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Differences Among Outcome Measures in Occupational Low Back Pain

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The rate of recurrence in low back pain patients has been reported as high as 70%; therefore, it is believed that researchers have a poor understanding of low back pain recovery. To enhance our understanding of recovery, a large cross-sectional study was conducted to compare outcome measures of return to work, impairment of activities of daily living, pain symptoms, and functional performance probability. A total of 208 workers were examined. The percentage of workers recovered based on return to work criteria was 99% compared to 25% for impairment of activities of daily living, 17% for symptoms, and 12.5% for functional performance probability. Single functional performance measures of range of motion, velocity, and acceleration had recovery rates of 59, 13, and 10%, respectively. It appears that all these criteria are measuring very different parameters of low back pain recovery. The residual loss in functional performance may indicate a decreased tolerance to physical demand providing potential insight for why recurrent low back pain rates are high.

KEY WORDS: outcome; return to work; low back pain; functional impairment.

INTRODUCTION

Low back pain recurrence rates have been reported as high as 70%; however, these rates vary greatly depending on the definition of recurrence (1–6). The high rate of recurrent low back pain as well as variability suggests that we do not have good understanding of low back pain recovery. Examining the various outcome measures that have been used in the past and developing our understanding of the relationship among them may provide insight as to why recurrence rates are so high.

Return to work is one of the most common measures of low back pain recovery (7–29). The decision for an injured worker to return to work is based on the subjective impression of the physician and may be influenced by the patient (worker). Thus, return to work is a subjective outcome measure. Pain symptoms are another commonly used outcome

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measure of low back pain recovery (9,26,30–40). Pain symptoms are also a subjective outcome measure because it is based on the patient's impression of the pain. Disability questionnaires, which measure subjective impairment of daily activity due to back pain, have also been used as outcome measures for those suffering from low back pain (29,30,41–45). Many of the studies mentioned earlier examined only one outcome measure, which suggests that low back pain recovery is a single event. It is hypothesized that quantifying recovery with multiple outcome measures will show discrepancies among the outcome measures and potentially allow us to view recovery as a process with several events as oppose to just one event.

Direct measurements of low back function such as range of motion (46) and strength have also been used as outcome measures. Range of motion and strength have both been shown to improve with exercise training programs (22,47–56). Functional improvement with treatment is important; however, the issue becomes how much functional improvement is necessary to be considered recovered and return to work without recurrent episodes of low back pain. Furthermore, we must be able to distinguish between impaired and non-impaired performance. Dynamic functional performance measures of velocity and acceleration distinguish between low back pain patients and asymptomatic groups more effectively than traditional range of motion (57). Marras *et al*. (57) using discriminant function found that the combination of range of motion, velocity, and acceleration distinguished best between low back disorder patients and asymptomatic controls with a sensitivity of 86% and specificity of 94% (57). Understanding how functional performance measures relate to one another as well as to disability questionnaires, pain and work status may enhance our knowledge of low back pain recovery and reduce the rate of recurrence.

The length of disability influences the likelihood of return to work (58–60). Thus, some workers may return to work before they are physically recovered from an injury. However, early return to work may increase the risk of recurrence (61). Secondary or recurrent low back injuries are more costly than initial injuries (62). Thus, a balance between early return to work and functional performance recovery to minimizing the risk of recurrence may reduce the overall cost due to low back pain. Examining differences in outcome between functional performance recovery and return to work may provide insight for determining the balance between functional performance recovery and return to work.

Examining multiple all outcome measures may provide a greater understanding of low back pain recovery, which in turn may lead to insight for reducing recurrence rates. Therefore, the primary goal of this study was to examine four major outcome measures (return to work, symptoms, self-reported impairment of activities of daily living and functional performance probability). The secondary goal was to compare the traditional functional impairment outcome measure of low back range of motion with new dynamic measures of low back velocity and acceleration.

METHODS

Approach

A cross-sectional study was designed to evaluate workers returning to work after an episode of work related low back pain. Outcome measures of return to work, symptoms, impairment of activity of daily living, and functional performance probability were observed.

Functional performance measures were further examined to compare traditional range of motion outcome to velocity and acceleration outcome. Quantifying the relationship among outcome measures may provide insight to a better understanding of recovery and lead to a reduction in recurrence rates.

Industry Participation

Over 40 manufacturing facilities in the Midwest United States participated in the study. These manufacturing facilities included automobile and truck assembly, automotive parts assembly, food processing, rubber manufacturing, printing, glass production, and metal processing. A company representative examined the medical records and OSHA logs for low back pain cases. The company representative approached the worker about participating in the study. In union facilities, a union representative contacted workers regarding participation in the study. If a worker agreed to participate, then a time was scheduled for the research team to visit the plant.

