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Self-Report Measure of Low Back-Related Biomechanical Exposures: Clinical Validation

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Low back pain and symptoms are major contributors to ambulatory visits, economic burden, and reduced readiness among military personnel and employers in the civilian workplace as well. While a link between low back pain and biomechanical exposures has been established, efficient surveillance methods of such exposures are still needed. Furthermore, the utility of self-report measures for biomechanical exposures has not been examined extensively. The present cross-sectional study analyzed questionnaire data from US Army soldiers ($n = 279$) working in previously identified occupational specialties that were associated with high risk for low back pain and/or low back pain disability. Demographic characteristics, physical workload, health behaviors, and psychosocial factors were assessed in addition to self-reported workplace biomechanical exposures using the Job Related Physical Demands (JRPDs). Outcomes included self-reported low back pain severity, low back symptoms, functional limitations, and general physical health. The results indicated that the self-report measure of biomechanical exposure had a high degree of internal consistency (Cronbach alpha, 0.95). The JRPD index correlated with low back symptoms, pain intensity, function, and perceived work load using the Borg scale. Regression analyses indicated statistically significant associations between the JRPD and back pain specific pain severity and physical function, but not for general physical health (SF-12) after controlling for age, gender, educational level, job type, and reported exercise and work stress. Specifically, higher JRPD scores (representing greater biomechanical exposure) were associated with higher levels of pain intensity and functional limitations. Higher JRPD scores were found to place an individual at a greater likelihood for being a case with low back pain within the past 12 months ($OR = 1.01$ per point increase in scale-95%; range 38–152; $CI = 1.00$–1.02, $p \leq 0.05$). While future longitudinal studies of the JRPD determining the predictive validity of the measure are needed, the present study provides evidence of the utility of the JRPD for assessing biomechanical exposures associated with low back pain within

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high-risk jobs. The findings suggest that the JRPD may assist with surveillance efforts and be useful as a process and/or outcome measure in research related to occupational rehabilitation.

KEY WORDS: biomechanical exposure; ergonomics; assessment; self-report; low back pain.

INTRODUCTION

Problems arising from musculoskeletal disorders (MSDs) involving the low back have been well-documented in both civilian and military (1,2) populations. In the Armed Forces, MSDs of the low back also are attributed to significant costs and have an impact on troop readiness (2).

Among US military services, musculoskeletal injuries involving the low back have been recognized as one of the leading source of ambulatory care, lost time, and disability (3–6). Feuerstein and colleagues (4) studied US Army disability cases for the period 1990–1994 and found back-related disorders to be the most prevalent source of musculoskeletal disorders that resulted in disability. Similarly, musculoskeletal disorders of a nonspecific category including lumbosacral strain were reported to be the leading cause of disabilities for FY 1993 in the Air Force (3). In a recent study of back and upper extremity disorders among enlisted US Marines, Huang *et al.* (6) found back disorders to be among the top sources of outpatient visits, work duty limitation, and lost days in 1997 and 1998. Specifically, back-related cases accounted for over 32,000 ambulatory visits during the 2-year period and approximately 9000 cases of work duty limitation in 1998 (6).

Risk Factors

While several conditions in the low back may contribute to back pain (e.g., sprains/ strains, sciatica, degenerative arthritis, and herniated nucleus pulpous (HNP) (7)), the literature has indicated that ergonomic factors can play an important role. Reflecting the complex nature of low back pain, risk factors reported in the scientific literature can be characterized as being multifactorial in nature (7,8). Although the etiology of back disorders is not clear, an extensive body of research has suggested that individual characteristics (age, gender, Body Mass Index, education), health behaviors (exercise, physical fitness, smoking status), psychosocial (job satisfaction, social support), work organizational (job demands, work pace, perceived control), and ergonomic factors play a role in the onset and exacerbation of work-related back disorders (2,7–10).

In a study of occupational back disability in the US Army, the military, Berkowitz and colleagues (2) found that soldiers in certain military occupational specialties (MOS) experienced a higher incidence of back disability (i.e., discharge from military). The high risk MOSs identified in that study included wheeled vehicle mechanic, heavy construction equipment operator, multichannel transmission systems, mechanic, field artillery men, practical nurses, and infantry soldiers (2). While occupations classified as "high risk" in several studies have been found to share a number of exposures associated with work-related MSDs, recent emphasis has been placed on examining biomechanical exposures predictive of low back outcomes (7,9). This emphasis arises from the potential to address risk factors associated with low back pain in primary and secondary prevention efforts through engineering to assisting workers and supervisors in identifying and modifying such exposures.

