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Longitudinal Quantitative Measures of the Natural Course of Low Back Pain Recovery

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Study Design. A prospective study was developed to quantify acute low back pain recovery.

Objective. To compare traditional self-report measures of low back pain recovery with a quantitative measure of recovery.

Summary of Background Data. The magnitude of low back disorders in society continues to be a problem. To prevent secondary injuries, an understanding of recovery must be gained by comparing the natural course of recovery using several outcome measures.

Methods. For this study, 16 occupational and 16 nonoccupational patients with low back pain were recruited. Recovery was monitored prospectively every 2 weeks for 3 to 6 months, using subjective work status, pain symptoms, activities of daily living, and objective functional performance probability (trunk kinematics).

Results. Return to work underestimated the percentage of subjects impaired, as compared with all other outcome measures. Symptoms, activities of daily living, and functional performance probability all showed similar patterns of recovery for 0 to 12 weeks. At 14 weeks, there was a lag in functional performance recovery. Both symptoms and activities of daily living indicated that 80% of the population was recovered, whereas functional performance indicated the figure to be 68%.

Conclusion. This prospective study demonstrates the natural course of recovery using several outcome measures. The objective kinematic functional performance measure of recovery quantifies a different aspect of impairment not evaluated by traditional subjective measures. Use of several outcome measures may lead to a better understanding of low back pain recovery or residual impairment, which may minimize the risk of recurrent injury. [Key words: low back pain, outcome measures, prospective, quantification, recovery] **Spine 2000;25: 1950–1956**

Previous history of low back pain (LBP) is one of its most common risk factors,[5,14,42,46] with recurrence rates reported to be as high as 70%.[45] Watson et al[50] found that lost time doubled for secondary injuries over that for first-time injuries. Epidemiologic studies have shown that only 10% of low back injury cases account for nearly 80% of total costs incurred by low back injuries.[21,49] It is hypothesized that a better understanding of LBP recovery may provide the knowledge necessary to prevent high-cost recurrent low back injuries.

Several low back disorder outcome measures described in the literature including return to work,[3,12,16,18,19,25,27,43,47,48] pain symptoms,[4,5,10,26,38] activities of daily living (disability questionnaires),[4,7,8,20,51] and physical measures.[6,11,13,22,23,28,29,35,40,41] Return to work, symptoms, and activities of daily living are based on the impression of the patient or the physician and may be defined as subjective measures. According to some researchers, physical measures, which provide a direct quantitative assessment of functional performance, may be defined as objective measures of recovery. Most outcome studies in the literature examine only one outcome. A better understanding about the natural course of LBP recovery may be gained by using both subjective and objective outcome measures.

Most LBP recovery measures reported in the literature evaluated impairment or disability outcome at one point in time.[5,8,13,15,18,23,26,35,37,40,43,51] There is a void in the literature on documenting the natural course of recovery. Use of multiple follow-up evaluations with several outcome measures may document discrepancies in the ratings of the various measures for severity of initial injury and progress during treatment. Therefore, the goal of this study was to monitor the natural course of LBP recovery prospectively using both traditional subjective outcome measures and objective quantitative kinematic measure for several follow-up evaluations in both occupational and nonoccupational patients to compare and contrast the information that can be derived from these measures during the recovery process.

Methods

Approach. A prospective study was designed to monitor LBP recovery using a variety of techniques at fixed follow-up times for a period of 3 to 6 months. To gain a better understanding of recovery, four outcome measures were monitored including work status, symptoms, activities of daily living, and the physical measure of functional performance probability. Functional performance probability is a technique that directly quantifies trunk motion performance and indicates the probability of normal or asymptomatic functional performance.[29] It is hypothesized that this prospective approach for evaluating traditional subjective measures and a quantitative objective measure will provide a more thorough understanding of the recovery process.