Subjects

Two hundred and eight workers that reported to medical or first aid with low back pain within the past 3 months participated in the study. The inclusion criteria consisted of 1) worker returned to work either full duty or light duty, 2) the worker sought medical care for work related low back pain at the plant medical department or medical provider within the past 3 months, 3) the worker had time away from their regular duty job due to low back pain. Workers were excluded from the study if their injury complaint referred to more than one injury site. Table I lists the anthropometric data from the workers. The average number of lost days for this episode of back pain was 12.7, the median number was 1 lost day and the standard deviation was 43.4.

Equipment

The lumbar motion monitor (LMM) was used to evaluate trunk kinematics (63). The LMM measures position, velocity, and acceleration in all three planes of the body and has

Table I. Anthropometric Data from Participants

Anthropometric measure	Mean	Standard deviation
Age (years)	41.8	10.3
Weight (kg)	84.6	19.4
Standing height (cm)	174.4	8.1
Shoulder height (cm)	145.0	7.3
Elbow height (cm)	109.1	5.6
Upper leg length (cm)	40.4	4.4
Lower leg length (cm)	50.5	4.2
Upper arm length (cm)	36.3	2.6
Lower arm length (cm)	47.3	3.2
Trunk length (cm)	52.3	5.1
Trunk breadth (cm)	32.6	3.6
Trunk depth (cm)	26.4	5.0
Trunk circumference (cm)	95.9	17.7
Percentage of males	72	

been previously validated (63). The monitor is placed on a person with orthoplast. The LMM was used to measure functional performance impairment during sagittal flexion and extension while controlling the twisting posture (57,64,65). A laptop computer was used to display feedback to the subject in order to perform the control tasks as well as store data.

Questionnaires

The McGill pain questionnaire (MPQ) (66) was used to measure pain symptoms. The Million Visual Analog Scales (MVAS) (67,68) was used to measure impairment of activities of daily living. The SF-36 was used to collect measures of physical and mental functioning (69).

Experimental Design

A cross-sectional study was designed to observe multiple outcome measures in workers with an episode of low back pain within in the past 3 months.

Major Outcome Measures

The outcome measures observed were return to work, symptoms, impairment of activities of daily living, functional performance probability. Return to work was either light duty or full duty. The pain symptoms were measured with the MPQ present pain intensity score. Impairment of activities of daily living was measured with the MVAS. The major functional performance outcome measure was the functional performance probability measured using the LMM full protocol (57,64,65).

Secondary Outcome Measures

The secondary outcome measures were all functional performance measures. The traditional range of motion outcome measure as well as dynamic measures of low back functional velocity and acceleration were examined.

Descriptive Measures

The SF-36 was used as a descriptive measure to indicate the initial level of the overall health. In addition, anthropometric measures were used to describe the population.

Procedure

The research study was explained to the worker by the research team and the worker signed a University Human subjects consent form. The MPQ, MVAS, and SF-36 questionnaires were completed. The LMM was placed on the worker for functional assessment. The functional performance protocol required the participant to control their twisting position

as they flexed and extended their trunk as fast as they could comfortably (57,64,65). The controlled twisting positions were 0, 15, and 30° clockwise and counterclockwise. The zero control task was completed first followed by two 15° controls tasks and the 30° control tasks. Workers completed as many tasks as possible. The worker was given a T-shirt for participating in the study.

Data Analysis

Functional Performance

Kinematic measures from the LMM were calculated with validated techniques (63). The output included range of motion, flexion velocity, extension velocity, flexion acceleration and extension acceleration. The data were normalized by age and gender and entered into an existing model, which distinguished between asymptomatic subjects and low back pain patients (57). The model generates a probability of functional performance being in the asymptomatic group (i.e., functional performance recovery). The model has a sensitivity of 86% and a specificity of 94% indicating accurate classification of patients and asymptomatic subjects (57).

Questionnaire Scoring

The present pain intensity measure was scored according to Melzack (66). The MVAS was scored by summing all 15 questions (68). The SF-36 scores are reported in transformed percentage format (69).