On the basis of various job analysis techniques and assessment methods, several studies of work-related low back pain and disorders have identified primary biomechanical risks to include heavy lifting, static work postures, frequent twisting and bending, forceful exertions, and whole body vibration (7,11–14).

However, the measurement method of these exposures across studies vary and include self-report, observational, and direct measurement (15–18). Observational methods are more commonly used (19) and have been found to potentially provide more accurate and precise assessment of ergonomic exposures (16,17). However, the use of such methods typically require one or more highly trained observer/ergonomist, take more time, and may require extensive and costly equipment (8,19). Observational methods described in the ergonomic literature include observations at the work place (i.e., use of expert checklists or detailed recording of work actions by the observer) or video-analysis (i.e., video taping workers in their job task; later the exposure is observed in slow motion (15,20)). The third category, direct measurement, involves the use of devices that are attached to the worker. The devices include goniometers, inclinometers, accelerators, and electromyographic recordings designed specifically for measurement of body postures and movements (20). Specific examples include trunk electromyography (21) to estimate spinal compression and inclinometers to measure trunk flexion (22).

Adjuncts or alternatives to the use of observational methods for assessing ergonomic risk factors include the use of self-report measures such as questionnaires. Several studies of exposure assessment for occupational back disorders have used self-administered questionnaires. For example**,** Hildebrandt (13) used questionnaires to assess physical workload of male steel workers, work climate and vibration by evaluating duration and frequency of work postures. The results of this study indicated that groups with high prevalence rates of low back symptoms were also associated with high exposures to unfavorable working conditions (13). While the use of self-report measurements may help reduce resources of time, equipment, and costs associated with ergonomic assessment, questions have arisen in relation to their validity. Only few studies have examined the validity of self-report measures highlighting the need for such research. Some studies have suggested that workers report exposure levels that are validated by observational assessments. For example, Wiktorin and colleagues (22) used exposure data from self administered questionnaires on work postures and validated it in relation to direct measurements and systemic observations on 39 men and 58 women from different occupations. Burdorf (23) compared a questionnaire, a self administered log and an observational method to evaluate the agreement between the three methods for evaluating postural load. The findings from that study demonstrated poor agreement between the methods and reported poor validity and reliability of the questionnaire methods.

Given the potential for a significant proportion of any work population to have low back pain (BLS, 2002), there is a need for validating measurement tools for low back-related biomechanical exposures to assist in intervention efforts. Furthermore, studies of self-report measures for low back-related biomechanical risk factors are needed given their potential utility in providing a practical and efficient method in terms of cost and effort for assessing and monitoring such exposures.

A self-report measure that has been used more recently in ergonomic research, in both the military and civilian populations, is the Job Requirements and Physical Demands (JRPDs) survey (24). Originally developed by the US Air Force, the Job Factors section (38 items) of the JRPD was developed to assess self-reported ergonomic exposure in a variety of occupational groups. This survey asks questions about the frequency of certain work-related movements and postures for both the back and upper extremities. Recently, Huang and colleagues (25) used the JRPD in a study of US Marines and reported that combined exposures to ergonomic and work organization stressors were associated with higher risks for both upper extremity and back disorders. Furthermore, Dane and colleagues reported that a subset of items from the JRPD were able to differentiate levels of pain intensity, functional limitation of the upper extremity in a group of office workers (26). However, no studies have specifically examined the measurement properties of the JRPD in relation to low back pain.

The aim of the present study was to examine the validity of the JRPD as a measure for assessing biomechanical exposures for low back pain. It was hypothesized that the JRPD would demonstrate acceptable measurement properties for assessing biomechanical exposures associated with low back outcomes and further delineate individuals with low back pain and functional limitations among US Army Soldiers working in high-risk jobs.

METHODS

Subjects

Data were obtained from a survey conducted by Feuerstein and colleagues (10) of 1025 male and female US Army active duty enlisted soldiers working in military occupational specialties (MOS) previously identified as high risk for back disability (2). Soldiers were recruited according to MOS and their assigned military units. The specific MOSs included Infantry (11B), Wheeled Vehicle Driver (88M), Heavy Construction Equipment Operator (62E), Construction Equipment Repairer (62B), Wheeled Vehicle Mechanic (63B), Multi-channel Transmission Systems Operator (31R), and Practical Nurse (91C). Soldiers were recruited from a representative sample of different types of installations with varying missions. The military installations included were Fort Meade, MD; Walter Reed Army Medical Center, Washington, DC; Fort Meyer, VA; Fort Belvoir, VA; Fort Eustis, VA; Fort Story, VA; Fort Lee, VA; and Fort Bragg, NC. Entire units were invited to participate in the study and all units attended group sessions at their local installation to obtain details of the study.

