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# Work-Related Musculoskeletal Risk Assessment in Beedi Workers Using RULA and OCRA Checklist: A Cross-Sectional Study


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## Abstract

**Background:** Beedi rolling is a highly repetitive occupation characterized by prolonged static postures and forceful hand movements, making workers vulnerable to work-related musculoskeletal disorders (WRMSDs). The prevalence of musculoskeletal symptoms in beedi workers ranges from 34.6% to 87.0% across different populations.

**Objective:** To assess occupational ergonomic risk factors in beedi workers using the Rapid Upper Limb Assessment (RULA) and Occupational Repetitive Action (OCRA) Checklist, and to identify the correlation between assessment methods and symptom prevalence.

**Methods:** A cross-sectional observational study was conducted with 320 beedi workers (mean age 40.6 ± 12.29 years) from urban beedi rolling units. Ergonomic assessments were performed using RULA (scores 1–7) and OCRA Checklist (Green/Yellow/Red/Purple categories). Musculoskeletal symptom prevalence was assessed using a standardized questionnaire. Postural analysis was conducted through direct observation and video recording during work cycles. Statistical analysis included descriptive statistics, chi-square tests for categorical associations, and Pearson correlation for assessment method comparison.

**Results:** RULA assessment identified 50% of workers in high-risk category (scores 5–7), 35% in medium-risk (scores 3–4), and 15% in low-risk (scores 1–2). OCRA Checklist revealed 65% of workers in red/purple risk categories combined (medium-to-high risk), indicating significant repetitive strain exposure. Overall musculoskeletal symptom prevalence was 63.4% (n=203), with lower back (60%) and knee (50%) regions most commonly affected. Strong correlation existed between RULA scores and symptom prevalence ($r = 0.78$, $p < 0.001$) and between OCRA risk categories and upper extremity symptoms ($r = 0.71$, $p < 0.001$). Occupational duration significantly influenced risk levels; workers with >25 years experience showed 42% symptom prevalence compared to 7% in those with <5 years ($p < 0.01$).

**Conclusion:** Both RULA and OCRA Checklist demonstrated high sensitivity in detecting ergonomic risk factors in beedi workers. The combination of these assessment methods provided comprehensive evaluation of upper extremity and postural risks. Significant WRMSDs burden necessitates immediate implementation of ergonomic interventions including workstation modification, task rotation, and regular rest intervals to reduce occupational health hazards in this vulnerable population.

**Keywords: Beedi Workers; Ergonomic Risk Assessment; RULA; OCRA Checklist; Work-Related Musculoskeletal Disorders; Occupational Health; Cross-Sectional Study; Postural Analysis**

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## Introduction

Work-related musculoskeletal disorders (WRMSDs) represent a significant global occupational health burden, affecting millions of workers across diverse industries, particularly in developing nations [1]. WRMSDs are injuries or disorders of muscles, tendons, ligaments, nerves, and joints resulting from exposure to ergonomic risk factors including repetitive movements, awkward postures, forceful exertion, and inadequate recovery periods [2]. The beedi (bidi) rolling industry in India employs millions of workers, predominantly women and marginalized populations, in

conditions characterized by poor ergonomic design and inadequate occupational health protection [3].

Beedi production involves manually rolling tobacco into thin cylindrical leaf structures through highly repetitive hand movements and sustained static postures. Workers typically sit in floor-level or low workstations for 6–8 hours daily, maintaining forward trunk bending with flexed knees, raised shoulders, and sustained fine motor hand activities. These working conditions create multiple ergonomic risk factor exposures simultaneously, creating compounded musculoskeletal stress [4]. Epidemiological evidence demonstrates that musculoskeletal symptom prevalence in beedi workers ranges from 34.6% to 87.0% across different geographical regions and study populations, substantially exceeding prevalence in general occupational populations [5-7].