Participants. For this study, 32 participants were recruited from primary and urgent care facilities. Of these 32 participants, 16 had occupationally related low back injuries and 16 had nonoccupational low back injuries. All the participants

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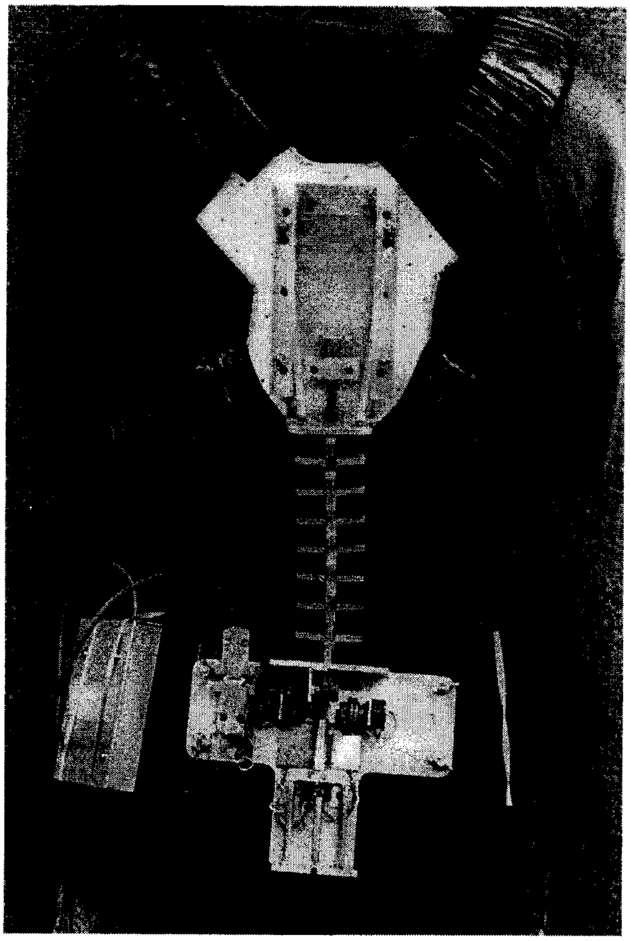

Figure 1. Lumbar motion monitor on subject.

had local LBP symptoms with no radicular symptoms (Quebec Task Force Category 1)[44] and were recruited within the first month of their symptoms. Participants were paid $10 per visit and a $50 bonus for completing all the visits. The University's Human Subjects Review Board approved the protocol for the study.

Equipment. The lumbar motion monitor (LMM) evaluates trunk kinematics. It measures position, velocity, and acceleration in all three planes of the body and has been previously validated.[30] The LMM was used as a measure of functional performance. As shown in Figure 1, the LMM is attached to the person using orthoplast. An oscilloscope provided visual feedback for the asymmetric control tasks. A comparator circuit supplied auditory feedback for both the subject and the experimenter. A portable computer was used for collecting and storing the data.

Experimental Design. *Low Back Evaluation Schedule.* A repeated measures design with two independent factors was used for this study. The first independent factor was time of evaluation. Evaluations were performed every 2 weeks for 3 months. At the end of 3 months, the outcome measures were evaluated to determine the degree to which the participant had recovered based on all four measures. Because the goal of the project was to compare outcome measures, all four measures were evaluated to determine recovery status. If the participant showed recovery on all four outcome measures at 3 months, the study was complete. Otherwise, data collection continued for 3 more months, with evaluations occurring at 1 month intervals. The second independent factor was the occupational or nonoccupational patient classification.

Low Back Recovery Measures. The measures of LBP recovery included four outcome measures: symptoms, activities of daily living, work status, and functional performance probability.

Self-Report Questionnaires. Self-report of LBP status was reported by three measures. First, symptoms were measured with the McGill Pain Questionnaire (MPQ).[36] The symptom outcome measure used from the questionnaire was the current pain intensity score. Second, activities of daily living were evaluated using the Million Visual Analog Scale (MVAS).[34,39] Finally, a work status questionnaire was used to indicate whether the participant was working.