All institution assurances for the present study were obtained from the Uniformed Services University of the Health Sciences (USUHS) Institutional Review Board for analysis of the data, which was deidentified/stripped of all personal identifiers for use in the present study.

Eligibility Criteria

Given the present study's focus on low back symptoms only, those subjects with reported musculoskeletal symptoms in the upper extremity regions (i.e., shoulder, elbow/forearm, wrist/hand), neck and upper back symptoms ($n = 746$), were excluded. The reports of such symptoms were based on a modified NIOSH symptom survey (27), which has been used in several investigations on musculoskeletal disorders (10,25,28,29). Further, inclusion criteria for the present study required that those individuals with low back symptoms must have reported experiencing them within the past 12 months. Seventy-six subjects met this case definition. All asymptomatic subjects were included in the present analysis as a comparison group resulting in a total sample of 279 for the present study.

Measures

Volunteers provided informed consent and completed a baseline survey consisting of 281 items related to individual factors/demographic characteristics, physical workload, workplace ergonomic exposures, musculoskeletal symptoms, and psychosocial factors.

Biomechanical Exposures

The Job Factors section (38 items) of the US Air Force Job Requirements and Physical Demands (JRPDs) survey (24) was used to assess biomechanical exposures. The scale include items which measure frequency of movements such as bending, twisting, lifting, and sitting; activities which are consistently found to be related to low back pain (7,12). Previous studies have established the validity of the JRPD in relation to direct assessments completed by ergonomists (24,26), but not specifically to LBP.

Each JRPD item has five possible responses based on amount and duration of biomechanical exposure (1 = *never*, 1 = *<5 hours/week*, 2 = *<2 hours/day*, 3 = *2 to 4 hours/day*, 4 = *>4 hours/day*). Individual total scores were computed by summing the total of the 38 items, with a possible range from 38 to 152. A higher score indicates a higher level (more adverse levels) of biomechanical exposure.

Demographic Characteristics

The demographic information obtained included age, gender, education, marital status, military rank, time in service, and military occupational specialty.

Physical Fitness

As a proxy for physical fitness, an item derived from the US Army Health Risk Appraisal (HRA) (30) was used to determine how frequently an individual engaged in aerobic exercise. Response categories were “rarely never,” “1 or 2 times/week,” or “3 or more times/week.” This item has been identified in previous studies as a predictive factor for low back disability (2) and lost time (10) in US Army soldiers. For the purpose of the present study, responses were examined according to whether or not an individual reported exercising a particular amount of times per week (i.e., yes/no for each response category).

Physical Workload

The Borg scale of perceived exertion (31) was used to assess the degree of physical effort at work. The question asks respondents to describe the perceived physical effort required of their job during a "typical day" using a 10-point scale (0 being *nothing at all* to 10 being *very, very hard*). Physical workload has been found to be a risk indicator for low back pain (32). Further, the Borg scale has been used in several ergonomic studies as a proxy for physical workload (10,25). In addition, researchers have demonstrated the scale to be significantly correlated with measures of physiologic exertion such as heart rate and oxygen uptake (33).

Clinical Outcomes

Outcomes examined were based on self-report and included the Standard Form-12, Visual Analog Scale, and Vermont Disability Prediction Questionnaire. The SF-12 (34) health survey is a multipurpose generic measure of physical and mental health. These items were derived from the longer SF-36 which has been used in past research on work-related musculoskeletal disorder populations (35–37). This study used summary scores from the physical health component only. The degree of pain severity was determined by self-report on a 10-point Visual Analog Scale (VAS). Function was also assessed on a 10-point VAS to determine perceived difficulty with completing work tasks within the next 6 months. Responses ranged from 0 being "no trouble at all" to 10 being "so much trouble I won't be able to do my job." These items were obtained from the Vermont disability prediction questionnaire (VDPQ), an index determined from past studies to be valid in predicting chronic disability due to low-back pain (38).

Statistical Analysis

All analyses were completed using SPSS (Statistical Package for the Social Sciences) 11.0 (Chicago, IL).