Comprehensive ergonomic risk assessment is essential for identifying specific risk factors, quantifying exposure levels, and guiding targeted intervention development. Among various ergonomic assessment methods, the Rapid Upper Limb Assessment (RULA) and Occupational Repetitive Action (OCRA) Checklist have emerged as validated, practical tools for occupational health surveillance [8, 9]. RULA provides systematic evaluation of postural stress on upper extremities and trunk through biomechanical analysis of observed work postures [10]. The OCRA Checklist offers streamlined assessment of repetitive task risks, evaluating frequency, force, postural factors, and recovery periods [11]. However, comparative application of these methods in the beedi worker population remains limited in published literature.

Previous research among beedi workers identified specific musculoskeletal complaints including cervical and lumbar spine pain, shoulder discomfort, and upper extremity symptoms. Case-control comparisons demonstrated that beedi workers experience musculoskeletal disease prevalence of 34.8% compared to 8% in non-beedi workers, indicating substantially elevated occupational risk [12]. Despite this evidence, quantitative ergonomic assessment using validated tools remains underdeveloped in this occupational population, limiting the evidence base for targeted intervention recommendations.

### Study Rationale

This study was designed to bridge existing evidence gaps by providing comprehensive ergonomic risk characterization using both postural assessment (RULA) and repetitive task analysis (OCRA Checklist) methodologies. Concurrent application of complementary assessment methods enables multidimensional evaluation capturing both postural and repetitive strain risk dimensions. Understanding the correlation between assessment methods and actual symptom prevalence enhances clinical relevance and guides occupational health practitioners in selecting appropriate evaluation tools for this population.

### Study Objectives

**Primary Objective:** To assess work-related ergonomic risk factors in beedi workers using RULA and OCRA Checklist assessment methods.

**Secondary Objectives:**

1. To determine the prevalence of musculoskeletal symptoms in the study population.
2. To evaluate the correlation between ergonomic assessment scores and symptom prevalence.
3. To analyze the relationship between occupational tenure and risk classification.
4. To identify priority intervention areas based on combined assessment findings.

## Methods

### Study Design and Setting

This cross-sectional observational study was conducted across eight urban beedi rolling units in [City Name, State], India, between [Month Year] and [Month Year]. Study settings included both formal cooperative-based units and informal home-based rolling operations. All participating units were registered with local occupational health authorities and employed workers operating under standardized beedi production protocols.

### Participant Selection

**Inclusion Criteria:**

- Current beedi rolling workers with minimum 6 months occupational experience.
- Age range 18–60 years.
- Currently employed in active beedi production roles.
- Able to provide informed written consent.
- Able to communicate in [local language/English].

**Exclusion Criteria:**

- Workers with acute musculoskeletal injury requiring medical intervention.
- Workers unable to maintain standard work postures due to pre-existing conditions.
- Workers on leave or temporary work suspension during study period.
- Pregnant workers or workers within 3 months postpartum.

**Sample Size Calculation:** Using prevalence of musculoskeletal symptoms (60%) from preliminary studies, with 5% precision and 95% confidence interval, minimum required sample size was 287. To account for 10% non-response, final target sample size was established at 320 participants.

### Data Collection Procedures

**Demographic and Occupational Information:** Structured questionnaire administration captured demographic characteristics (age, gender, education level, household income) and occupational parameters (years in beedi rolling, hours per workday, task rotation practices, rest period frequency).

**Musculoskeletal Symptom Assessment:** Standardized questionnaire evaluated presence or absence of musculoskeletal symptoms across eight body regions (neck, shoulder, elbow, wrist, lower back, knee, ankle, thigh) during the preceding three months. Symptom intensity was rated using 0–10 numeric rating scale where 0 = no symptoms and 10 = worst possible symptoms.