Functional Performance. Functional performance was measured with the LMM. The functional performance protocol required participants to control their twisting position as they flexed and extended their trunk as fast as they could comfortably.[29–31] The controlled twisting positions were 0°, 15° clockwise and counterclockwise, and 30° clockwise and counterclockwise.

Procedure. All the participants were screened at the first visit by an orthopedic surgeon (P.G.). Once approved for the study, the participant completed all the questionnaires and the functional performance evaluation. This procedure was repeated at subsequent evaluations.

Data Analysis. *Questionnaires.* The current pain intensity score was used from the MPQ. The MVAS was scored by summing all 15 questions. An indicator variable was used for work status.

Functional Performance. The kinematic measures from the LMM were calculated with validated techniques.[30] The output included range of motion, flexion velocity, extension velocity, flexion acceleration, and extension acceleration from each of the planes. The data were normalized by age and gender and entered into an existing model, which distinguished between asymptomatic control subjects and patients.[31] The model generates a probability of the functional performance being in the asymptomatic group (*i.e.*, the probability of functional performance recovery). The model has a sensitivity of 86% and a specificity of 94%, indicating accurate classification of patients and asymptomatic control subjects.[31]

Outcome Measure Recovery Criteria. A decision criteria was developed for each of the four major outcome measures: 1) work status, 2) MPQ, 3) MVAS, and 4) functional performance probability from the LMM. Participants had to be working to be considered recovered on the basis of the work status. The MPQ criterion for recovery was a current pain intensity score of 0 (no pain). An MVAS score less than 30 was used to indicate recovery. A score of 30 would indicate that, on the average, each question had a score of 2 or less. A functional performance probability of 0.5 or greater denoted recovery. The functional performance probability cutoff is based on a previously developed discriminant function model, which used a 0.5 criteria.[31] All four indicators of recovery were used to

Table 1. Demographic Means for the Occupational and Nonoccupational Participants Who Completed the Study

Anthropometric Measure	Occupational (n = 13)	Nonoccupational (n = 15)
Age (yr)	35.6 ± 12.2	34.5 ± 12.5
Men (%)	77	56
Standing height (cm)	179.3 ± 10.0	174.2 ± 11.1
Weight (kg)	89.6 ± 19.5	81.8 ± 19.7

determine whether a person had completed the study at 3 months or needed to continue for 6 months. It should be noted that changing the criteria for recovery may influence the results of the study.

Statistical Analysis. Multivariate analysis of variance (MANOVA) and analysis of variance (ANOVA) were performed for the independent measures of time, injury group, and their interaction. Follow-up *post hoc* analyses were performed. Descriptive statistics of the outcome measures as a function of time illustrate the natural course of recovery.

■ Results

Of the 32 participants recruited, 28 participants (15 of the 16 nonoccupational and 13 of the 16 occupational participants) completed the study. Four (12%) participants dropped out of the study before completion for reasons unrelated to the study. Table 1 lists the means and standard deviations of several demographic measures for both occupational and nonoccupational participants who completed the study. At 3 months, 11 of 15 nonoccupational participants and 7 of 13 occupational participants were finished. Completion at 3 months was based on indication of recovery from all four outcome measures. As indicated by at least one of the four outcome measures, 10 participants were not considered recovered at 3 months. Therefore, these participants completed 6 months of evaluations. The statistical tests of repeated measures were performed for data from the first 3 months (n = 28) because there was not enough statistical power to evaluate data from 3 to 6 months (n = 10).

Influence of Injury Group on the Repeated Measures

The statistical analysis results evaluating overall differences between occupational and nonoccupational groups indicated no significant differences. The *P* values listed in Table 2 showing differences between groups for each dependent measure also indicate no significant differences.

Influence of Time Duration on the Outcome Measures

The statistical analysis indicated that all four outcome measures improved significantly with time ($P < 0.0001$). Figure 2 illustrates changes in work status, MVAS, MPQ, and functional performance probability as a function of time. On the average, participants started the study 2 weeks into their symptoms. Therefore, the time starts at 2 weeks with all the figures. The mean values with different letters indicate significant improvement between those evaluations.

