# Investigating Individual and Occupational Factors and their Interactions on Low Back Pain Severity in Workers

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Low back pain (LBP) is the most prevalent work-related musculoskeletal disorder. Current ergonomic prevention strategies focus on reducing the effect of occupational risk factors. However, other underlying mechanisms may exist since not all workers performing the same task develop an injury. In this study, 36 LBP patients with a previous MRI scan were recruited to investigate the effects of individual and occupational factors and their interactions on LBP severity. Individual and occupational factors information was obtained through questionnaires. LBP severity ratings were obtained through a self-reported Visual Analog Scale (VAS) and the Oswestry Disability Index (ODI) questionnaire and served as the dependent variables. Stepwise linear regression analysis was performed on the variables. For ODI, a model consisting of interaction effects between individual and occupational risk factors with an adjusted $R^2$ value of 0.84 was obtained. These preliminary results may help to develop models to predict and, hence, prevent chronic LBP.

## INTRODUCTION

Low Back Pain (LBP) is the most prevalent work-related musculoskeletal disorder (WMSD) and has attracted a lot of research in order to identify developmental risk factors and effective interventions. In 2009, about 242,000 cases of LBP requiring days away from work were reported (BLS, 2010). WMSDs develop gradually, are difficult to control in the later stages and recur making them hard to diagnose and treat. Therefore, identification of risk potential at an early stage is required to mitigate chronicity and disability in workers.

Low back pain is described as pain in the lumbosacral region of the spine (Garg & Moore, 1992). Another term that is used for back pain in the industry is 'back injury' and implies that work-related factors are the major cause of LBP. However, the amount of heavy lifting in the workplace has declined in recent years though frequency of LBP reporting has not (Videman & Battie, 1999). Therefore, the onset of LBP could be due to other factors, such as individual factors, that compound existing workplace factors. Further, studies on the transition of low back pain from an acute to chronic state have identified several individual and psychosocial risk factors (Fransen et al, 2002). Early identification of individuals at risk could help in preventing this transition and can help prevent risks from persistent pain and disability (Shaw et al, 2005). Current ergonomic prevention strategies focus on reducing the effect of occupational risk factors. However, it is believed that other underlying causal mechanisms may exist since not all workers performing the same task develop an injury.

Research has identified three general classifications of risk factors for low back WMSDs: individual (associated with the person predisposing them to the condition—e.g., age, gender, genetics, etc.), psychosocial (associated with organizational work practices—e.g., overtime, stress, etc.) and occupational (associated with the work task—e.g., posture, force, etc.) (Table 1). Besides the occupational factors involving force, posture, lifting, bending, twisting etc.; individual factors such age, gender, physical fitness, obesity (weight/BMI), smoking, alcohol consumption, and family history of LBP have been identified as being associated with LBP (Garg & Moore, 1992; van Tulder, Koes, & Bombardier, 2002). However, research findings for several individual risk factors are mixed. Most research on these factors were done assuming that the factors can explain the causality of low back pain by itself. However, these factors are not mutually exclusive and interaction effects also need to be studied to fully explain the incidence of low back pain (Marras, 2005).

Table 1: Potential risk factors for LBP

| Classification | Risk Factors | | | |
|---|---|---|---|---|
| Personal | Age | Gender | BMI | Family history |
| | Genetics | Smoking | Alcohol | Physical activity |
| Psychosocial | Perceived stress | Job stress | Job satisfaction | Social relations |
| | Decision latitude | Job security | Job demands | Organizational level |
| Occupational | Physical load | Force | Repetition | Vibration |

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| | | | |
|---|---|---|---|
| Bending | Twisting | Lifting | Posture |

It is hypothesized that individual and occupational factors interact to significantly affect LBP severity ratings. Understanding how individual factors may have contributed to LBP is critical in mitigating LBP and its severity. Therefore, the objective of this study was to study and identify individual and occupational factors, and their interactions that contribute to LBP severity in a patient population.

## METHODS

This paper describes methods and results taken from a larger study. Only those aspects of the larger study directly relevant to the current paper are described.