Subject Characteristics

T tests and chi-square tests were used to determine any group differences in baseline characteristics among the cases and controls.

Internal Consistency

To measure homogeneity among index items, Cronbach's alphas were computed as a measure of the internal consistency of the JRPD items (39).

Construct Validity

Construct validity of the JRPD and the Borg scale was determined using bivariate correlation analyses. Pearson correlation coefficients were used to describe the magnitude of association between the two scales.

Discriminant Validity

Multiple linear regression analyses were used to determine the association between biomechanical exposures, as assessed by the JRPD, and dependent variables of pain intensity, functional limitations, and general physical health. Bivariate correlation analyses were used to select independent variables for the regression model that represented constructs of potential confounders determined a priori. These analyses also enabled the identification of possible colinear variables. In addition to biomechanical exposure level (JRPD), the final model adjusted for age, gender, educational level, type of job (MOS), exercise status, and work stress. All variables were simultaneously entered into the linear regression model.

A multivariable logistic regression analysis was used to compute odds ratios and 95% confidence intervals for case status (presence or absence of low back symptoms) in relation to levels of biomechanical exposure. Univariate logistic regression analyses were first performed to identify variables that were significantly related to case status. Independent variables that were associated with the dependent variable at a significance level of $p < 0.25$ (40) were selected for inclusion in the final multivariate logistic regression analysis that examined the JRPD.

RESULTS

Subject Characteristics

Study participants ranged in age from 18 to 46 years and had a mean age of 23.5 years (SD = 4.6). On average, subjects had 3.1 years of service (range = 0–18 years, SD = 3.5). This sample consisted of 93% males and 7% females. The subjects were more likely to be single (59%), high school graduates (61%), and in the ranks of E-1 to E-4 (82%). Approximately 60% of the participants had an infantryman (11B) MOS. Cases were more likely to be females (12%) than comparison group (5%, $\chi^2 = 4.17$, $p = 0.04$) and have a MOS of wheeled vehicle drivers (88M) (23%, $\chi^2 = 12.9$, $p = 0.05$). There were no differences between cases and comparison group on age, length of time in service, rank, or marital status (Table I).

JRPD Measurement Properties

Figures 1–3 illustrate the distribution of the JRPD scores by case status. The range for total JRPD scores was 38.0–163.0 (mean = 87.3, SD = 26.9) (Fig. 1). The mean total score for the cases was 93.1 (SD = 26.1) (Fig. 2), and 85.2 (SD = 27.0) for the controls (Fig. 3).

Internal Consistency

The JRPD indexed demonstrated a high degree of internal consistency among the 38 items. Cronbach alpha for this sample was 0.95 (Table II). In addition, Table II provides Cronbach alpha values for each individual item when removed from the scale.

Table I. Demographic Characteristics ($n = 279$)

	Cases			Controls		
	n	*M*	*SD*	*n*	*M*	*SD*
Age (years)	75	23.2	4.6	201	23.6	4.6
Time in service (years)	76	3.5	39.5	203	3.5	41.9
Gender						
Male	67 (88.2)			193 (95.1)		
Female	9 (11.8)			10 (4.9)		
Military job type (MOS)						
Infantryman (11B)	46 (62.2)			121 (61.1)		
Construction equipment repairer (62B)	0 (0.0)			5 (2.5)		
Heavy construction equipment operator (62E)	4 (5.4)			6 (3.0)		
Unit-level wheeled vehicle mechanic (63B)	3 (4.1)			12 (6.1)		
Wheeled vehicle driver (88M)	17 (23.0)			23 (11.6)		
Practical nurse (91C)	3 (4.1)			14 (7.1)		
Other	1 (1.4)			17 (8.6)		
Rank						
Private (E1)	4 (5.3)			13 (6.6)		
Private (E2)	19 (42.0)			42 (21.2)		
Private first class (E3)	17 (22.4)			45 (22.7)		
Specialist/corporal (E4)	26 (34.2)			57 (28.8)		
Sergeant (E5)	7 (9.2)			24 (12.1)		
Staff Sergeant (E6)	3 (3.9)			14 (7.1)		
Sergeant first class (E7)	0 (0.0)			1 (0.5)		
Other						
Education						
High school diploma/GED	49 (64.5)			120 (59.4)		
Some college	22 (28.9)			69 (34.2)		
2 yr degree	2 (2.6)			12 (5.9)		
4 yr degree	2 (2.6)			1 (0.5)		
Some graduate work	1 (1.3)			0 (0.0)		
Marital						
Single	41 (56.9)			124 (64.2)		
Married	25 (34.7)			57 (29.5)		
Separated	3 (4.2)			6 (3.1)		
Divorced	3 (4.2)			6 (3.1)		

