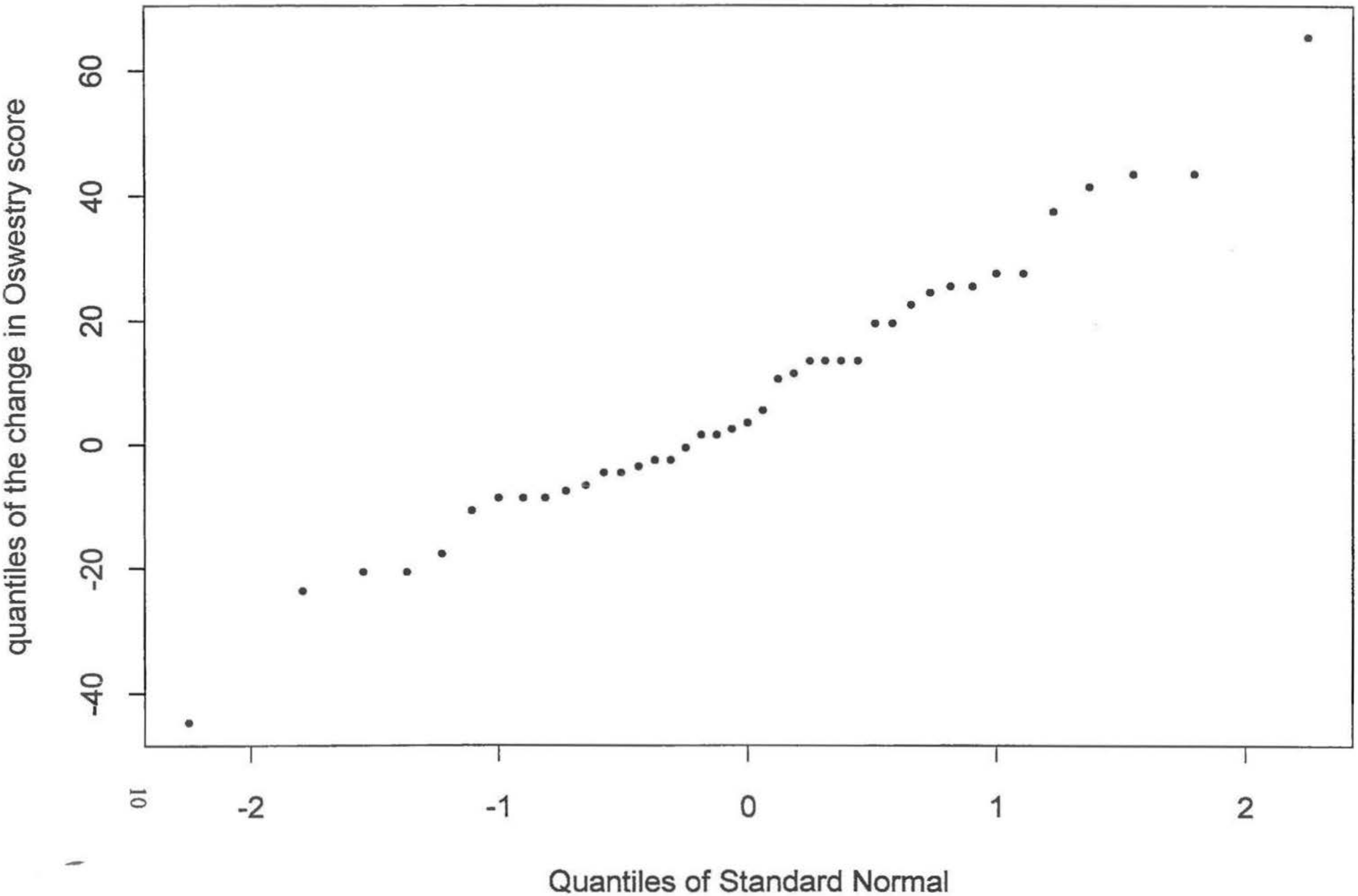


FIGURE 3: Distribution of change in Oswestry score between patients

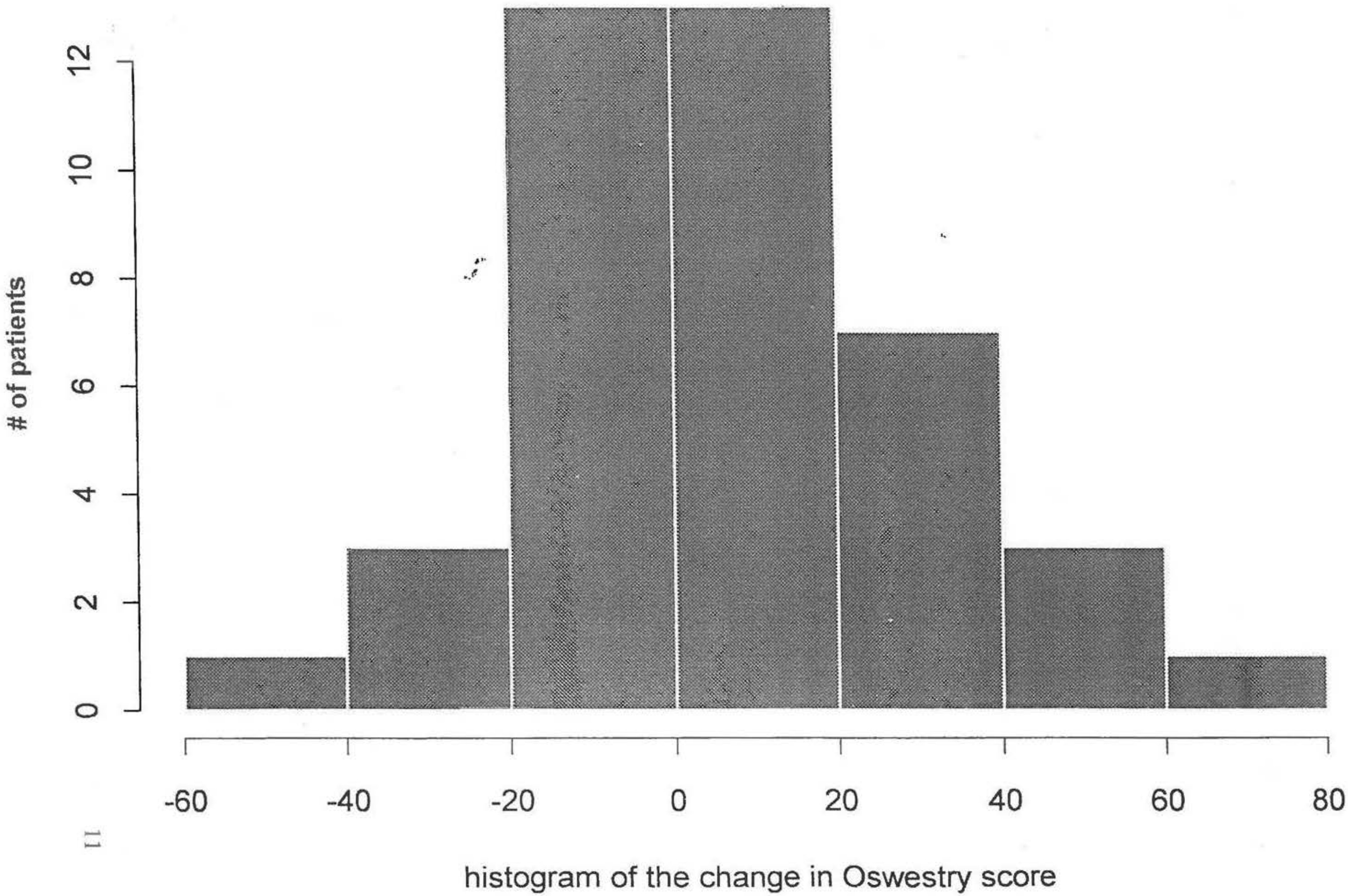


FIGURE 4: The relationship between the change in Oswestry score for females vs. males