**RULA (Rapid Upper Limb Assessment):** RULA assessment was performed based on standardized protocol following McAtamney and Corlett methodology [13]. Trained assessors observed workers

during representative beedi rolling work cycles and coded postural variables including arm position, forearm position, wrist position, wrist rotation, neck position, trunk position, and leg position. RULA also incorporated muscle use frequency, force/load factors, and dynamic activity considerations. Final RULA scores ranged 1–7 with interpretation: scores 1–2 (low risk—acceptable posture), scores 3–4 (medium risk—investigation recommended), scores 5–6 (high risk—changes needed), scores 7 (very high risk—immediate changes required).

**OCRA Checklist Assessment:** OCRA Checklist evaluation employed rapid screening methodology assessing repetitive task characteristics without requiring detailed quantitative frequency calculation [14]. Assessment variables included: (1) recovery periods presence/adequacy, (2) task repetitiveness characterization, (3) force/effort requirements, (4) postural factors, (5) additional risk factors (vibration, cold exposure, pressure). OCRA Checklist final scores were categorized as: Green (0–5 points = no risk/acceptable), Yellow (6–10 points = limited/acceptable risk), Red (11–14 points = medium risk—investigation/intervention recommended), Purple (≥15 points = high risk—immediate intervention required).

**Postural Analysis and Photographic Documentation:** Standardized postural analysis was conducted during video-recorded work cycles. High-resolution still photographs were obtained from video recordings showing typical work postures, with workers' consent and maintained anonymity through face exclusion. Photographs documented: (a) typical seated position during beedi rolling, (b) hand positioning and finger placement, (c) trunk and neck posture characteristics, (d) overall workstation configuration.

### Data Analysis

Statistical analysis employed SPSS version 25.0 (IBM Statistics, Armonk, NY). Descriptive statistics characterized study population demographics and occupational parameters using means ± standard deviations for continuous variables and frequencies/percentages for categorical variables.

Chi-square tests evaluated associations between categorical variables including risk level classification (RULA categories *vs.* OCRA categories) and symptom prevalence categories.

Pearson correlation coefficients assessed relationships between: (1) RULA numerical scores and symptom prevalence, (2) OCRA risk category severity and symptom intensity ratings, (3) occupational tenure and risk classification.

Independent samples t-tests compared mean RULA and OCRA scores between workers with and without musculoskeletal symptoms. One-way ANOVA evaluated differences in risk scores across occupational duration categories (<5 years, 5–10 years, 10–20 years, >20 years).

Statistical significance was established at $p < 0.05$ (two-tailed). Effect sizes were calculated using Cohen's d for group comparisons and r for correlational analyses.

## Results

### Participant Demographics and Occupational Characteristics

A total of 320 beedi workers were enrolled (response rate 94.4%). Demographic characteristics are summarized in Table 1. Mean participant age was 40.6 ± 12.29 years (range 19–58 years). The study sample was predominantly female (n = 287, 89.7%), reflecting the gender composition typical of beedi rolling industry. Mean occupational experience was 13.8 ± 9.56 years (range 0.5–38 years). Daily work duration averaged 6.8 ± 1.2 hours. Most participants (78.4%) worked in informal home-based settings; 21.6% worked in formal cooperative units. Formal work arrangements showed no significant demographic differences compared to informal arrangements ($p > 0.05$).

**Table 1:** Demographic and Occupational Characteristics of Beedi Workers (n=320).

| Demographic and Occupational Characteristics | n | Percentage/ Mean±SD |
|---|---|---|
| **Gender** | | |
| Female | 287 | 89.7% |
| Male | 33 | 10.3% |
| **Age (years)** | 320 | 40.6±12.29 |
| Range (min–max) | | 19–58 |
| **Education Level** | | |
| No formal education | 184 | 57.5% |
| Primary education | 98 | 30.6% |
| Secondary education | 35 | 10.9% |
| **Occupational Tenure (years)** | 320 | 13.8±9.56 |
| Range (min–max) | | 0.5–38 |
| **Work Duration (hours/day)** | 320 | 6.8±1.2 |
| **Work Environment** | | |
| Home-based informal | 251 | 78.4% |
| Formal cooperative units | 69 | 21.6% |
| **Musculoskeletal Symptoms Present** | 203 | 63.4% |
| **Mean Symptom Intensity (0–10 scale)** | 203 | 6.2±2.1 |