Disability Outcome Measures. One of the most common outcome measures in the low back disorder literature is return to work. Figure 2A shows the percentage of participants working as a function of time. At the initial evaluation, 78% (22/28) of the participants were working, and no significant change in work status occurred after 4 weeks. This indicates that participants were not off work because of their low back disorder. In addition, work status may not be a responsive measure of LBP recovery. It is hypothesized that disability measured by work status is more a function of the job than the severity of the person's impairment.

The MVAS outcome measure evaluates how symptoms influence the patient's activities of daily living. Figure 2B illustrates that indeed MVAS scores decrease as a function of time. At the initial visit, the mean score was 75.4. The statistical analysis showed that the MVAS score significantly decreased to 25 at 12 weeks. Thus, the mean MVAS score indicated that there was minimal interference of pain symptoms with activities of daily living 12 weeks after the injury.

Impairment Outcome Measures. The MPQ symptom measure showed a significant decrease in symptoms between 2 and 4 weeks and between 4 and 6 weeks. Figure 2C shows that beyond 8 weeks no significant change in symptoms occurred. The absence of significant change in MPQ symptom scores during the last month of testing may indicate that the current pain intensity measure of symptoms is not sensitive to changes in mild pain levels.

The functional performance probability of recovery shown in Figure 2D illustrates significant changes between evaluations as a function of time. The figure illus-

Table 2. Analysis of Variance *P* Values for Each Dependent Measure for the Main Effects of Time and Group As Well As Their Interaction

Category	Dependent Measures	Time	Injury Group	Interaction of Time and Injury Group
Outcome measures	Work status	0.0108*	0.7571	0.4812
	MVAS	0.0001*	0.0882	0.2380
	MPQ	0.0001*	0.0633	0.9403
	Functional performance Probability	0.0001*	0.4778	0.0031*

* Significant difference at 0.05.
MVAS = Million Visual Analog Scale, MPQ = McGill Pain Questionnaire.