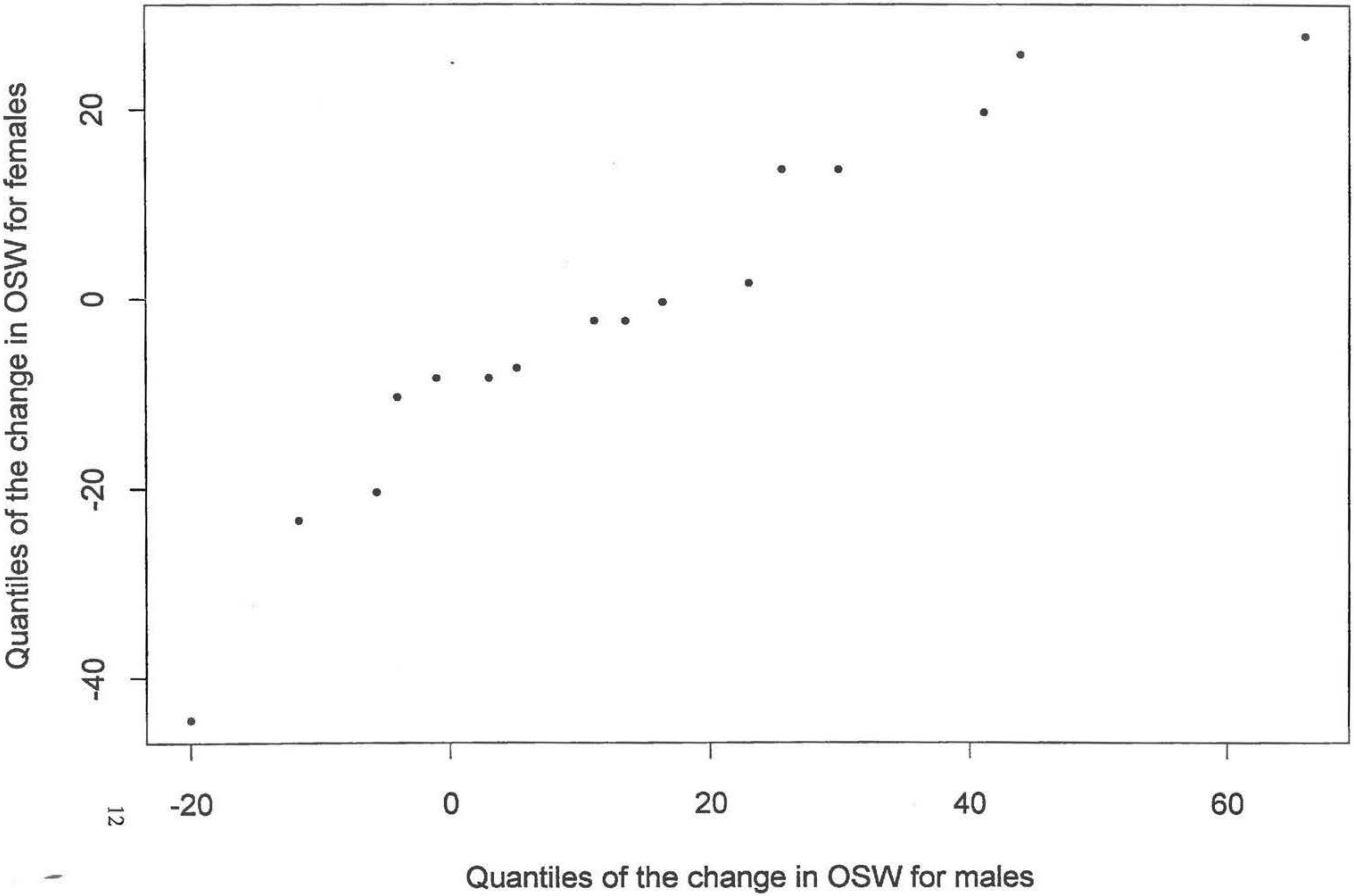


FIGURE 5: DISTRIBUTIONS
OF CHANGE IN OSWESTRY FORM FOR MALES AND FEMALES

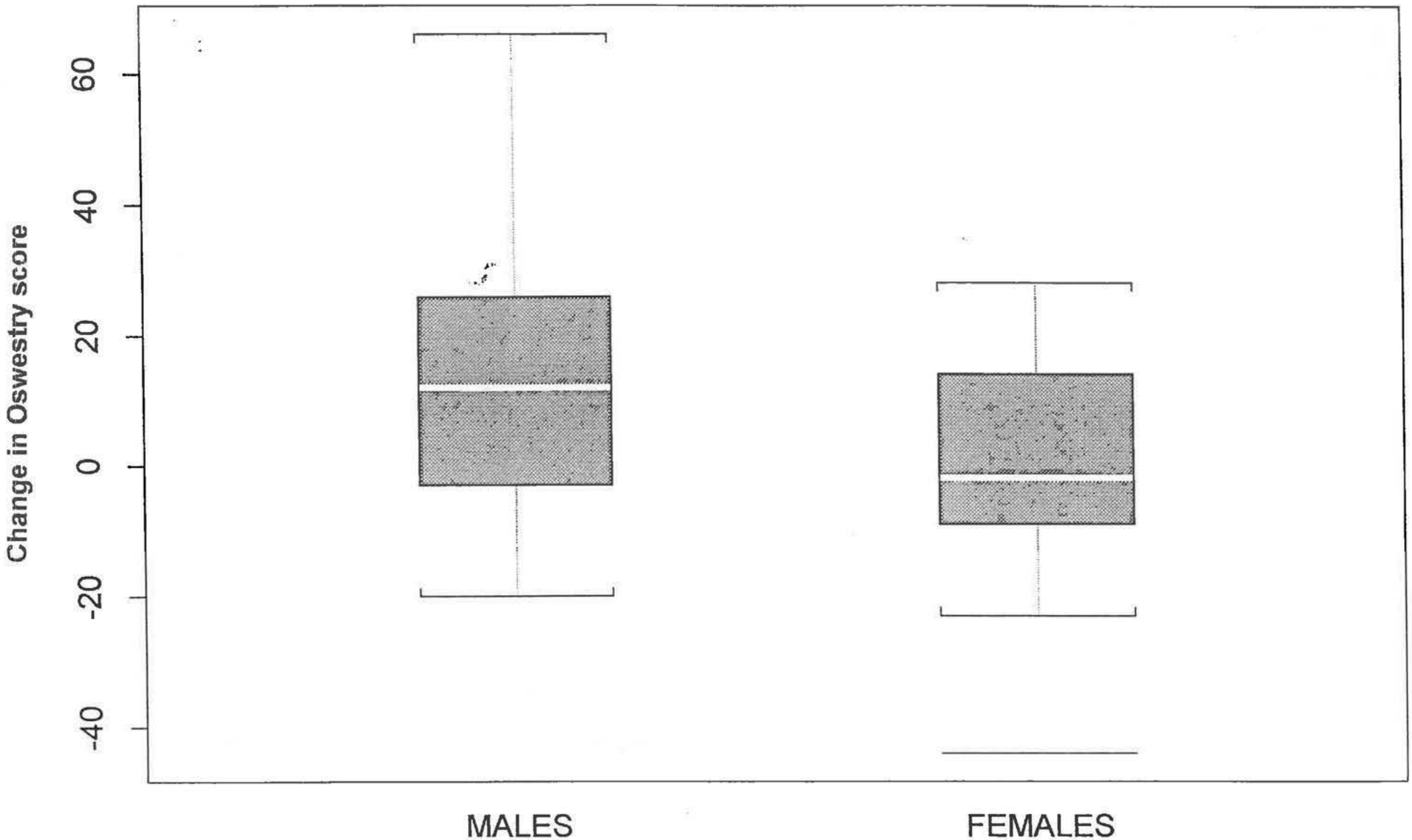