### Participants

Thirty six participants were recruited for the study (Table 2). These were LBP patients who previously had an MRI scan of their low back. Eligibility criteria required that participants were above the age of 18 years, currently in or were in jobs involving manual labor, currently suffer from low back pain and who had a previous lumbar MRI scan taken. Both males and females were eligible. Participants were compensated $50 for completing the study protocols.

### Independent Variables

The independent variables included individual and occupational factors information obtained from the participants.

*Individual Factors.* Age, gender, Body Mass Index (BMI), family history of LBP, physical activity level, alcohol consumption and smoking habits were obtained using a custom demographic questionnaire. BMI was calculated from the height and weight measurements taken using the equation: BMI = weight (kgs) / height $(m)^2$. Family history of LBP was denoted with a 'yes' or a 'no'. Physical activity level, smoking and alcohol consumption were categorized using generally accepted category levels. Actual levels were combined to obtain 2 levels for each variable to be used in data analysis due to homogeneity of the data (Table 3).

Table 2: Descriptive statistics of personal factors. Values are Mean (SD).

| Factor | Level | N | ODI | VAS |
|---|---|---|---|---|
| Age | 18 to 49 years | 15 | 46.40 (16.15) | 8.41 (1.30) |
| | 50 to 65 years | 15 | 48.27 (17.56) | 7.77 (1.79) |
| | Above 65 years | 6 | 48.33 (14.66) | 7.83 (1.99) |
| Gender | M | 18 | 45.78 (16.78) | 7.97 (1.73) |
| | F | 18 | 49.22 (15.69) | 8.13 (1.55) |
| BMI | Ideal (Below 25) | 2 | 47.00 (12.73) | 8.07 (0.50) |
| | Overweight (25 to 30) | 17 | 48.00 ( 19.04) | 7.80 (1.90) |
| | Obese (Above 30) | 17 | 47.06 (13.93) | 8.30 (1.40) |
| Family History | Yes | 23 | 49.39 (14.06) | 8.01 (1.54) |
| | No | 13 | 44.15 (19.36) | 8.13 (1.81) |
| Physical Activity | No to Low | 25 | 47.12 (15.66) | 7.80 (1.68) |
| | Moderate to High | 11 | 48.36 (17.82) | 8.63 (1.38) |
| Smoking | No to light | 24 | 44.25 (13.68) | 8.11 (1.57) |
| | Moderate to Heavy | 12 | 54.00 (19.09) | 7.94 (1.77) |
| Alcohol | No to light | 27 | 45.85 (16.45) | 8.13 (1.56) |
| | Moderate to Heavy | 9 | 52.44 (14.76) | 7.82 (1.87) |

*Occupational Factors.* Scores from a risk factor assessment section obtained from the demographic questionnaire (for repetition, force, vibration and posture) were collected. Categories and scoring guidelines from RULA (McAtamney & Nigel Corlett, 1993) were used to design the section for force and posture. Repetition and vibration was indicated with a 'yes' or 'no'.

### Dependent Variables

The dependent variables included the self-reported LBP severity ratings: the Oswestry Disability Index (ODI) low back pain scale and a VAS (visual analog scale) pain scale. The ODI is a 10 item questionnaire with a 6-point ordinal scale that is used to assess back pain (Grotle et al., 2004) and was completed by the participant. A total score of 50 is possible and the final score obtained was expressed as a percentage value by dividing it by 50 and multiplying by 100. A 10 cm visual analog scale having anchors at 'No pain' and 'Worst imaginable' was used as the pain scale and the value was recorded in mm.