Outcome Measure Recovery Criteria

Decision criteria for each recovery measure were developed. Return to work full duty based on company records was the recovery criteria for work status. The symptom recovery measure was no pain on the present pain intensity scale of the MPQ. An MVAS score of less than 30 was used to indicate recovery. A score of 30 would indicate that, on average, each question had a score of 2 or less. A functional performance probability of 0.5 or greater designated functional performance recovery. These criteria values have been previously defined by Ferguson *et al*. (70). In addition to the four major outcome measures, secondary functional performance measures (range of motion, velocity, and acceleration) were also examined. The secondary outcome recovery criteria for range of motion, velocity, and acceleration was 1 standard deviation below the mean for the workers age and gender category from the Marras *et al*. (57) database.

Statistical Analysis

Descriptive statistics were completed on the outcome measures. Frequency analysis was performed to quantify the percentage of the sample recovered for each outcome measure. The κ coefficients were used to quantify the association between each pair of

Table II. Outcome Measures and Questionnaire Results

Measures	Mean	Standard deviation
Outcome measure		
Work status	0.99	0.10
Pain	1.5	1.0
MVAS	50.4	27.4
Functional performance probability	0.20	0.25
Range of motion	0.79	0.34
Velocity	0.45	0.22
Acceleration	0.40	0.26
SF-36		
Physical function	68%	24%
Role physical	53%	42%
Bodily pain	51%	21%
General health	68%	25%
Vitality	51%	22%
Social functioning	76%	25%
Role emotional	73%	37%
Mental health	80%	14%

outcome measures. The κ coefficient is appropriate for measuring the association between categorical variables (71).

RESULTS

Table II lists the means and standard deviations for the outcome measures. Figure 1 illustrates the percentage of subjects recovered for each major outcome measure. Based on full duty return to work criteria, 99% of the workers were recovered. Twenty-five percent of workers were recovered based on activities of daily living (MVAS). Figure 1 also illustrates that 17% of the population was recovered based on symptoms and only 12.5% were recovered based on functional performance probability (FPP). The functional performance probability score combines range of motion, velocity, and acceleration into one score. Traditionally, range of motion has been used as a functional performance outcome measure. Therefore, we examined each functional performance measure separately. The percentage of subjects recovered based on range of motion was 59%, velocity was 13%, and acceleration at 10%, as illustrated in Fig. 2.

Table III lists the κ coefficient and 95% confidence interval indicating the degree of association between outcome measures. The confidence interval crossing zero indicates no significant association between the two outcome measures. None of the outcome measures were significantly associated with work status. The table indicates that four combinations of outcome measures were significantly associated. The combinations of outcome measures that were significantly associated included 1) pain and MVAS questionnaires, 2) functional performance probability and acceleration, 3) velocity and acceleration, 4) range of motion and velocity. Fleiss *et al*. (71) have interpreted κ coefficients above 0.75 to indicate excellent agreement beyond chance, 0.4–0.75 represent fair agreement beyond chance and below 0.4 indicate poor agreement beyond chance. The κ coefficients in Table III indicate the association between functional performance probability and acceleration as well as range of motion and velocity was statistically significant but poor (71). The κ coefficients indicate

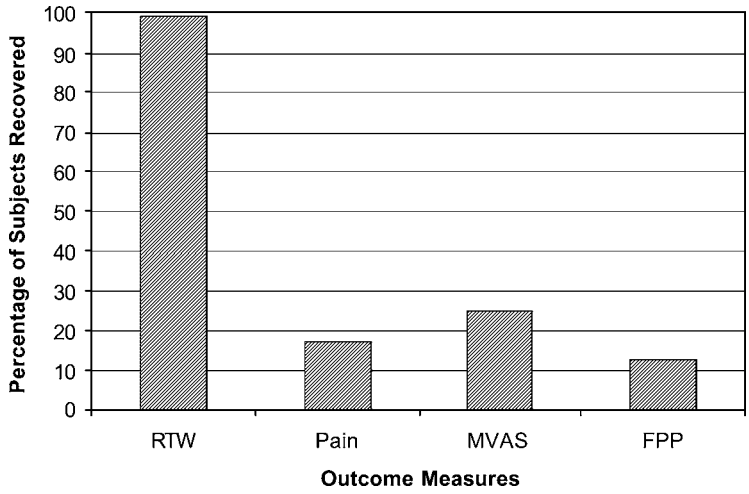

Fig. 1. Percentage of subjects recovered as a function of outcome measures. RTW: return to work, MVAS: Million Visual Analog Score, FPP: functional performance probability.

a stronger yet modest degree of association between velocity and acceleration as well as MPQ and MVAS.

The SF-36 general health survey results are reported in transformed percentage format in Table II. The percentage scores were all over 50%. The highest score was for mental health at 80%. Overall, the general health survey shows that the subjects in the study were in good health.