FIGURE 6: The relationship between the change in Oswestry score for non-smokers vs. smokers

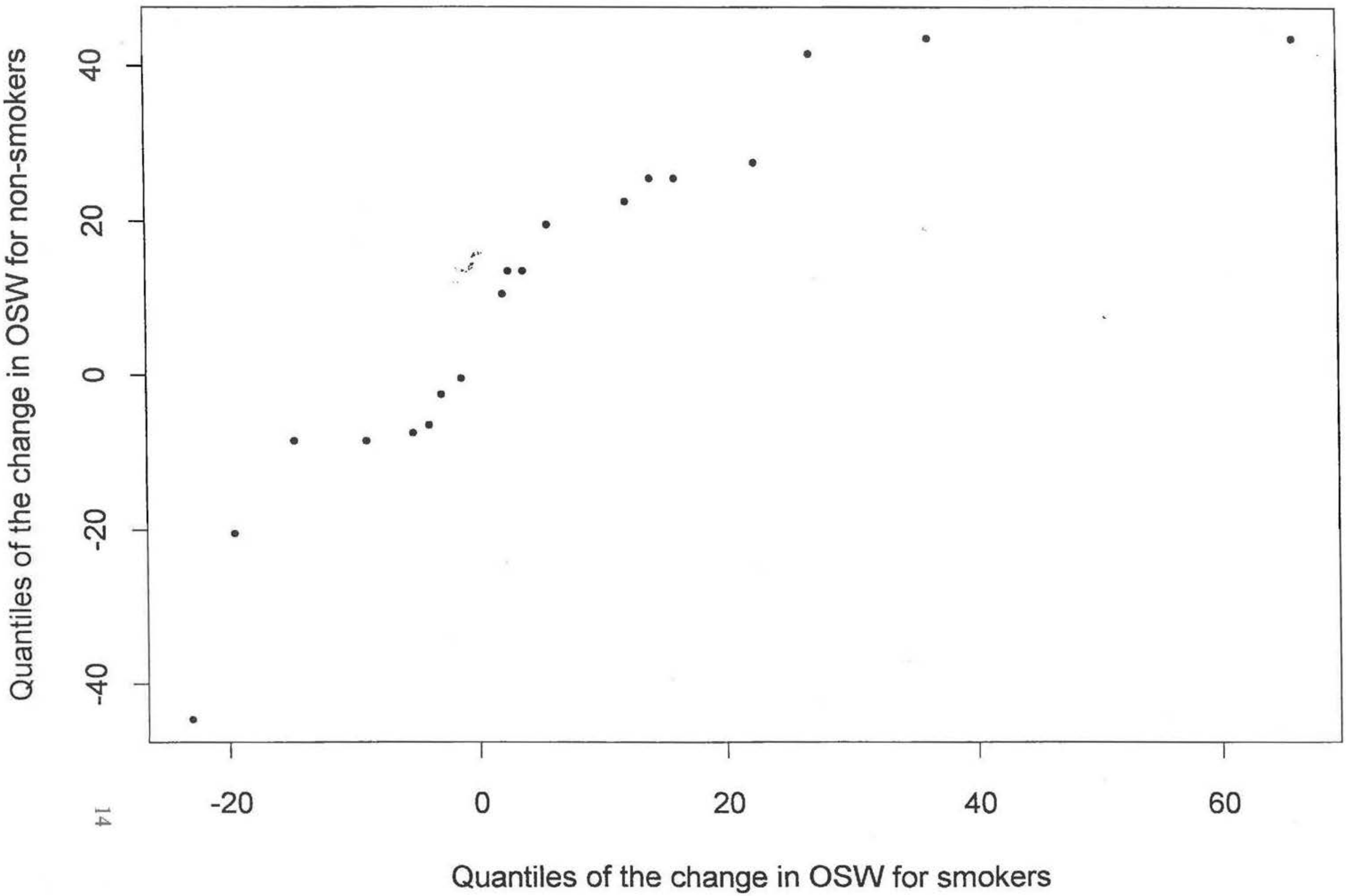


FIGURE 7:

DISTRIBUTIONS OF CHANGE IN OSWESTRY SCORE

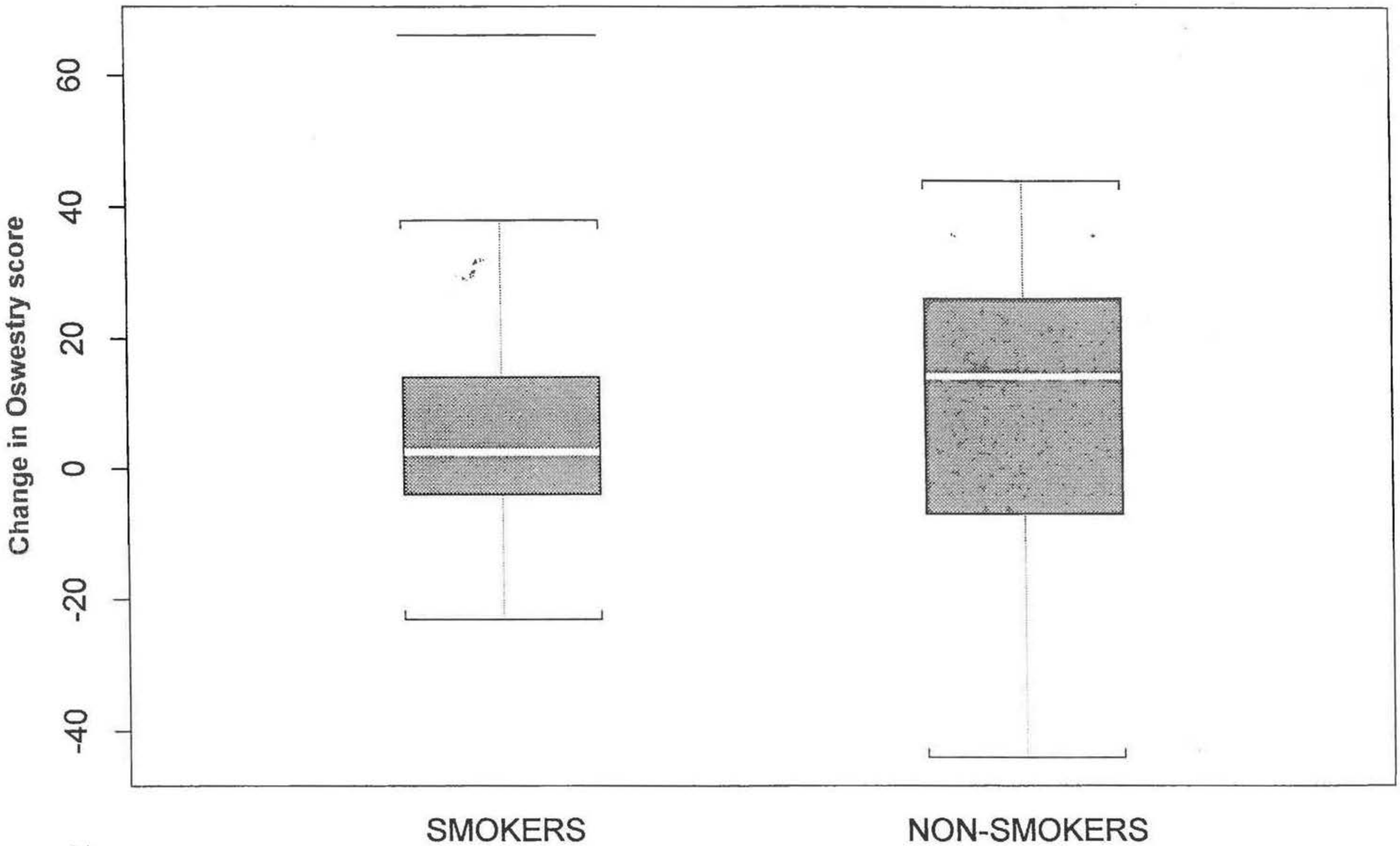


FIGURE 8: Distribution of change in Oswestry score between Nonsmokers

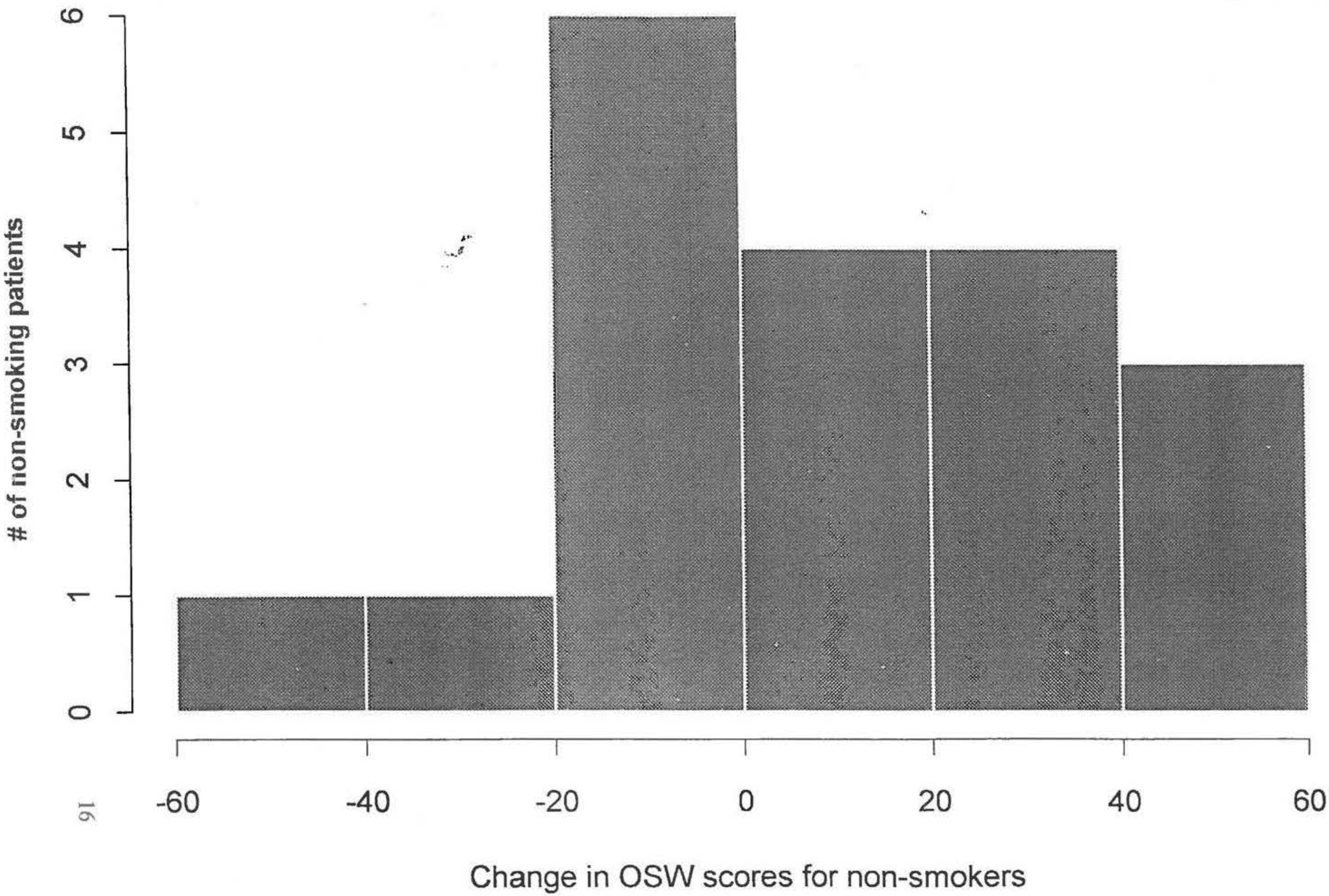


FIGURE 9: The relationship between the change in Oswestry score for fusion patients vs. microdiskectomy patients