Construct Validity

The JRPD was significantly correlated with the Borg scale ($r = 0.46$, $p < 0.01$). In addition, the JRPD index was significantly correlated with low back symptoms ($r = 0.13$, $p < 0.05$), pain intensity ($r = 0.18$, $p < 0.01$), function ($r = 0.20$, $p < 0.01$), and work stress ($r = -0.12$, $p < 0.01$). The correlation coefficients for both the JRPD and Borg scale with each of the clinical outcomes examined (pain intensity, symptoms, physical function, and general physical health) are given in Table III.

Discriminant Validity

A summary of the multiple linear regression analysis is shown in Table IV. The results indicated that the JRPD had a statistically significant association with levels of pain severity and physical function, but not general physical health after controlling for age, gender, educational level, MOS, exercise status, and work stress. These variables only explained

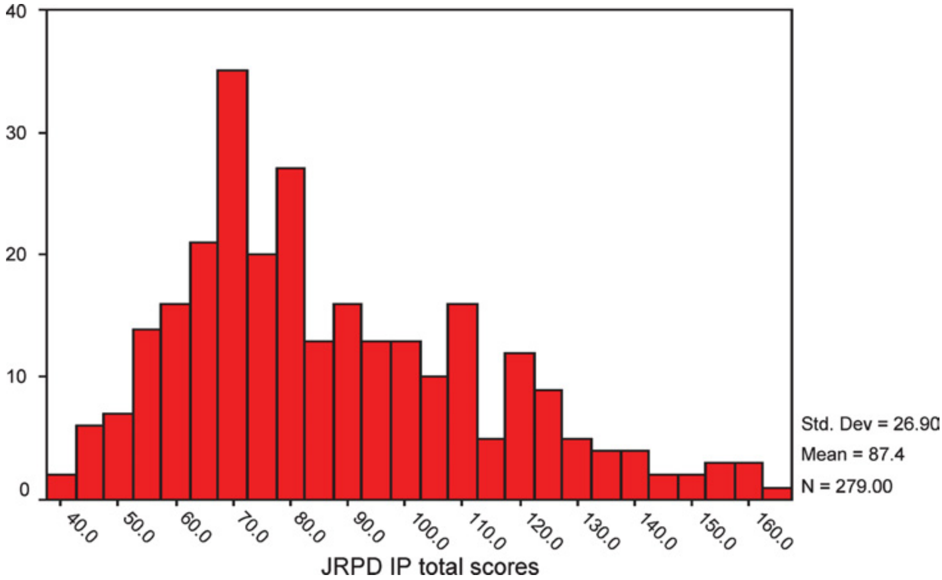

Fig. 1. Distribution of the Job Requirements and Physical Demands (JRPD) scores for full sample ($n = 279$).

5.5% of the variability in general physical health, but 17.9% of the variability in physical function, and 15.2% of the variability in pain severity.

A summary of the logistic regression analyses is shown in Table V. The results of the logistic regression analysis indicate that the individual's score on the JRPD placed him/her