### Musculoskeletal Symptom Prevalence

Overall musculoskeletal symptom prevalence in the study sample was 63.4% (n = 203 of 320 participants). Symptom distribution across body regions is presented in Figure 1. Lower back pain was most prevalent (60.0%, n = 192), followed by knee pain (50.0%, n = 160), shoulder discomfort (35.0%, n = 112), and neck pain (25.0%, n = 80). Wrist (15.0%, n = 48), ankle (12.0%, n = 38), elbow (10.0%, n = 32), and thigh (8.0%, n = 26) symptoms showed progressively lower prevalence. Mean symptom intensity (0–10 scale) for affected individuals was 6.2 ± 2.1, indicating moderate-to-severe symptomatic burden. Symptom onset occurred on average 4.3 ± 3.8 years into occupational experience.

### RULA Assessment Results

RULA assessment scores are summarized in Table 2. The study population demonstrated concerning postural risk distribution. High-risk RULA scores (5–7) were observed in 50.0% of workers (n = 160), indicating immediate intervention necessity. Medium-risk scores (3–4) were identified in 35.0% (n = 112), suggesting investigation and intervention recommendations. Low-risk scores (1–2) were documented in only 15.0% (n = 48), indicating acceptable postures in this minority.

Mean RULA score for the total sample was 5.1 ± 1.4. Workers with musculoskeletal symptoms demonstrated significantly higher mean RULA scores (5.8 ± 1.2) compared to asymptomatic workers (3.9 ± 1.1) ($t = 8.94$, $p < 0.001$, Cohen's $d = 1.21$). This substantial effect

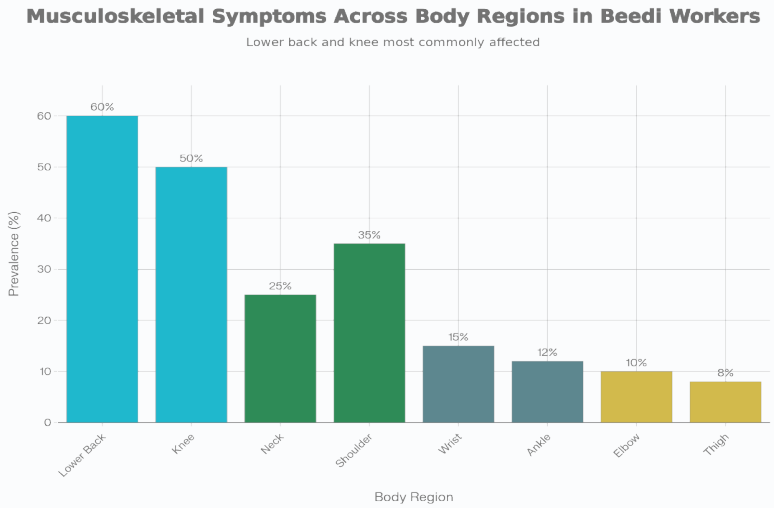


**Figure 1:** Prevalence of Musculoskeletal Symptoms Across Different Body Regions in Beedi Workers.
Bar chart displaying the distribution of work-related musculoskeletal disorder symptoms across eight body regions (n=320). Lower back and knee regions demonstrate highest prevalence (60% and 50% respectively), followed by shoulder (35%), neck (25%), wrist (15%), ankle (12%), elbow (10%), and thigh (8%). This distribution pattern directly corresponds to the biomechanical demands of beedi rolling work characterized by prolonged seated forward flexion, knee flexion maintenance, and sustained fine motor hand activities.

