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Assessing the Risk of Falls using the Ratings of Perceived Loss of Balance: A Pilot Study

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Author Note: Dr. Sang D. Choi, Ph.D., CPE, CSP is Professor and Director of Center for OESH in the Department of Occupational & Environmental Safety& Health at the University of Wisconsin - Whitewater, USA. Professor Choi is a nationally and internationally recognized scholar and practitioner in the areas of occupational ergonomics and industrial safety. He is the recipient of the University-Wide Outstanding Research Award and the National Safety Council Research Award. Dr. Choi has been serving as Program Committee Chair, Keynote Speaker and Session Chair at prestigious national and international conferences. Professor Choi's academic experience comprises teaching graduate and undergraduate courses in occupational ergonomics, construction accident prevention, analysis and design in safety, system safety analysis, and research methods. His field experience includes projects in multiple work environments including construction, manufacturing, healthcare, food process, steel production, and office settings projects. Dr. Choi's research interests are occupational ergonomics & safety, fall prevention & protection, work-related musculoskeletal disorders, aging workforce, human-computer interaction, work system analysis, prevention through design, and research to practice – practice to research.

Abstract: Workers in the roofing industry are over three times more likely to experience fatal occupational injuries when compared to construction workers overall. Falls from roofs occur more frequently than other types of falls, particularly among residential roofers. Workers working at residential construction sites had a higher risk of roof fatalities. The use of a subjective rating scale in matching human psychological feelings has long been in existence. Subjective evaluation has been widely used as a simple and valid measure to estimate the physiological response in applied situations, but hitherto not used to understand workers' psychophysical safety requirements during roofing task performance associated with inclined surfaces (e.g., steep roofs). The simple *Ratings of Perceived Loss of Balance (RPLB)* could be effectively used to monitor loss of balance or risk of falls in the construction work settings (e.g., pitched/sloped surfaces). The objective of this pilot study is to explore the effect of working posture on *RPLB*. Six male volunteers participated in the simulated roof shingling operations. A residential section of roof (26° slope) was constructed to simulate a roof-shingling task. After the participants were familiar with the procedures, each simulated roofing task was performed in a random order for 20 minutes in three different working postures (bending, kneeling and side sitting) respectively. Upon completion of each roof singling posture, the participant was asked to immediately provide their *RPLB*. Each participant's working heart rate and body discomfort in each working posture was also collected. The participants with "bending" working posture completed additional 11%-15% more shingles/sheets. However, the "bending" reported the greater body discomfort in the mid-to-lower back ranging moderate discomfort to very uncomfortable. The "kneeling" working posture induced the highest physiological workload, and also recorded the highest *RPLB* score. More detailed information on the preliminary findings and discussion are provided in the paper.

Keywords: falls, Ratings of Perceived Loss of Balance (RPLB), risk assessment, roofing construction

1. Introduction and Background

Roofing is one of the most hazardous tasks in the construction industry [Bureau of Labor Statistics (BLS), 2014]. Workers in the roofing industry are over three times more likely to experience fatal occupational injuries when compared to construction workers overall. Fall injuries not only bring suffering to construction workers, but also increase financial burdens to their families, employers, and society. The National Council on Compensation Insurance (NCCI) reported that falls from elevations cost insured roofers $54 million per year, about $106,000 per injured roofer, which is much higher than the average cost of falls from elevations of other occupations. Falls from roofs occur more frequently than other types of falls, particularly among residential roofers. About 67% of deaths due to falls from roofs in construction occurred to small establishments with 10 or fewer employees. Workers working at residential construction sites had a higher risk of roof fatalities (Choi, 2012). After

examining the influence of sloped surfaces on postural balance and adaptation period, Choi (2008) found that workers were experiencing a greater postural instability at an earlier phase of a task on a steeper surface, whereas a significant decrement in postural control on a flat surface existed after working on an inclined (pitched) surface.