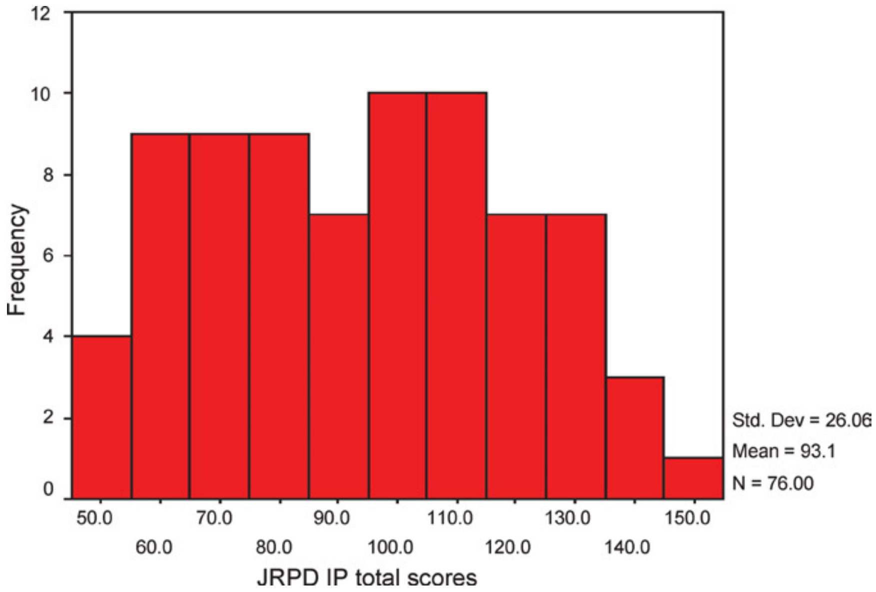

Fig. 2. Distribution of JRPD scores of low back cases ($n = 76$).

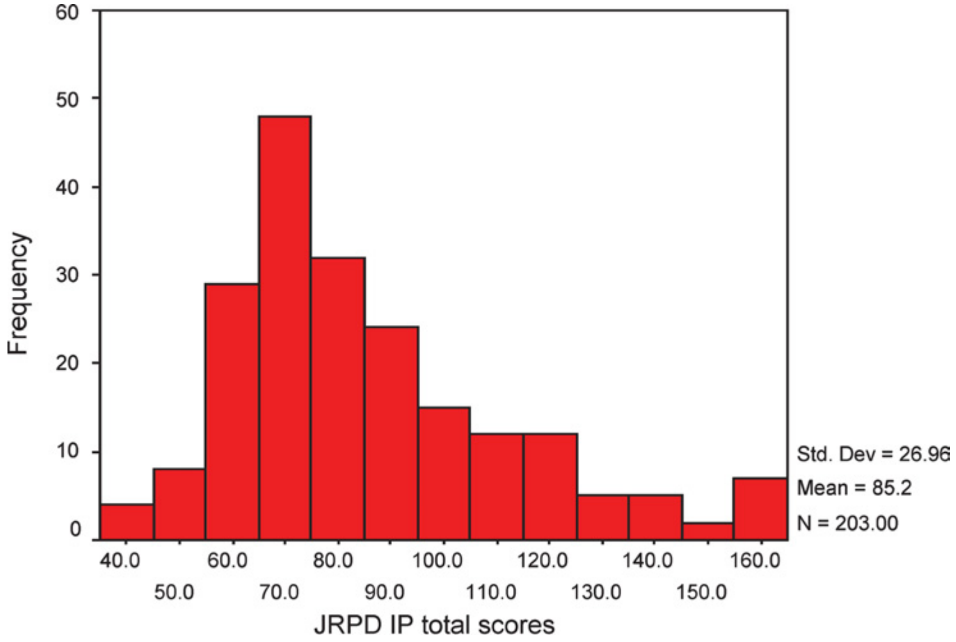

Fig. 3. Distribution of JRPD scores of asymptomatic controls ($n = 203$).

at a greater likelihood for being a case (OR $= 1.01$, $p \leq 0.05$, 95% CI 1.00–1.02) (Table V). It should be noted that this odds ratio represents a point increase on the scale. To assist with understanding these odds ratios, the odds ratio for a one standard deviation increase in score would be 1.3. This model classified 74% of the observations accurately.

DISCUSSION

This study is the first to describe the association of the JRPD index and low back symptoms among a sample of workers in previously identified high-risk jobs for low back pain. The JRPD index was moderately correlated with another measure of physical workload and clinical outcomes and demonstrated a high internal consistency among the constituent items. Furthermore, findings indicated that higher JRPD scores (representing greater biomechanical exposures) were significantly associated with higher levels of pain intensity and functional limitations, but not general physical health. Higher JRPD score was also associated with a greater likelihood to be a case with low back pain within the past 12 months. These findings suggest that the JRPD is a useful self-report tool for assessing biomechanical/ergonomic exposures associated with low back-related outcomes. The findings of this study are consistent with the existing literature on the role of biomechanical risk factors in low back pain (12,14,32,41,42). While previous studies have utilized observational or self-report methodology, few have specifically examined both type of exposure and duration of such exposures. The present study also indicates that a particular emphasis should be placed on efforts to reduce/eliminate bending, twisting of the low back, heavy lifting, and whole body vibration in these high risk jobs.