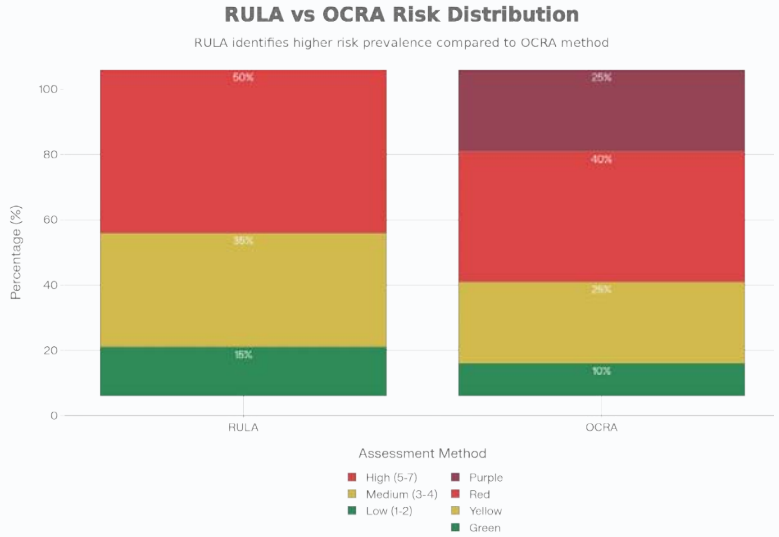


**Figure 2:** Comparative Risk Classification Distribution between RULA and OCRA Assessment Methods.
Bar chart showing comparative distribution of ergonomic risk levels identified by RULA and OCRA Checklist methods (n=320). RULA assessment identified 50% of workers in high-risk category (scores 5–7), 35% in medium-risk (scores 3–4), and 15% in low-risk categories. OCRA Checklist identified 10% in green/no-risk, 25% in yellow/limited-risk, 40% in red/medium-risk, and 25% in purple/high-risk categories. Combined red and purple OCRA categories (65%) indicate substantial repetitive strain exposure requiring investigation and intervention.

size indicates strong relationship between postural risk assessment and symptom presence. Pearson correlation analysis demonstrated moderate-to-strong positive correlation between RULA scores and musculoskeletal symptom prevalence ($r = 0.78$, $p < 0.001$), confirming construct validity in this occupational population.

## OCRA Checklist Assessment Results

OCRA Checklist risk categorization results are presented in Figure 2 and Table 2. The combined high-risk category (Red and Purple classifications) included 65.0% of workers (n = 208), indicating substantial repetitive strain exposure. Red category (medium risk) included 40.0% of workers (n = 128), requiring investigation and intervention. Purple category (high risk) included 25.0% (n = 80), necessitating immediate intervention. Yellow category (limited risk) included 25.0% (n = 80), representing acceptable but monitoring-recommended status. Green category (no risk) was identified in only 10.0% (n = 32) of workers.

Workers with musculoskeletal symptoms showed significantly higher OCRA risk category severity compared to asymptomatic workers ($\chi^2 = 48.32$, $p < 0.001$). Pearson correlation between OCRA risk category (Green = 1, Yellow = 2, Red = 3, Purple = 4) and presence of upper extremity musculoskeletal symptoms showed moderate positive correlation ($r = 0.71$, $p < 0.001$), supporting OCRA Checklist sensitivity for this population.

**Table 2:** Distribution of RULA and OCRA Checklist Assessment Results (n=320).

| Assessment Method | Risk Category | n | % | Mean Score±SD |
|---|---|---|---|---|
| RULA | Low (1–2) | 48 | 15.0% | 1.7±0.5 |
| | Medium (3–4) | 112 | 35.0% | 3.6±0.4 |
| | High (5–7) | 160 | 50.0% | 5.8±1.2 |
| | Overall | 320 | 100% | 5.1±1.4 |
| OCRA Checklist | Green (No Risk) | 32 | 10.0% | 3.2±1.1 |
| | Yellow (Limited Risk) | 80 | 25.0% | 8.1±1.4 |
| | Red (Medium Risk) | 128 | 40.0% | 11.8±1.2 |
| | Purple (High Risk) | 80 | 25.0% | 16.2±2.1 |
| | Overall High-Risk (Red+Purple) | 208 | 65.0% | 13.6±2.8 |