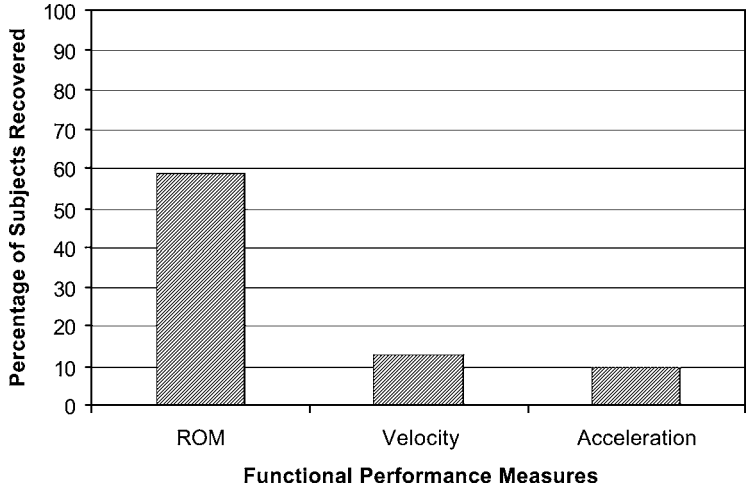

Fig. 2. Percentage of subjects recovered for each functional performance outcome measure. ROM: range of motion.

Table III. The κ Coefficients with Confidence Intervals

Outcome measures	κ	95% lower and upper confidence interval	
Return to work and functional performance probability	0.0028	−0.0012	0.0067
Return to work and pain	0.0041	−0.0017	0.0098
Return to work and MVAS	0.0065	−0.0026	0.0155
Return to work and ROM	−0.0192	−0.0455	0.0072
Return to work and velocity	0.0029	−0.0013	0.0070
Return to work and acceleration	0.0023	−0.0010	0.0056
Functional performance probability and pain	0.0943	−0.0588	0.2474
Functional performance probability and MVAS	0.0769	−0.0589	0.2127
Functional performance probability and range of motion	−0.0553	−0.1367	0.0261
Functional performance probability and velocity	0.1135	−0.0507	0.2778
Functional performance probability and acceleration	0.2471*	0.0610	0.4331
Pain and MVAS	0.4286*	0.2830	0.5741
Pain and range of motion	−0.0365	−0.1290	0.0560
Pain and velocity	−0.0624	−0.1770	0.0523
Pain and acceleration	0.0076	−0.1252	0.1404
Range of motion and velocity	0.1733*	0.1020	0.2445
Range of motion and acceleration	0.0524	−0.0168	0.1217
Velocity and acceleration	0.5149*	0.3343	0.6955

*Indicates a significant association between outcome measures.

DISCUSSION

The results indicate that workers were returning to full duty jobs when pain symptoms, functional performance, and activities of daily living were still indicating impairment. Return to work underestimated disability in comparison to the other three outcome measures. These results corroborate the findings of Baldwin *et al*. (2) who found that return to work was not an indicator of complete recovery from a disabling injury. In fact, Baldwin *et al*. (2) found that socioeconomic characteristics, job characteristics, and economic incentive influenced work status and that 61% of workers had subsequent work disability after first returning to work. In the 1990s, Bureau of Labor Statistics indicated that the number workers with musculoskeletal disorders (MSDS) that continue to work on restricted duty has been increasing, whereas the number of workers with lost days due to MSDS has been decreasing (72). These statistics suggest that the number of workers continuing to work with pain and impairment of function has been increasing in the past decade. Furthermore, Dionne *et al*. (9) has also shown low correlation between pain, functional limitation, and work status. Considering an individual recovered based on work status alone may lead to an erroneous evaluation of the individual's low back recovery status. The lack of recovery based on symptoms, activities of daily living, and functional performance when returning to work full duty may suggest that workers have had an exacerbation of their existing injury as oppose to a recurrence. Complete or true recovery may occur only when multiple outcome measures (return to work, symptoms, functional performance, etc.) all indicate recovery.

The largest difference among the four major outcome measures was between work status at 99% recovered and functional performance probability with only 12.5% of the workers recovered. As one may expect, there was not a significant association between the two measures based on the κ coefficient. The lack of association is a very insightful finding for potential explanation of the risk of recurrent injury. The impaired level of functional performance may indicate a reduced tolerance level to physical loading on the spine,

which in turn may increase the risk of recurrent low back injury. In addition, Marras *et al*. (73) have shown that those with impaired low back functional performance probability have increased muscle co-activity, which results in increased loading on the spine. The workers that return to work with impaired functional performance probability may have increased muscle co-activity, which in turn would increase spine loading. The combination of decreased spine tolerance and increased spine loading due to muscle co-activity may provide a biomechanical explanation for the high rates of recurrent low back pain and needs to be investigated in prospective studies.

