B. Collections of Information Employing Statistical Methods

1. Respondent Universe and Sampling Method

Data will be collected from 320 employees at cooperating underground and surface mines. Efforts will be made to obtain data from a variety of mining environments, including low-seam coal mines, high-seam coal mines and surface mining operations to evaluate the differences in postural demands and exposure to other risk factors in these varied environments. The population examined in this initial pilot study is expected to be a Midwestern industrial sand mine, and will consist of approximately predominantly (perhaps exclusively) male miners, due to the high preponderance of males in the mining industry (approximately 98%). Additional cooperating sites, are being sought during this phase of tool development. Based on the results of the initial study, the goal will be to develop criteria which will help identify workers at risk of low back disorders based on scores obtained on the tool.

Questions to be included in the draft tool are individual factors, occupational posture stresses (including environmental restrictions), lifting and lowering exertions, moment associated with most difficult lift, whole-body vibration exposure and psychosocial factors. The following sections briefly describe some of the questions to be used to ascertain this information, and the rationale for inclusion of certain items.

Individual Factors

Items on occupation, length in current job and with current employer and shift length are obtained in an effort to gain an estimate of cumulative exposure to stresses. Gender and age data are collected to estimate compressive strength of spines according to Jager and Luttmann (1991). Body mass index (BMI) will be calculated from height and weight data and will be assessed as a risk factor related to obesity (Deyo and Bass, 1989). Smoking history is known to be associated with development of low back disorders, with some authors showing a dose-response relationship (Deyo and Bass, 1989; Leigh and Sheetz, 1989). Thus, number of cigarettes smoked per day will be obtained.

Postural Stresses

A great deal of attention will be paid to postural stresses, which are quite prevalent in mining. Environmental restrictions are evaluated with a question on seam height. Research has shown that the mid-range of mine seam heights (48”-60”, where stooping predominates), is associated with increased low back disorder rates than are lower of higher seams (Gallagher, 2005). The worker will be asked to estimate the percentage of time spent in standing, sitting, forward bent, kneeling and squatting postures to determine, albeit grossly, the postural stresses encountered in a typical work shift. One item asked is to evaluate the degree to which the worker is free to change posture as opposed to having to maintain posture. A question is included on the amount of flexion during the first hour on the job, as early morning flexion has been implicated as potentially riskier than flexion later in the day (Snook et al. 2002).

Lifting Stresses

Several items are included to evaluate the lifting demands experienced by the worker. The first two items are an effort to get at the weekly and daily lifting requirements of the job. The lifting of specific weights (25 and 50 pounds) have been found to be significantly associated with low back experience in several epidemiology studies (Kelsey et al., 1984; Walsh et al. 1989). Questions about lifting items below knee height are asked in an attempt to evaluate the amount of lifting done in torso flexion. Recent studies have indicated that fatigue failure of the spine is much more rapid with increased torso flexion (Gallagher 2005). A question on lowering items to knee height or below is included as this eccentric activity of the back musculature may be associated with increased risk of muscle strain (Armstrong, 1990). The employee is also asked to simulate the most stressful lifting job he has to do. This exercise is done to get an estimate of the maximum load moment experienced on the job. The load moment appears to have a high association with those who experience low back disorders (Marras et al. 1999)

Exposure to Whole-Body Vibration

Exposure to whole-body vibration (WBV) is common in mining and represents another important risk factor for low back pain (Magnusson et al. 1996, Walsh et al. 1989). Several epidemiologic studies have suggested dose-response relationships in terms of the duration and intensity of exposure and low back complaints. Daily exposures of over 4 hours are associated with increased risk in several studies (Bernard et al. 1997). Questions to capture exposure to WBV include those on duration of exposure, intensity (using road conditions as the metric), and quality of the seat in the worker’s typical equipment or vehicle.

Psychosocial variables

Psychosocial issues have emerged as an important issue in the discussion of musculoskeletal disorders (Davis and Heaney, 2000). Multiple studies have found that psychosocial variables are important in explaining the incidence of low back complaints. Factors such as job satisfaction, job stress, and time pressures on the job appear to be important considerations when examining low back disorders. Several questions are included in the proposed tool to address psychosocial issues, which can be significant concerns in many mining workplaces.