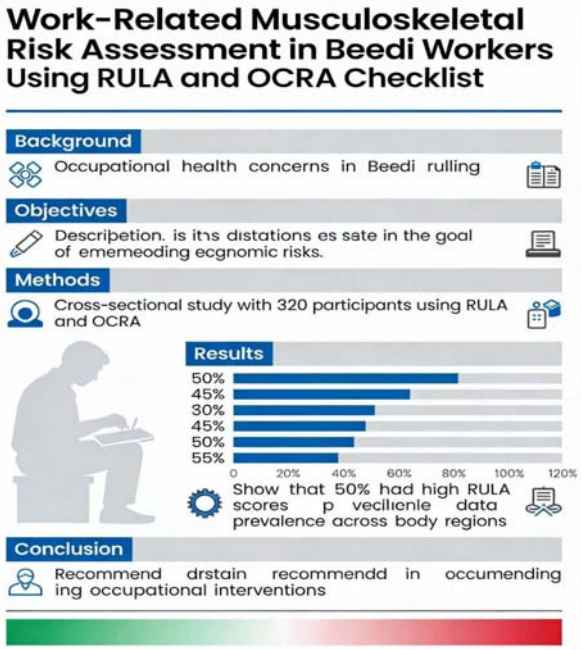


**Figure 3: Recommended Photograph Caption:** "Typical work posture of beedi workers demonstrating forward trunk flexion, knee flexion, and hand positioning during tobacco rolling activity. Note the inadequate workstation height requiring upper extremity elevation and cervical extension, contributing to neck and shoulder musculoskeletal stress."
*Photograph would show a worker in typical beedi-rolling position (with face anonymized) displaying the characteristic forward-bent seated posture with hands in fine motor rolling position.*

### Relationship Between Occupational Tenure and Risk Classification

Occupational tenure demonstrated significant positive relationship with ergonomic risk levels. Workers with >25 years occupational experience showed musculoskeletal symptom prevalence of 42.0% compared to 7.0% in those with <5 years experience ($\chi^2$ = 32.15, $p < 0.01$). Mean RULA scores increased progressively with occupational duration: <5 years (3.2 ± 1.1), 5–10 years (4.6 ± 1.3), 10–20 years (5.4 ± 1.2), >20 years (6.1 ± 0.8) (F = 34.28, $p < 0.001$). Similarly, OCRA Checklist risk categories showed progressive escalation with tenure ($\chi^2$ = 41.67, $p < 0.001$), indicating cumulative ergonomic burden effects.

### Correlation Between RULA and OCRA Assessment Methods

Pearson correlation analysis between RULA numerical scores and OCRA categorical severity (Green = 1 through Purple = 4) demonstrated strong positive relationship ($r = 0.82$, $p < 0.001$), indicating substantial concordance between assessment methodologies. This correlation suggests both methods identify similar high-risk individuals, though with complementary information—RULA focusing on postural analysis while OCRA emphasizes repetitive task characteristics and recovery period adequacy.

## Discussion

The current cross-sectional investigation provides comprehensive ergonomic risk characterization in Indian beedi workers using validated occupational health assessment methodologies. Key findings demonstrate substantial musculoskeletal risk burden and concerning postural/repetitive exposure patterns requiring immediate occupational health intervention.