Table II. Internal Consistency of JRPD Items

JRPD item description	Cronbach α if item deleted
1. Work with hands at or above chest level	0.94
2. Lay on back or side and work with arms up	0.94
3. Hold/carry large stacks of materials during course of work	0.94
4. Force or yank components of work objects to complete task	0.94
5. Reach/hold arms in front of or behind body to perform tasks	0.94
6. Bend/tip head forward or backward to work	0.94
7. Cradle phone or other devices between neck and shoulder	0.95
8. Bend wrist up/down or to the side while working	0.94
9. Apply pressure or hold item/material/tool longer than 10 seconds at a time	0.94
10. Use hands in a way similar to wringing out clothes during work tasks	0.94
11. Perform series of repetitive tasks/movements during normal course of work	0.94
12. Work surface presses into palm/wrist/sides of fingers leaving red marks	0.94
13. Use hand/palm like a hammer to do aspects of work	0.94
14. Hands/fingers are cold during work	0.94
15. Work at fast pace to keep up with quota or machine	0.94
16. Tool vibrates/jerk hands and arms	0.94
17. Repeatedly throw/toss items during work	0.94
18. Twist forearms similar to turning a screwdriver during work	0.94
19. Wear gloves that are bulky or reduce ability to grip	0.95
20. Squeeze or pinch work objects with force similar to open a lid on a new jar	0.94
21. Grip work objects/tools similar to gripping tightly onto a pencil	0.94
22. Bend to lift or move components or to do other aspects of work	0.94
23. Lean forward continually to work	0.94
24. Wear of personal protective equipment restricts movement	0.94
25. Repeatedly bend back (forward, sideways, backward or twist) to work	0.94
26. Body is twisted when objects are lifted	0.94
27. Vibration can be felt through surface when standing or seated	0.94
28. Lift or carry objects with one hand	0.94
29. Lift or handle bulky items	0.94
30. Lift materials that weigh more than 25 pounds	0.94
31. Work requires kneeling or squatting	0.94
32. Constantly move or apply pressure with one or both feet	0.94
33. Unable to rest both feet flat on floor when seated	0.94
34. Stand on hard surfaces	0.95
35. Glare on computer screen or work surface	0.95
36. Difficult to hear on telephone or concentrate because of noise in work area	0.94
37. Look at monitor screen constantly so not to miss important information	0.95
38. Difficult to see objects working with (monitor, paper, parts)	0.94

Notes. $n = 279.0$; $\alpha = 0.95$

Table III. Correlation of the JRPD and the Borg Scale With Clinical Outcomes

Variable	JRPD Index (r)	Borg scale (r)
NIOSH—Low back symptoms	0.130*	0.184*
VAS—Pain severity	0.179**	0.273**
VAS—Trouble sit/stand (function)	0.200**	0.307**
SF-12 General physical Health summary	−0.115	−0.198**

Notes. $n = 279$; r = Pearson's correlation coefficient. JRPD, Job Requirements and Physical Demands Survey; Borg, Borg scale of perceived effort; NIOSH, National Institute for Occupational Safety and Health; VAS, Visual Analog Scale; SF-12, Short Form-12.
$^{*}P \leq 0.05$; $^{**}P \leq 0.01$.

Table IV. Factors Associated With Pain Intensity, General Physical Health, and Functional Limitations

	Outcome variables		
	Pain intensity coefficients[a]	SF-12 physical health coefficients[a]	VAS functional limitation coefficients[a]
Age (years)	−0.04	0.00	0.07
Gender (female)	0.44	1.21	−0.90
Educational level	0.05	0.13	−0.05
MOS			
Construc equip repairer (62B)	−0.92	2.64	−0.28
Heavy construction equip op (62E)	−0.91	1.18	−1.89*
Unit wheeled Veh mech (63B)	−0.98	−1.00	−0.33
Wheeled vehicle Driver (88M)	−0.37	1.65	−0.31
Practical Nurse (91C)	−1.32*	2.76	−2.05**
Other	−1.16*	1.63	−1.46*
Exercise status			
Exercise 1–2x/wk	0.11	−0.72	−0.03
Exercise 3+ x/wk	−0.84	2.55	−1.36*
Work stress	0.35**	−0.49	0.50**
JRPD	0.01*	−0.02	0.02**
Constant	1.33	52.01	−0.92
R^2	0.15	0.06	0.18

Notes. $n = 279$.
[a] Coefficients from multiple linear regression model.
$^{*}P \leq 0.05$. $^{**}P \leq 0.01$.