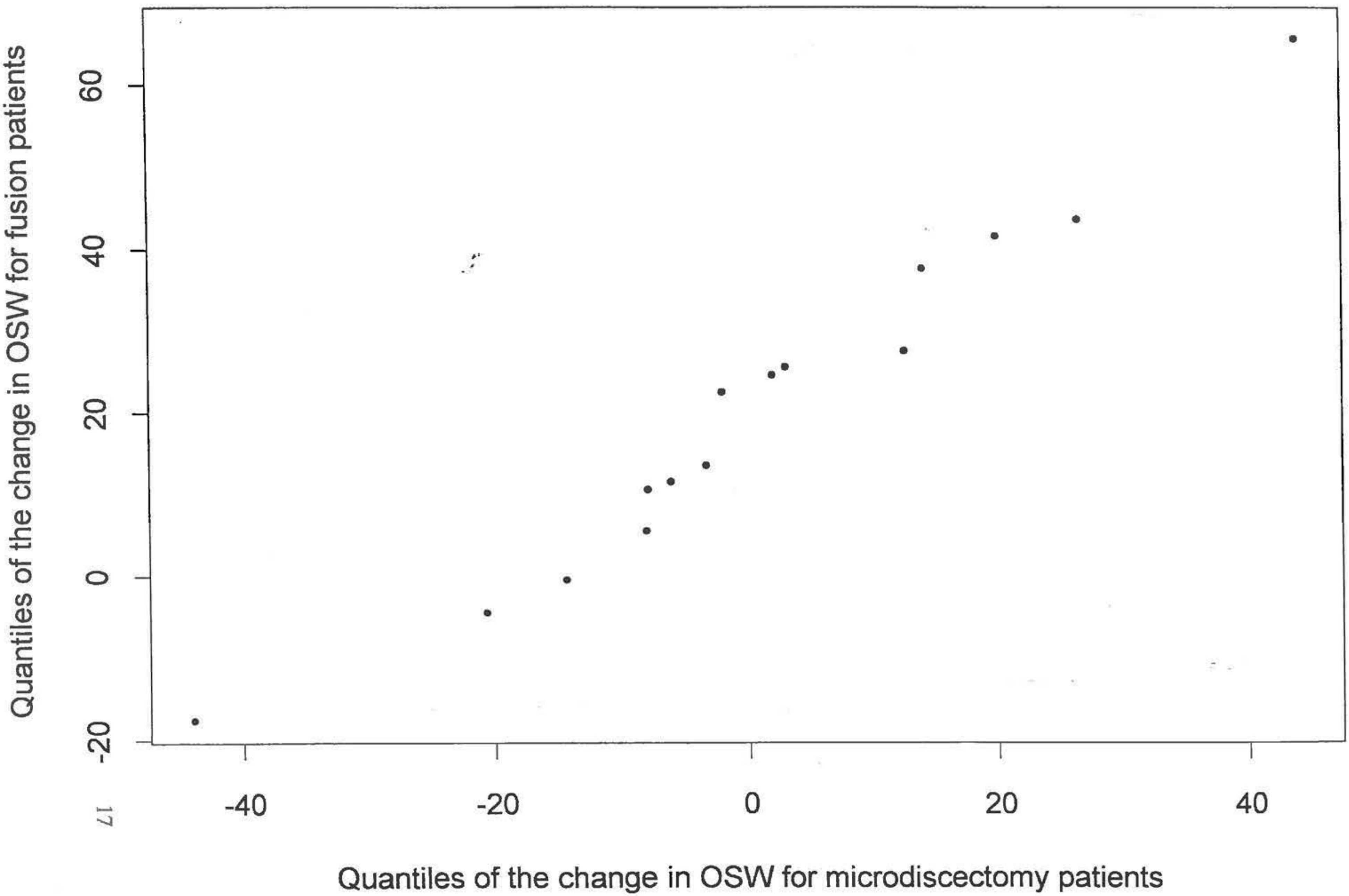


FIGURE 10: Distributions of change in Oswestry score for fusion and microdiscectomy patients

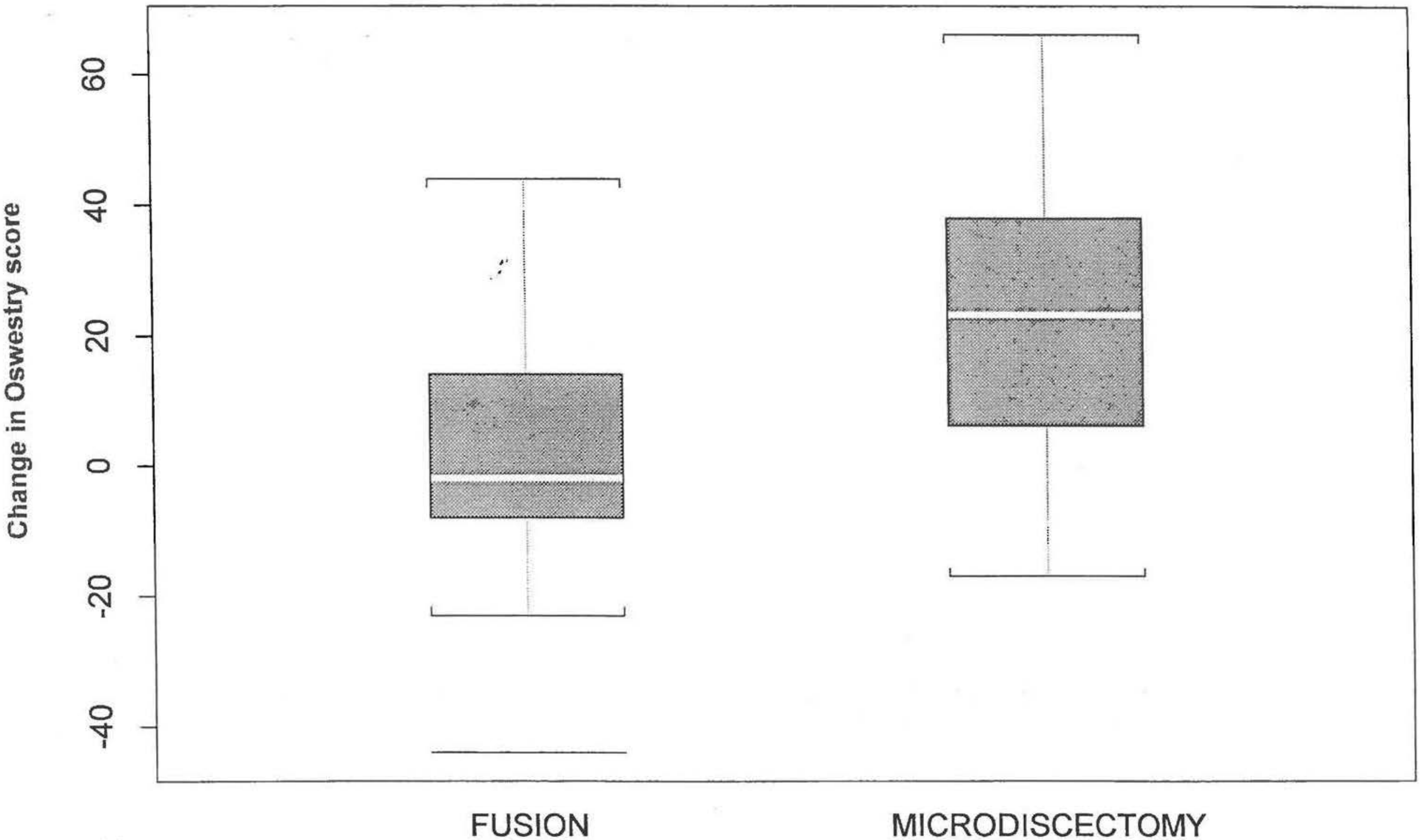


FIGURE 11: The relationship between patients with litigation non-pending and patients with litigation pending.