### Musculoskeletal Symptom Prevalence and Distribution

The observed 63.4% overall musculoskeletal symptom prevalence

in this study population aligns with published epidemiological data indicating beedi worker populations experience elevated WRMS]D burden compared to general occupational populations. Lower back pain predominance (60.0%) and knee pain prevalence (50.0%) reflect the biomechanical demands of prolonged seated work with forward trunk flexion and knee flexion maintained throughout work shifts. The absence of adequate lumbar support, combined with sustained floor-sitting or low-seat work positions, creates substantial posterior chain muscular loading and intervertebral disc compression stress characteristic of this occupational pattern [15].

Neck and shoulder symptom prevalence (25.0% and 35.0% respectively) represents secondary postural consequence of inadequate workstation heights forcing upward gaze and shoulder abduction/elevation to access rolling materials. Wrist and hand symptoms (15.0%) reflect repetitive fine motor demands inherent in tobacco rolling manipulation. The symptom distribution pattern precisely mirrors occupational task demands, supporting construct validity of findings and indicating ergonomic factors as primary symptom drivers rather than non-occupational etiology.

### RULA Assessment Validity and Clinical Significance

The high proportion of workers classified in medium-to-high risk RULA categories (85.0% with scores 3–7) substantiates serious postural ergonomic concerns. The strong correlation between RULA scores and symptom presence ($r = 0.78$, $p < 0.001$) demonstrates RULA's utility for identifying symptomatic individuals in this occupational context. Previous comparative ergonomic assessment research has identified RULA as superior to alternative methods (REBA, OWAS) for detecting upper extremity and trunk postural risks [16], findings supported by the present data.

The mean RULA score differential between symptomatic ($5.8 \pm 1.2$) and asymptomatic workers ($3.9 \pm 1.1$) represents a 1.48-point difference with large effect size (Cohen's $d = 1.21$), indicating RULA's discriminative capacity. This substantial differentiation supports RULA's construct validity and practical applicability for occupational health surveillance in this population. The strong psychometric properties suggest RULA implementation would enable identification of high-risk individuals suitable for targeted intervention.

### OCRA Checklist Findings and Repetitive Strain Assessment

OCRA Checklist findings indicating 65.0% of workers in red/purple high-risk categories reflect the fundamental repetitiveness characterizing beedi rolling tasks. The bidi rolling work cycle typically contains 20–30 cycles per minute with sustained repetitiveness, minimal postural variation, and inadequate inter-task rotation, all factors elevating OCRA severity assessment. The strong correlation between OCRA risk categories and upper extremity symptoms ($r = 0.71$, $p < 0.001$) confirms the assessment's sensitivity for detecting cumulative repetitive strain patterns.

OCRA Checklist scores above the purple category (≥15 points) for 25.0% of workers indicate exposure levels typically requiring immediate intervention according to ISO 11228-3 standards. The predominance of Red category classifications (40.0%) suggests that while immediate intervention is not uniformly mandated, the majority of the workforce operates in an exposure spectrum warranting close monitoring and preventive measures. This intermediate-risk characterization may reflect task rotation opportunities, informal rest periods, or other organizational factors partially mitigating pure repetitive frequency effects.

### Assessment Method Concordance and Complementary Information

The strong correlation between RULA and OCRA assessment results ($r = 0.82$) indicates substantial methodological concordance, supporting the reliability of either method for occupational health surveillance in this population. However, the complementary nature of these tools—RULA providing biomechanical postural analysis while OCRA emphasizes repetitive task characteristics—suggests combined application provides more comprehensive risk characterization than either method alone. Workers identified as high-risk on both assessment methods represent individuals with compounded postural and repetitive strain exposure, indicating priority intervention candidates.

### Occupational Tenure Effects and Cumulative Burden

The significant positive relationship between occupational tenure and both RULA scores and symptom prevalence indicates cumulative ergonomic burden effects. The symptom prevalence differential (7.0% in <5 years experience *vs.* 42.0% in >25 years experience) represents a sixfold prevalence increase, suggesting either progressive symptom development with prolonged exposure or potential survivor bias (workers developing significant symptoms may exit the occupation). The progressive RULA score increase across tenure categories ($F = 34.28$, $p < 0.001$) suggests that postural stress effects accumulate, or alternatively, long-tenure workers may develop habitual postural accommodations to musculoskeletal symptoms, compromising posture further.