Covariance Structure Model

A path diagram for the hypothesized covariance structure model is presented below.

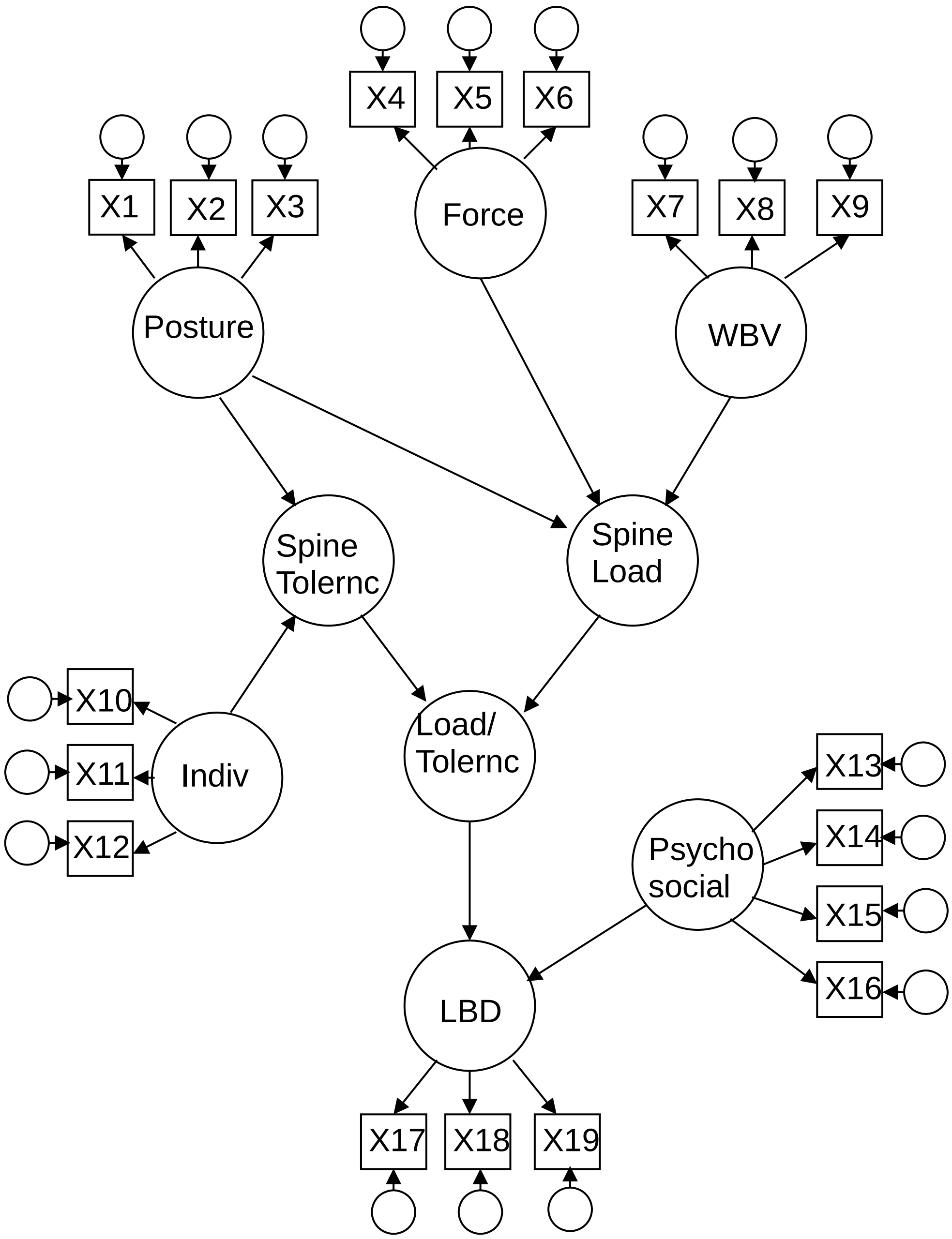

Figure 1. Path diagram for proposed covariance structure model. (Note WBV = Whole-Body Vibration, Indiv = Individual Factors, LBD=Low Back Disorders)