In addition to the results related to biomechanical exposures, findings indicated that frequency of exercise is associated with low back outcomes. Given the military population studied, participants were in an environment where a regimented/structured exercise program is a daily routine. Frequent aerobic exercise (3+ times/week) was associated with lower pain severity, higher level of function, and better overall physical health. Despite the exercise requirement in all workers in the present study (i.e., critical aspect of being on active duty), these findings are consistent with previous findings indicating that lower levels of self-reported aerobic exercise have been shown to contribute to occupational low back pain associated with lost time in US Army soldiers (10). Additionally, Riihimaki *et al.* (43) found an association between lower frequency of aerobic activity and sciatic pain in a nonmilitary population of machine operators. It is possible that those soldiers with higher

Table V. Determinants of Low Back Symptoms Case Status

			95% CI	
Variable	β	OR	Lower	Upper
Gender (female)	0.68	1.98	0.66	5.94
Wheeled vehicle driver (88M)	0.66	1.93	0.86	4.34
MOS 8 (Other)	−1.89	0.15	0.02	1.22
Exercise 1–2 x/wk	−0.11	0.90	0.28	2.88
Exercise 3+ x/wk	−0.73	0.48	0.18	1.29
Work stress	0.41	1.51**	1.12	2.04
JRPD	0.01	1.01*	1.00	1.02
Constant	−2.53	0.08**		

Note. OR represent adjusted odds ratios
$^{*}P < 0.05$. $^{**}P < 0.01$.

intensity of low back pain were unable to tolerate frequent aerobic activity. However, given the cross-sectional nature of the present study, no cause–effect relationships can be determined for this link or other potential associations. Further studies of aerobic exercise and low back pain may help clarify such associations.

The present study found a significant association between work stress and the low back outcomes related to pain severity and case status. A number of studies have indicated that psychosocial factors are associated with low back pain (10,44–46). This finding highlights the importance of also addressing job stress factors.

In this sample, cases were more likely than controls to be female, similar to previous findings that support a higher prevalence of back pain among females in both military and civilian studies (10,47). Since this factor cannot be addressed in intervention efforts, it serves to point out that particular attention should be given to females in relation to work tasks and potential biomechanical exposures.

Limitations

This study consisted of US Army soldiers who are generally screened and denied entry into the military for significant back/musculoskeletal problems. Therefore, these individuals may have a low prevalence of preexisting back problems. This fact contributes to the study's ability to examination of the associations of work-related back risk factors among healthy worker. However, this worker selection criteria can limit conclusions in light of a healthy worker effect. That is, the generalizability may be limited to a military population or workgroups that exclude workers with a history of back problems. Furthermore, the study focused on high risk jobs since subjects were selected from high-risk MOSs (i.e., more serious and or high-risk cases).

The cross-sectional design limits conclusions based on temporal associations since information on biomechanical exposure and clinical outcomes were determined simultaneously. That is, the determination of whether exposure precedes the outcome cannot be established, nor was the intent of this study. However, this study can make conclusions regarding the coexistence of ergonomic exposures and back pain. Prospective studies of the prediction of low back pain onset using JRPD are needed to validate the direction of these associations.

Another limitation of the present study was that all data were collected by self-report. The use of self-report methods may under- or overestimate exposure and/or outcomes. Future studies should also examine the use of concurrent observational measurement of biomechanical exposures to further validate the JRPD and low back outcomes.

Finally, the sample included individuals with existing low back pain. Since prevalence is a function of both onset of low back pain and duration with the condition, one must consider that a "survivor bias" may be in effect.

Musculoskeletal disorders of the low back present a substantial economic burden and impact on productivity and military readiness. The ability to better identify factors related to the problem and plan targeted primary and secondary prevention strategies rests on improved surveillance. One chief limitation of self report indices commonly used in epidemiologic studies/ergonomic surveillance is the lack of standardization. Also few of these measures have any established clinical validity. Observational methods are often considered the gold standard of ergonomic exposure surveillance but applicability of these methods in studies of large populations are limited because they require significant resources of time, labor, and cost (8,16,17). The main results of this study indicate that the JRPD, a self-report index of biomechanical exposure demonstrates acceptable measurement properties (internal consistency, determinant validity, and construct validity) and has potential for use in the surveillance of low back biomechanical exposures and for its use in clinical outcome studies. Lastly, the findings of this study points to the need for future prospective/longitudinal studies to further validate the role of ergonomic exposure (as measured by the JRPD) in working populations who may develop low back problems and populations of workers in which ergonomic exposures exacerbate occupational low back pain.

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