Table 3: Levels used to categorize physical activity, smoking and alcohol consumption

| **Physical Activity Levels** | | **Smoking Levels** | | **Alcohol Consumption Levels** | |
|---|---|---|---|---|---|
| *Actual* | *Combined* | *Actual* | *Combined* | *Actual* | *Combined* |
| < 3 times a week (short workouts) | No to Low | None | No to light | Abstain | No to light |
| < 3 times a week (long | | < 5 a day | | Light – 3/week | |

| | | | | | |
|---|---|---|---|---|---|
| workouts) | | | | | |
| 3 to 5 times a week (short workouts) | | 5 - 10 a day | | Moderate – 4 to 14/week | Moderate to Heavy |
| 3 to 5 times a week (long workouts) | | 10 - 15 a day | | Heavy – >14/week | |
| > 5 times a week (short workouts) | Moderate to High | > 15 a day | Moderate to Heavy | | |
| > 5 times a week (long workouts) | | | | | |

## Procedures

Participants were recruited through a local physician. Patients suffering from low back pain were provided with the PI's contact information. Upon contacting the researcher, if eligibility criteria were met, participants were asked to meet the researcher at the Student Health Center on Mississippi State University's campus. Formal informed consent documents were completed. Participants were then asked to complete a short questionnaire for basic information (e.g., age, gender, race, height, weight, individual habits etc.), the risk assessment section, and the ODI and the VAS pain severity scale.

## Data Analysis

Stepwise linear regression analysis was performed on the variables to investigate effects of the individual factors (age, gender, BMI, family history of LBP, alcohol consumption, smoking habits and physical activity level), occupational factors (force, posture, repetition and vibration), and all two-way interactions on the LBP severity measures, ODI and VAS. Prior to analysis, diagnostic tests were conducted to check if any of the assumptions for linear regression were violated. Scatter plots of each of the independent variable vs. the dependent variable as well as residual plots were generated. No patterns were observed for the variables. Normality assumptions were verified by normal quantile plots. All analysis was done using the Statistical Analysis Software (SAS) 9.2 and JMP 7 software from SAS and an alpha level of 0.1 was used to determine significance. A 0.1 alpha level was used due to the exploratory nature of the study and the small sample size.

# RESULTS

A linear model with an $R^2$ value of 0.91 and adjusted $R^2$ of 0.84 was obtained for ODI (Table 4). For VAS, a model with only repetition included was obtained with an $R^2$ of 0.13 and adjusted $R^2$ of 0.10.

Table 4: Stepwise linear regression results. Values are p-values

| Variable | ODI | Coefficients |
|---|---|---|
| BMI | 0.0010 | -0.50 |
| Family History | 0.0213 | -0.75 |
| Physical Activity | 0.0005 | 2.28 |
| Alcohol Consumption | 0.0008 | -4.12 |
| Smoking | <0.0001 | -7.35 |
| Posture | <0.0001 | 1.22 |
| Repetition | 0.0001 | 0.76 |
| Vibration | 0.0046 | -1.40 |
| BMI X Posture | 0.0003 | 0.76 |
| History X Phys. Activity | 0.0064 | 4.67 |
| Phys. Activity X Posture | 0.0004 | 4.38 |
| Phys. Activity X Repetition | 0.0074 | 7.04 |
| Alcohol X Smoking | 0.0325 | -4.07 |
| Alcohol X Vibration | 0.0169 | -4.82 |
| Smoking X Repetition | <0.0001 | -8.33 |

Individual factors such as BMI, family history of LBP, alcohol consumption, smoking and physical activity were found to be significant predictors of ODI scores. Occupational factors such as posture, repetition and vibration were also included in the model. Interaction effects of BMI and posture, physical activity and posture, vibration and alcohol consumption, smoking and repetition, alcohol and smoking, family history of LBP and physical activity, and physical activity and repetition were also found (Table 4).

# DISCUSSION

Individual factors in addition to occupational factors may influence LBP severity ratings as seen in this study. A previous study conducted on health care workers found that individual factors alone explained 12% of the risk of first-time LBP (Adams, Mannion, & Dolan, 1999). Here it was observed that 4 individual factors were predictors of ODI. One of these was family history of LBP which also interacted with physical activity levels, indicating that LBP may be hereditary to some degree.

Obesity has been studied as a possible risk factor for LBP and BMI was a factor included in the severity model in this study. Higher mechanical stresses and abnormal loads on the spine due to the additional weight, loss of endurance, and reduced healing due to inability of blood flow and vital nutrients to reach injured areas because of the presence of fatty tissue are some reasons of how obesity may lead to LBP (Orvieto et al., 1994; Manchikanti, 2000).