As can be seen, posture, whole body vibration (WBV), forceful exertions, individual factors and psychosocial factors are incorporated as exogenous latent variables in the model, while spinal loading, spine tolerance, load tolerance ratio and low back disorders are treated as endogenous variables. Beta parameters in the model are designated by the single-headed arrows, of which there are 9. Indicator variables associated with each exogenous variable will be derived from scores assigned to responses the specific items (or item combinations) contained in the exposure assessment tool. In general, each exogenous variable will consist of 3-4 indicators derived from the assessment tool (Klein 1998). These will all be associated with a corresponding error term. All told, the total number of parameters in the model will be 32 (19 error terms for indicators, 9 beta estimates [directional arrows], variances for 4 endogenous variables). The sample size of 320 was determined based upon maintaining a ratio of 10:1 for subjects to free model parameters in structural equation modeling studies (Klein 1998).

Data collected in this study will be analyzed using the RAMONA routine in the statistical analysis program SYSTAT. RAMONA has useful features not available to other covariance structure modeling programs in that it is the only program that allows the user to fix the variance of an endogenous latent variable (simplifying interpretation of parameter estimates). It is currently one of two programs (SePath is the other) to provide correct results when the model is fit to a correlation matrix. Other programs provide incorrect standard errors and (in some situations) incorrect fit measures. Examination of the Beta loadings and the point estimate (and confidence interval) of the Root Mean Square Error of Approximation (RMSEA) will be examined to estimate the degree of fit (specifically by testing the null hypothesis of close fit) and the overall plausibility of the hypothesized model.

2. Procedures for the Collection of Information

Data collection will be performed at cooperating mine sites in the following manner: Investigators will arrive at the mine site and pass the exposure assessment tool out to miners, generally before or after a change of shift. They will note which mines they are gathering responses from. The miners will fill out the form and investigators will collect the forms once the miners have finished filling them out. It is also possible that data collection will occur at a mine’s annual refresher training, where a large proportion of the work force may be in attendance. Once again, the assessment tool will be distributed and self-administered by the miners, then collected by the investigators.

3. Methods to Maximize Response Rates and Deal with Nonresponse

Based on previous experience with similar types of self-administered questionnaires in the mining industry, it is anticipated that the response rate will be at least 90%. Other NIOSH researchers have had excellent response rates for their studies. (example PRL’s study on Personal Mine Dust Monitors (0920-0698). There are no adverse consequences to nonresponse to this exposure assessment tool.

4. Tests of Procedures or Methods to be Undertaken

Feedback on the initial version of assessment tool was obtained from a sample of eight miners at a Wisconsin sandstone operation. In general, the tool appeared to be easy for the miners to fill out, and appeared to give good feedback regarding the exposures to low back pain risks. However, based on this pilot testing, a few wording changes were made to the questions regarding seam height, lifting frequency, and smoking history. Also, a few questions were omitted based on the pilot tests.

5. Individuals Consulted on Statistical Aspects and Individuals Collecting and/or Analyzing Data

The project officer (Dr. Gallagher) is well-versed in statistical techniques having taken approximately 45 hours of statistics in his graduate studies. He minored in quantitative psychology and epidemiology (with an emphasis on biostatistics) in his doctoral program. Among the statistical techniques he has studied are ANOVA, linear regression, Cox regression, logistic regression, factor analysis, covariance structure modeling, non-parametric statistics, advanced experimental design. He teaches an introductory statistics course in the Department of Industrial Engineering at the University of Pittsburgh, and is negotiating currently to teach a course in experimental design at the same institution. He has published numerous studies in national and international journal, many of which have employed advance statistical techniques and experimental design procedures.

The persons who will collect and/or analyze the data are listed below.

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