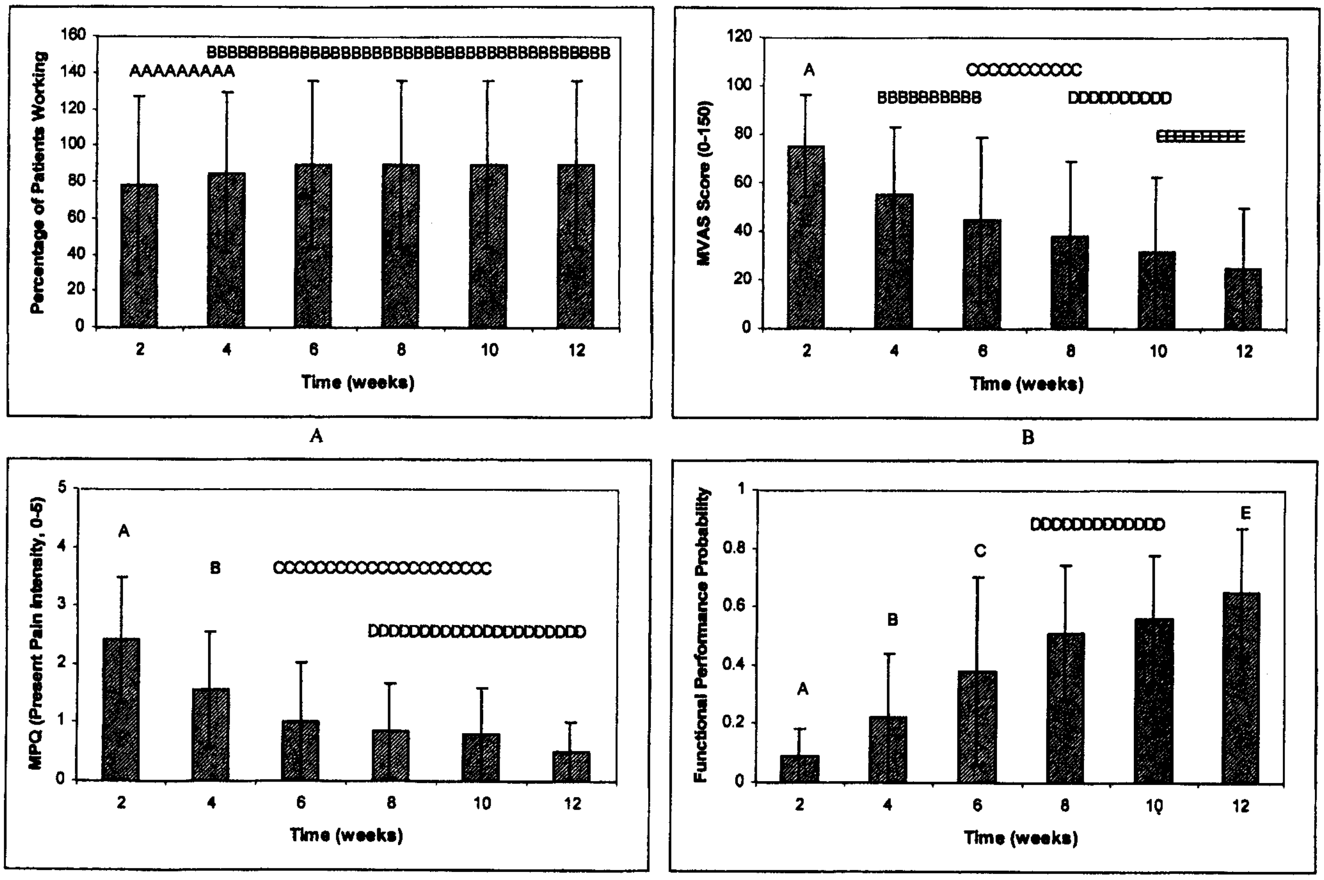

Figure 2. Major outcome measures of work status (**A**), Million Visual Analog Scale (MVAS) (**B**), McGill Pain Questionnaire (MPQ) (**C**), functional performance probability (**D**) as a function of time. Note: Bars with the same letter are not significantly different. At all observations, n = 28.

trates significant improvement every 2 weeks for the first 8 weeks, as indicated by different letters associated with each observation period in the figure. The evaluations at 8 and 10 weeks did not differ significantly, but significant functional improvement occurred during that time. Functional performance probability was the only measure that significantly improved during the last 2 weeks of the study. Compared with the other outcome measures, the functional performance probability showed the most distinct statistically significant improvement over the study time.

Influence of Time and Injury Group on the Outcome Measures

The statistical analysis indicated that the rate of improvement was significantly different for the occupational and nonoccupational groups. Table 2 lists the *P* value of each individual outcome measure for the interaction. Only the functional performance probability values show a significant difference in the rate of recovery between the two groups ($P = 0.0031$). Figure 3 shows that the nonoccupational group was initially slightly more impaired than the occupational group. The nonoccupational group had a faster rate of improvement. Therefore, by the last visit, the nonoccupational group had a higher functional performance probability than the occupational group. On the average, the nonoccupational group recovered 1 month earlier than the occupational group according to the functional performance probability outcome measure. The functional performance probability was the only outcome measure to in-

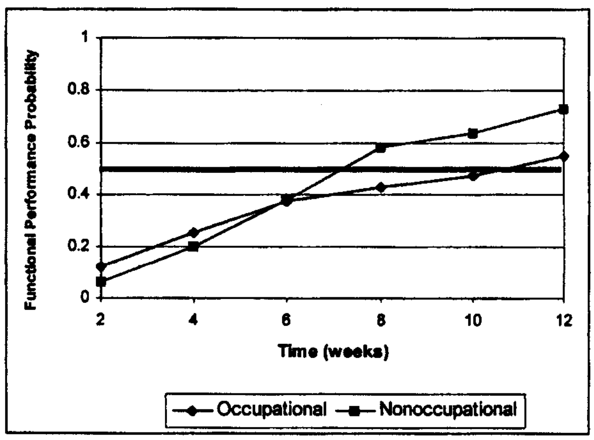

Figure 3. Interaction of injury group and time for the functional performance probability.

dicate a difference in the rate of recovery between the occupational and nonoccupational patients.