Smoking and alcohol consumption as well as few interaction effects of these were found to be significant predictor variables. Several mechanisms by which smoking affects LBP are suggested. A study noted breathing ability differences while handing loads may contribute to LBP as the muscles used for breathing are also used to maintain the spine. Therefore, smokers and others whose lung elasticity has been weakened may be at risk of LBP (McGill, Sharratt, & Seguin, 1995). Alcohol consumption may contribute to LBP by inducing uncoordinated movements altering biomechanical loads on the spinal structures. Further, alcohol consumption has been associated with psychosocial problems which are thought to contribute to LBP and chronicity.

The association of physical activity to LBP is not well understood. Several studies have reported a higher incidence of LBP and disc herniation in populations that exercised regularly, but others reported the opposite results (Manchikanti, 2000). Extreme sports, on the other hand were associated with greater disc degeneration (Videman, et al., 1995). Physical activity by itself and through interactions was found to significantly affect severity of LBP in this study indicating that physical activity may be an important factor to consider in LBP studies.

Posture and repetition significantly affected LBP severity levels in this study. Frequent bending and twisting in jobs has been thought to be a cause of back injuries. Lifting in addition to bending and twisting, and when done repetitively was found to be even more harmful. It was observed that the incidence of LBP in workers who performed heavy manual lifting was 8 times greater than workers with sedentary jobs (Manchikanti, 2000). An explanation for how bending can be harmful is that while bending, muscles are no longer active and only the soft tissues play a role. These types of tasks generate loads on the spine that exceed failure loads. In the aged workers, this further enhances their risk of injury (Pope, et al., 2002). In addition to trunk postures, it was found that jobs that required sitting for prolonged periods were also at an increased risk of LBP. Studies also reported that people who had jobs that required them to drive for more than half their work day had an increased risk of disc herniation due to combined effects of sitting and vibration (Manchikanti, 2000).

Vibration as well as interaction effects of vibration were found to be significant. A study demonstrated that automobile driving was more frequent in those with LBP than those without, further suggesting the possible link between whole body vibration and LBP (Frymoyer, et al., 1983). Recent studies have also shown that vibration has an additive effect with genetic risk factors (Virtanen, et al., 2007).

The two severity measures used in this study, VAS and ODI, measure different things. The VAS ratings represent the worst pain felt by the participant at any point in their low back whereas the ODI represents severity based on the participant's disability to do different activities. The factors being investigated in this study may be useful in predicting interference in daily activity, rather than worst pain felt. . However, certain trends in VAS severity was observed and it is also possible that the factors studied here may affect VAS ratings but were not found to be significant in the model for various reasons, one being the small sample size.

Previous models developed for other MSDs such as Carpal Tunnel Syndrome (CTS) found that interactions among different factors contributed to the disorder. It was also found that a mixed model including interaction terms was more accurate and had better predictive ability than the models with only personal or occupational risk factors (Babski-Reeves & Crumpton-Young, 2003a, 2003b).

A limitation of this study is the sample size. The results may not have the accuracy that is required to generalize the results due to the limited sample size. However, the information obtained from this study will be beneficial for future studies. Further, the occupational factors were obtained through a questionnaire reported by the participants and not through any objective methods of data collection since the population being studied was a patient population with LBP and it was not possible to subject them to tasks to study the effect of the occupational factors on them. Therefore, the data obtained was purely subjective.

This study investigated interactions between individual and occupational risk factors that could possibly be used as variables in a model to predict LBP severity. Models incorporating different risk factors were developed previously. However, most models developed were logistic regression models that predict whether a person will or will not be a sufferer of LBP, but do not predict the severity level of LBP (Marras, Ferguson, Burr, Schabo, & Maronitis, 2007). In the present situation where a large percentage of the population report LBP, prediction of severity levels may be beneficial.

## ACKNOWLEDGEMENTS

This research is funded by the Deep South Center for Occupational Safety and Health that is supported by Grant # 2T42OH008436-03 from NIOSH. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

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