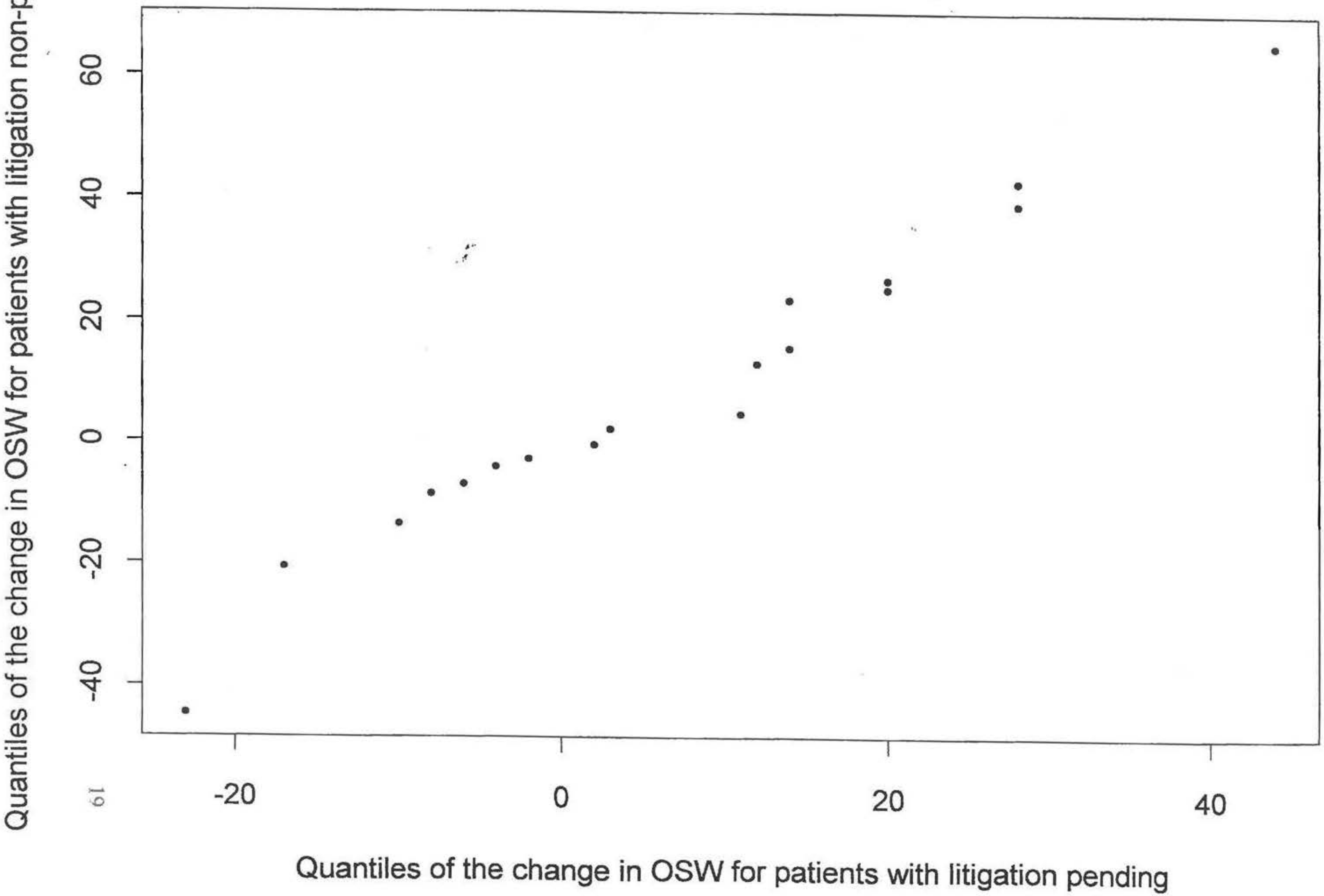


FIGURE 12: Distributions of change in Oswestry score for patients with litigation pending and patients with litigation non-pending