■ Discussion

This prospective study evaluated the natural course of LBP recovery using traditional subjective measures of recovery as well as an objective trunk kinematic measure in both occupational and nonoccupational patients. On the average, participants continued to work during their acute LBP episode. Symptoms decreased significantly during the first 6 weeks; activities of daily living improved significantly every 4 weeks; and functional performance probability improved 10% every 2 weeks during the first 3 months of evaluations. The quantitative kinematic functional performance measure of recovery provides another dimension to the assessment of recovery that is not measured by traditional subjective measures. Using all the outcome measures collectively may provide a better assessment of maximum medical improvement, which may minimize the risk of recurrent injury.

The findings showed no overall significant difference in recovery between occupational and nonoccupational patients, which is in agreement with some research,[1,37] yet contrary to other research.[9,17,24] It is hypothesized that the contradictions in the literature concerning differences in recovery between occupational and nonoccupational patients may be the result of several factors. First, the contradictions in the literature may be caused by differences in follow-up evaluation time. Second, the discrepancies may be the result of different outcome measures. Finally, previous researchers have not necessarily controlled for the diagnostic category of the subject, which may influence outcome. It is theorized that previous researchers may have found differences between occupational and nonoccupational groups based on differences in the severity or diagnosis of the initial injury, which was not controlled or even discussed in previous studies. It is the hypothesis of the current authors that because the diagnostic category was controlled in the current study, no significant differences were found.

The use of multiple outcome measures provides an opportunity to evaluate differences in the recovery indication among the outcome measures. Figure 4 shows the percentage of participants impaired as a function of time for each of the four outcome measures. The kinematic functional performance probability outcome measure provides a quantitative measure of recovery that is comparable to the traditional symptoms and activity of daily living outcome measures, but independent of the subjective impression of the patient or physician. Figure 4 shows that the MVAS, MPQ, and kinematic functional performance probability all demonstrated similar trends in the indication of recovery from 0 to 12 weeks after injury. However, from 14 to 18 weeks (box in Figure 4), 32% of the participants were impaired according to functional performance probability, but only 20% according to symptoms or MVAS.

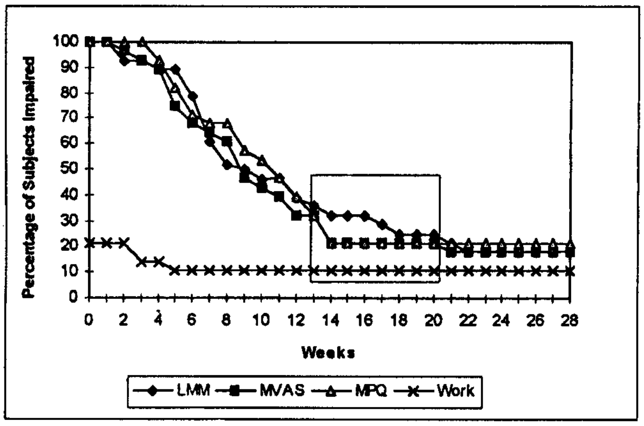

Figure 4. Percentage of subjects impaired as a function of time by outcome measure.

Further evaluation showed that 39% of the participants' symptoms recovered before their functional performance probability. Perhaps this reflects a point in recovery at which patients are free from pain but their musculoskeletal system has not recovered sufficiently for them to recruit their muscles in a typical manner. This may alter the loading pattern of the musculoskeletal system. Therefore, it is hypothesized that during the period when symptoms have recovered and functional performance has not, patients are most at risk for recurrent injury.