The traditional functional performance measure of range of motion had the highest percentage of recovered workers among the functional performance outcome measures. This finding is interesting because the American Medical Association guidelines have recommended range of motion for evaluating permanent impairment for decades (46). The physicians making the decision on returning workers to full duty would have been trained using these AMA guidelines. In addition, therapeutic exercise programs for the back often involve stretching exercises, which may enhance range of motion (74). In our case, the few workers who were returned to light duty were actually recovered based on range of motion, whereas 40% of workers who were working full duty were not recovered based on range of motion, which resulted in the lack of association between return to work and range of motion outcome measure. Range of motion has been shown not to be a good indicator of functional performance recovery (57,75). Range of motion has been used for decades as a criterion of impairment determinations and return to work decisions even though it is not a good indicator of recovery. This may provide one explanation for the high rate of recurrent low back pain.

Research has shown a functional performance recovery pattern where range of motion recovered first, followed by recovery of velocity and then finally acceleration (57,75). In the current cross-sectional study, functional performance measures show that 59% of the population was recovered based on range of motion, 13% for velocity and 11% for acceleration. Thus, at this cross-section in time a greater percentage of the population was recovered based on range of motion than velocity or acceleration. These results set up the possibility of the sequence of range of motion recovering first followed by velocity and then acceleration as found previously. Further longitudinal studies on this population would be necessary to confirm this sequence of events.

Psychological recovery is another component of the low back pain recovery process, which has been studied using fear avoidance beliefs (76,77,78). Fear of movement/reinjury has been shown to influence physical performance in those with low back pain (76,77,78). The functional performance recovery sequence of range of motion, followed by velocity and acceleration may suggest a process of recovery from both a physical and cognitive perspective. It is hypothesized that recovery of acceleration is indicative of psychological recovery from the standpoint that the worker is not hesitating when moving due to fear of recurrent low back pain. Furthermore, it is theorized that return to work or return to full duty based on dynamic functional performance recovery measures may reduce the risk of recurrent low back pain. Further research would be necessary to confirm these hypotheses.

Gallagher *et al*. (12) have found that the length of disability influences lost time. The longer the worker is off work the less likely return to work becomes (58,59,60). Thus, a balance must be struck between sending workers back to work and improving symptoms, functional performance and impairment of activities of daily living to minimize risk of recurrent injury. One possible solution is not to consider return to work as the major end

point for treatment and have workers return to work but still remain in treatment to enhance recovery of pain symptoms as well as other outcome measures. While this maybe an optimal approach to follow many times such a rehabilitation plan is not supported by insurance carriers because return to work has occurred. Based on the present results and others (9,24,61) indicating the important outcome measures in low back pain are not correlated this long-term approach should certainly be carefully evaluated by insurance and workers compensation carriers. Furthermore, the approach to accommodate work that considers a workers' return to light duty jobs depending on the availability of these job or restricting the length of the workday especially overtime may be other approaches to minimize the risk of recurrence.

The difference among the four major outcome measures points to the importance of evaluating multiple outcome measures when determining disability recovery. Pransky *et al*. (61) have shown that occupationally related low back pain influenced not only lost time but also physical function. While work status may be the easiest to measure and of most interest from an economic impact perspective, it appears to underestimate the magnitude of the disability in comparison to all other outcome measures used in this study. Recovery based on symptoms, functional performance and impairment of activities of daily living present an extremely different perspective of the disability status of this population. It is hypothesized that residual functional performance impairment leads to reduced tolerance to physical demands and higher risk of recurrence.

Limitations

There were several limitations to this study. First, the study was cross-sectional in nature. Second, we do not have information on those who were approached to participate but declined. Third, the type of treatment or intervention was not controlled. Finally, the amount of time between onset and actual participation in the study was not controlled nor was the diagnosis of a specific low back disorder.

CONCLUSION

Return to work was not correlated with any other outcome measure in the study. Workers in the study were returned to work full duty jobs with impaired physical function, impaired daily activities, and pain symptoms. The four major outcome measures used in this study assessed very different characteristics of low back pain recovery suggesting that quantifying low back pain recovery with a single outcome measure is inadequate.

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