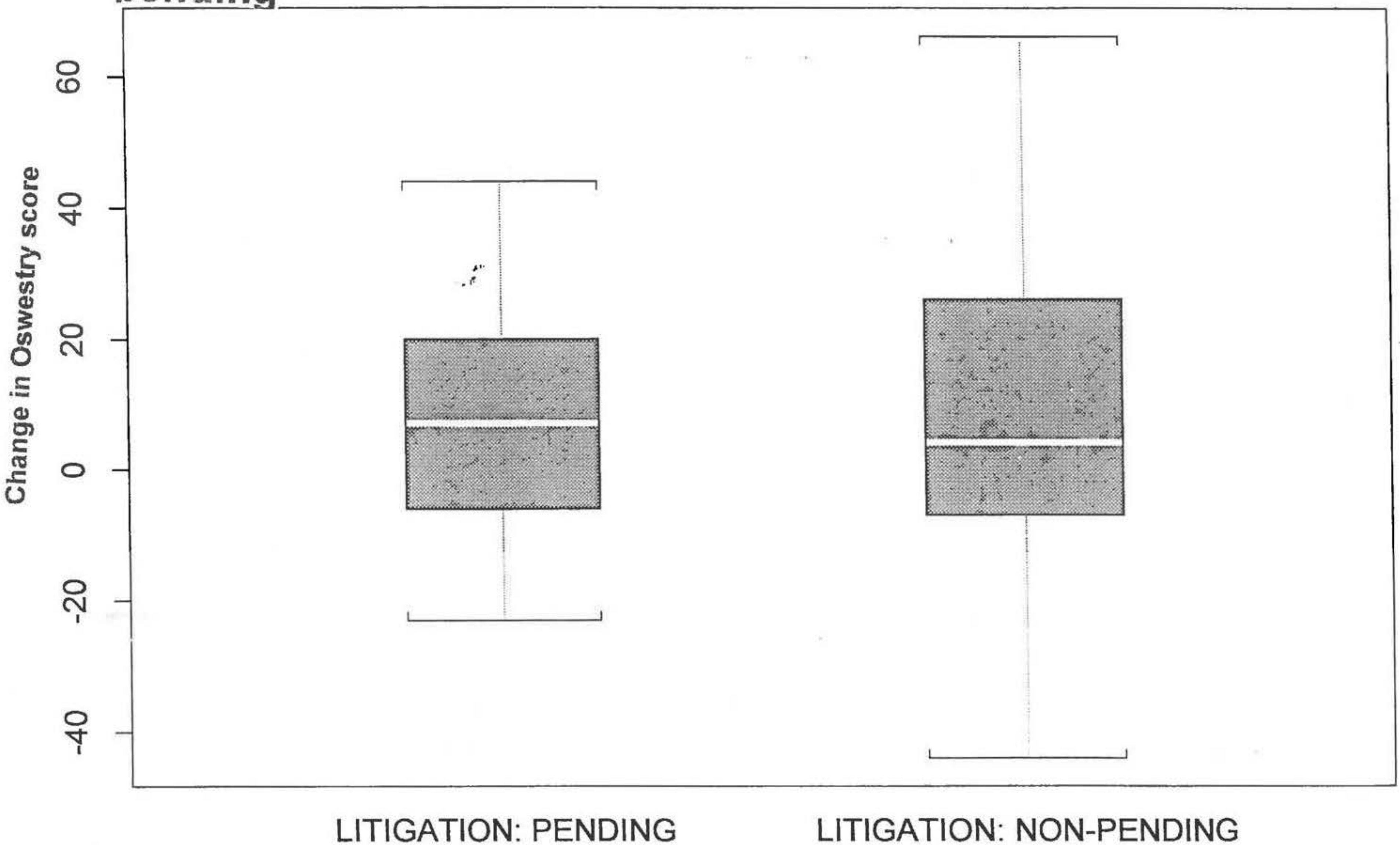


FIGURE 13: The relationship between time elapsed from injury to surgery and a change in Oswestry score

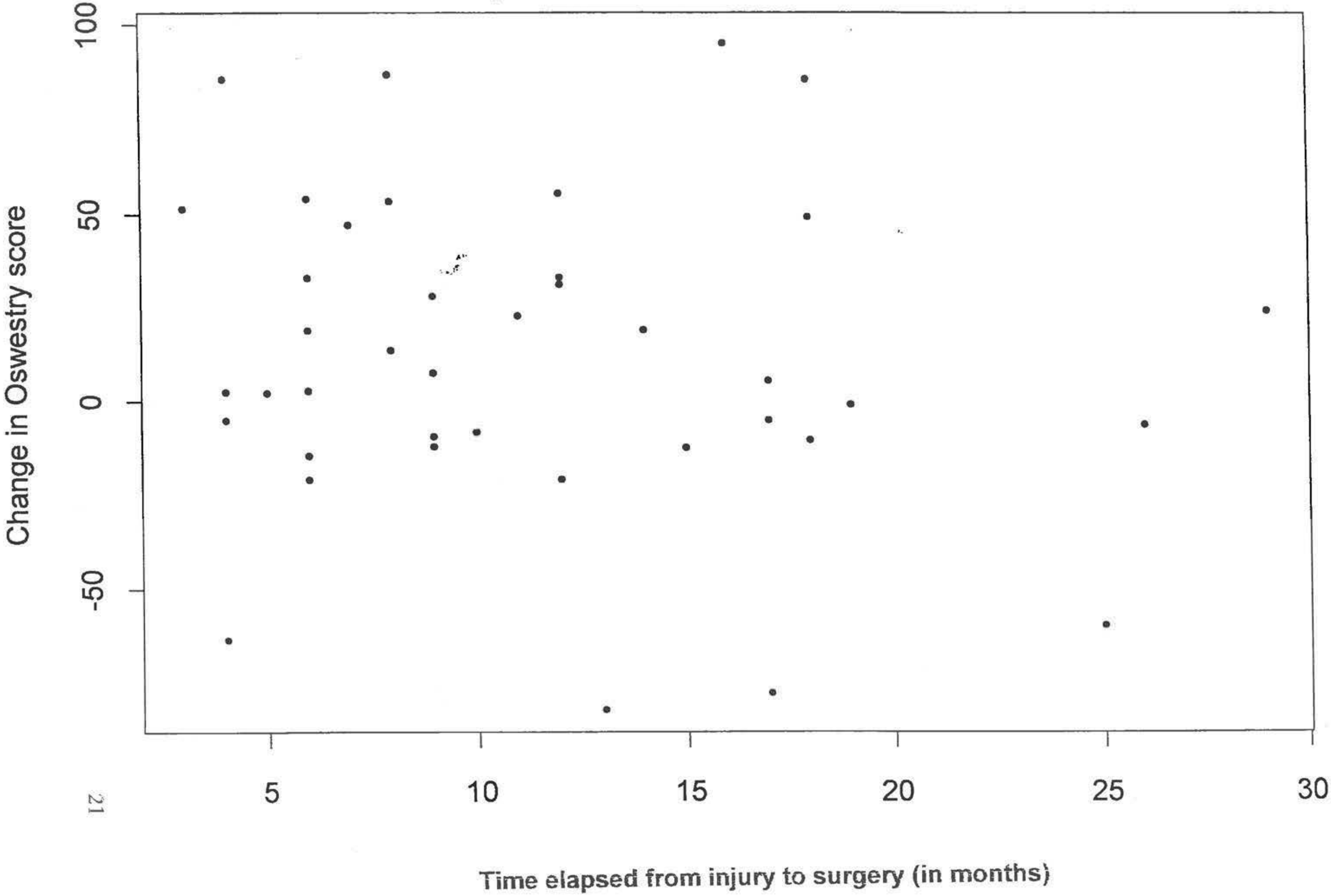
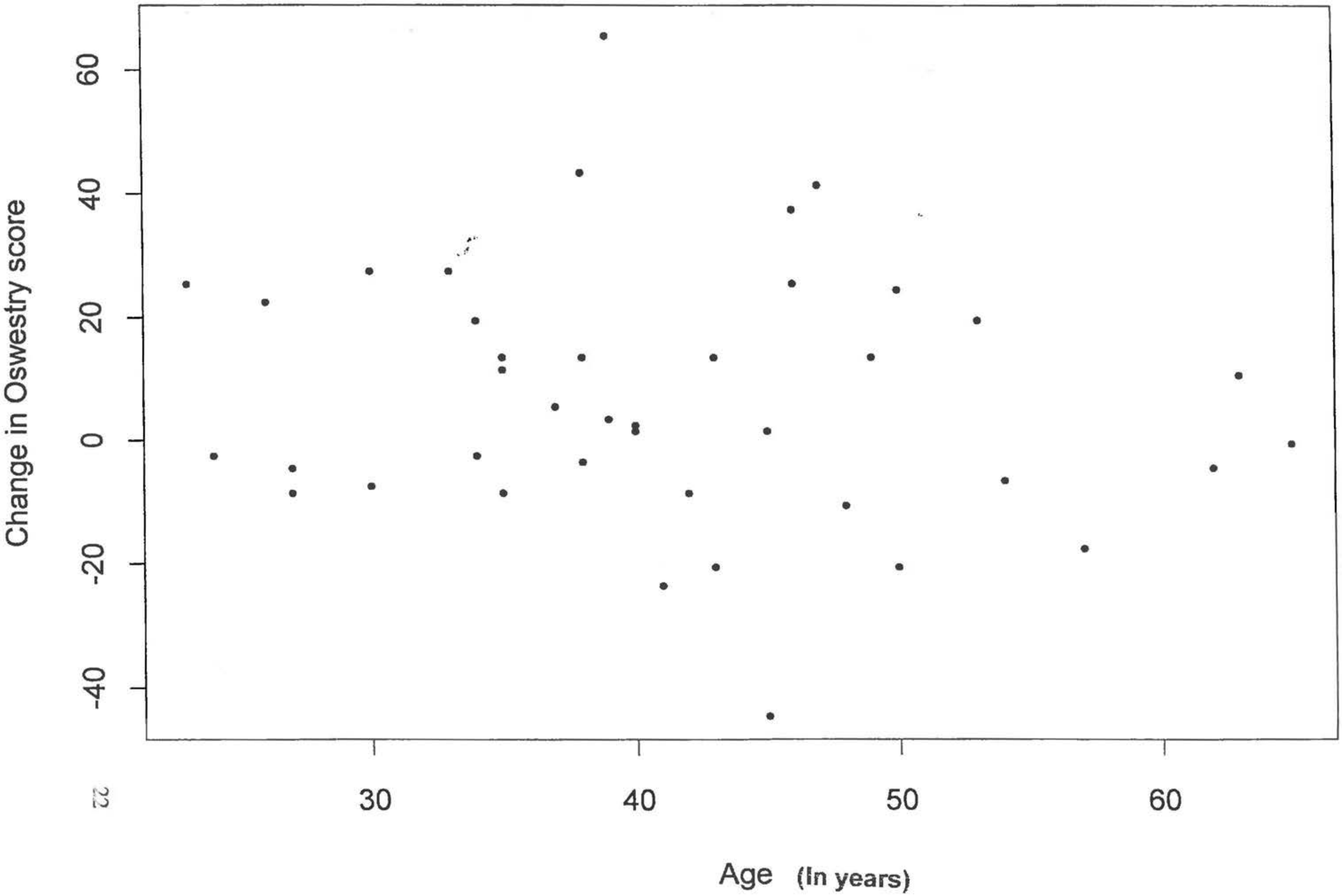