As seen in Figure 4, work status showed only 21% of the participants to be impaired at the initial visit, whereas the MVAS, MPQ, and functional performance indicated that 100% of the participants were impaired. This indicates that people are continuing to work although subjective symptoms and objective functional performance measures show them to be impaired. Baldwin et al[2] suggested that return to work is a misleading outcome measure. The results of the current study clearly denote that it is a misleading indicator of impairment. However, by definition, work status is a measure of disability. It is hypothesized that lost time is a function of psychosocial factors, physical job demands, and administrative controls (light duty), and not that of functional performance, symptoms, or activities of daily living. This hypothesis is supported by correlations between work status and the other three major outcome measures, which were all less than 0.5. The weak correlations indicate that the work status recovery measure is independent of the worker's functional performance, symptoms, or activities of daily living status.

Finally, Figure 4 provides an opportunity to evaluate the categories of impairment and disability. Work status and MVAS measures may be classified as disability measures, whereas symptoms and functional performance probability may be classified as impairment measures. The similarity between MVAS recovery and the two impairment measures indicates that MVAS may be a measure of impairment rather than a measure of disability. The figure further shows that disability measured by

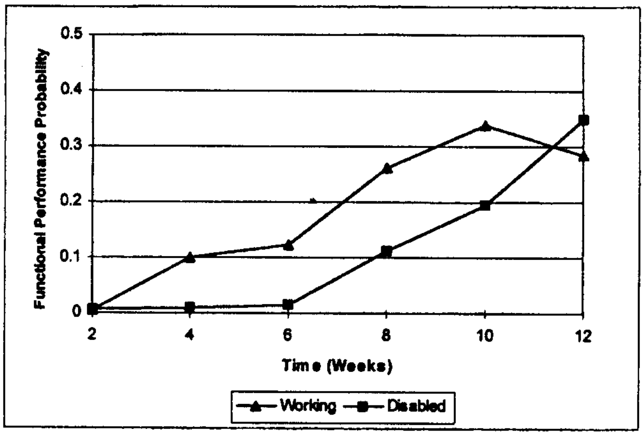

Figure 5. Functional performance probability as a function of time for a disabled participant (not working because of injury) and a working participant.

work status clearly is not a function of impairment level, regardless of whether impairment is measured by symptoms or functional performance.

The independence between functional performance and work status is further illustrated in an example from two participants. Figure 5 displays the functional performance probability as a function of time for two participants. The figure shows extremely low functional performance initially and steady improvement for both participants, indicating a similar level of impairment. However, one participant was disabled for the entire study, whereas the other participant worked the whole time. The disabled participant had a manual material handling job that required lifting up to 80 pounds. The participant who worked while impaired had a job that required clerical work. Clearly, in this case disability was not dependent on functional performance as much as the relation between functional performance and job demands. This finding shows that light duty or transitional work may indeed reduce lost time and disability. Thus, return to work is more reflective of the job demand than impairment status as measured by either subjective pain score or objective kinematic measures.

This study demonstrates that the natural course of recovery depends on the outcome measure observed. Each subjective and objective outcome measure documents a different quality of recovery. Kinematic functional performance probability appears to be more sensitive to improvements during later stages of recovery than traditional subjective outcome measures. Therefore, evaluating multiple outcome measures to assess recovery may provide a more complete picture of patient recovery and residual impairment.

Several limitations of this study must be kept in mind. First, only one diagnostic category was evaluated. Second, treatment was not controlled. Finally, the results may change if different decision criteria are used for cutoff points in determining recovery. Future research is needed to evaluate how treatment, diagnostic category, and recovery criteria influence the natural course of recovery for patients with LBP.

■ Conclusion

The kinematic functional performance probability outcome measure provided a sensitive quantitative measure of recovery comparable with symptom and activities of daily living outcome measures, but independent of the subjective impressions of patients and physicians.

■ Key Points

- This prospective study evaluated acute LBP recovery.
- The natural course of recovery was evaluated with three traditional outcome measures and a quantitative functional performance measure.
- Compared with all other outcome measures, return to work underestimated the percentage of subjects impaired.
- Functional performance was the most sensitive measure of visit-to-visit improvement.

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