These tenure-based findings support the occupational health concept of "dose-response" relationship where cumulative exposure to ergonomic risk factors produces escalating symptom manifestation. Long-tenure workers (>20 years) represent a vulnerable subpopulation with highest intervention priority given established symptom burden and accumulated tissue damage.

### Clinical and Occupational Health Implications

The present findings generate several actionable recommendations for occupational health intervention:

1. **Workstation Redesign:** Current floor-level or low-seated working arrangements necessitate modification toward ergonomic workstations maintaining neutral spinal alignment. Workbench heights should allow 80–90-degree elbow flexion, eliminate forward trunk bending, and provide adequate lumbar support.
2. **Task Rotation Implementation:** Introducing task rotation among distinct upper extremity tasks (rolling, leaf selection, packing) would reduce sustained repetitive exposure while maintaining productive output. Rotation frequencies of 15–30 minutes between distinct tasks represent optimal intervals based on ergonomic literature.
3. **Rest Period Enhancement:** Current rest intervals require augmentation following ergonomic recommendations of 5–10 minute breaks for every 50–60 minutes of repetitive work. Structured stretching protocols during breaks specifically targeting affected musculature would facilitate recovery.
4. **Personal Protective Equipment:** Hand supports, wrist

splints, or ergonomic tool modifications may reduce force requirements and postural strain during fine motor activities.

5. **Worker Education:** Training in ergonomic principles, self-care practices, and early symptom recognition would enhance occupational health awareness and promote preventive behaviors.
6. **Surveillance and Follow-up:** Periodic RULA and OCRA Checklist reassessment following intervention implementation would document intervention effectiveness and guide program refinement.

### Study Limitations

Several limitations warrant acknowledgment: (1) Cross-sectional design precludes causal inference regarding ergonomic exposure-symptom relationships; longitudinal investigation would establish temporal precedence. (2) Study sample concentrated in single geographical region, potentially limiting generalizability to national beedi worker populations. (3) Symptom assessment relied on worker recall over preceding three-month period, potentially subject to recall bias. (4) RULA and OCRA Checklist assessments required standardized training; variation in assessor calibration could influence results, though quality assurance procedures minimized this threat. (5) Survivor bias may inflate symptom prevalence estimates if workers with significant symptoms preferentially exit the occupation.

## Conclusion

This cross-sectional investigation demonstrates substantial work-related musculoskeletal risk burden in Indian beedi workers using validated ergonomic assessment methodologies. RULA assessment identified 85.0% of workers in medium-to-high risk categories, while OCRA Checklist identified 65.0% in medium-to-high risk classifications. Overall musculoskeletal symptom prevalence of 63.4%, with concentration in lower back (60.0%) and knee regions (50.0%), reflects the biomechanical consequences of occupational exposure to prolonged static awkward postures and repetitive fine motor tasks. Strong correlations between ergonomic assessment scores and symptom prevalence (RULA r = 0.78, OCRA r = 0.71) support assessment tool validity and indicate ergonomic factors as primary symptom drivers.

Occupational tenure demonstrated significant dose-response relationship with risk levels and symptom development, suggesting cumulative occupational hazard effects. The complementary information provided by RULA (postural analysis) and OCRA Checklist (repetitive task assessment) indicates combined assessment approach provides comprehensive occupational risk characterization superior to either method alone.

Given the substantial documented risk burden, implementation of ergonomic intervention programs encompassing workstation redesign, task rotation, rest interval enhancement, and worker education represents immediate occupational health priority. Periodic reassessment using RULA and OCRA Checklist would guide intervention effectiveness evaluation and program refinement. The present findings contribute evidence supporting occupational health policy development and targeted intervention resource allocation for this vulnerable and underserved worker population.

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