FIGURE 14: The relationship between age and a change in Oswestry score



DISCUSSION

There are many factors which influence recovery from spinal surgery independently from whether or not the patient is receiving compensation. Gender and surgery type appear to be useful outcome predictors for recovery in Workers' Compensation patients. The results of the gender analysis agree with Little et al (1994). The fact that male patients have greater reduction in pain level after surgery could be due to elements which have not been accounted for, and which could independently serve as outcome predictors. The level of physical exertion involved in the occupation or the violence with which the injury occurred could produce a greater initial pain level. A greater initial pain level might cause the relative change in Oswestry score to be larger than for less severe preliminary pain. Little et al. (1994) found that patients undergoing fusion who did well had reported higher initial disability scores, and that a lower initial disability score index correlated negatively with outcome. Although Leavitt (1992) concluded that a high level of physical exertion does not singly account for a prolonged disability time, it could still indirectly explain the fact that male patients have a greater post-surgical pain reduction, assuming that males are more likely to have jobs which involve a greater physical exertion.

Kroussel-Wood et al. (1994) determined that men are more likely to be classified as unfit for work, and although such a work status can be used as a negative outcome measure, it may also be accounted for by greater physical exertion. Work status and Oswestry scores may not be positively associated, because pain or functional level does not independently determine successful return to work. Pihlajamäki et al. (1996) found that there was no correlation between relief of pain and return to work. Other authors disagree about the validity of work status as an outcome measure: Lancourt and Kettelhut (1992) claim that return to work is the strongest indicator of success. However, Carpenter et al. (1994) note that work data is not a reliable indication of outcome, as they are affected by numerous other factors.

Microdiskectomies as a predictor of positive outcome is supported by studies which found a higher success rate for microdiskectomies when compared to macrodiskectomies. Although microdiskectomies were compared with fusions in this study, most all of the fusion surgeries included macrodiskectomy procedures. Although Kahanovitz et al. (1989) determined that the only advantage offered by microdiskectomy was a shorter hospital stay, this is not confirmed by the present study.

An unexpected result of this study is that smoking is not a significant factor in recovery, as this contradicts most literature. However, these results should be taken with caution because the non-smokers data may not be normal, as Figure 8 has shown. The conclusions of this test may thus be biased.

Although this study found no relationship between litigation and outcome, Sanderson et al. (1995) reports that patients involved in compensation claims have higher Oswestry disability scores. However, they also conclude that employment status is a more accurate predictor than litigation, because employed patients seeking compensation are shown to have little increase in disability over those employed patients not seeking compensation. Because this study did not address employment status, a direct relationship between litigation and outcome may not have been obvious. It is also important to note that actual settlement of compensation litigation does not effect reported pain or Oswestry disability (Greenough and Fraser 1989).

The results of the effect of age also contradicts some current research (Frederickson et al. [1988], Franklin et al.[1994]), but agrees with Carpenter et al. (1996), who also determined that age did not correlate with outcome. Whitehurst et al. (unknown year) made the recommendation that spinal surgery may still be successful even in the elderly, and that age need not be a deciding factor.

A lack of association between time from injury to surgery and outcome was not anticipated. However, in this case, the use of the Oswestry score alone may be misleading. Return to work may be a more effective outcome measure for this factor because a longer time between injury and surgery could effect a longer time between surgery and return to work.

While this study is useful for identifying gender and surgery type as post-surgical outcome predictors in Workers' Compensation patients, it also contains several limitations. The sample size is comparatively small, and may thus yield slightly biased results. The retrospective study design is restrictive due to incomplete data and response. Although the Oswestry scale is effective for determining post-surgical improvement based on pain and functioning, it is complete only if success is defined in terms of these criteria alone. However, success is a product of other measures as well, including return to work and patient satisfaction.

Successful recovery from spinal surgery is a comprehensive goal influenced by many factors, only one of which is Workers' Compensation. The present study identifies but a few of the other possible outcome predictors. Multiple surgeries, number of vertebral levels fused, surgical approach (anterior, posterior, or posterolateral), psychological disturbance, and family and employment situations may also be contributive. As such, it may be important to consider comprehensive treatment plans which incorporate aspects of these and other factors.

ACKNOWLEDGEMENTS

The author gratefully acknowledges Laurie Shepard for her assistance, and Tom Kozbowski for the statistical analysis.

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