The use of a subjective rating scale in matching human psychological feelings has long been in existence. Subjective evaluation has been widely used as a simple and valid measure to estimate the physiological response in applied situations, but hitherto not used to understand workers' psychophysical safety requirements during roofing task performance associated with inclined surfaces (e.g., steep roofs). Such ratings are important complements to physiological and biomechanical measurements of task performance and work safety. If an easy scale could be used to assess balance/risk of fall in a broad range of situations (e.g., residential/roofing construction) that could be very valuable. The simple (and easy to use) "Ratings of Perceived Loss of Balance (RPLB)" scale (Choi, 2005) could be effectively used to monitor loss of balance (risk of falls) in the construction work settings (e.g., pitched/sloped surfaces).

The objective of this pilot study is to explore the effects of working postures on ratings of perceived loss of balance (RPLB), physiological measures and body discomfort level.

2. Methods and Procedures

2.1 Experimental Setting and Apparatus

A workstation designed by Choi (2003) was re-constructed to simulate a roof-shingling task (Figure 1). The roofing workstation consisted of three components: base (5.49 × 3.66 m), inclined surface (5.49 × 3.96 m), and back support (5.49 × 3.05 m).

2.1.1 Workstation

The simulated roofing wooden deck/inclined surface was 26 degree (pitch) standard slope. The dimensions of simulated roofing workstation have shown in Figure 1.

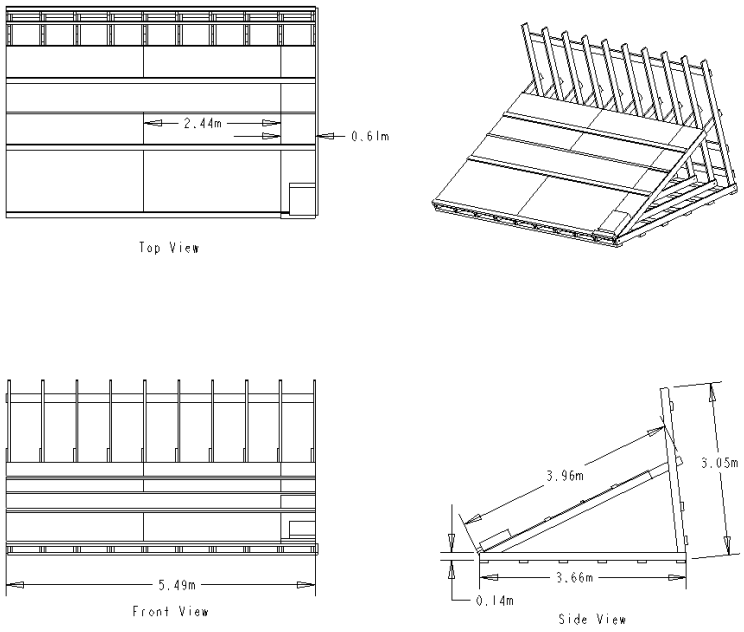

Figure 1. Dimensions of the Roofing Workstation (26º).

2.1.2 Shingles

Dimensional asphalt shingles were used in this experiment. A dimensional shingle is textured, over-layed, or laminated and is designed to produce a three-dimensional effect.

2.1.3 Nail Gun and Air Compressor Connector/Hose

A Hitachi NV45AB coil roofing nailer and an air compressor hose were used for the simulated roof shingling operations.

2.1.4 Anthropometrics and Strength Measurements

An anthropometric kit was used for taking anthropometric measures as well as a handgrip dynamometer were used to measure the maximum voluntary contraction (MVC).

2.2 Experimental Procedures

Each participant was allowed to become familiar with the experimental conditions and procedures.
After the participant was familiar with the procedures, each simulated roofing task was performed in a random order for 20 minutes in three different working postures (bending, kneeling, side sitting), respectively. After which, the participant was asked to immediately provide their Body Discomfort scores and Ratings of Perceived Loss of Balance (RPLB) (Table 1).

- Simulated roofing task 1 – *"Bending (forward) Posture"*
- Simulated roofing task 2 – *"Kneeling (both knees) Posture"*
- Simulated roofing task 3 – *"Side sitting Posture"*

Table 1. Ratings of Perceived Loss of Balance (RPLB)

"Please rate your feelings on the 0 - 7 scale"	*NT*	*JN*	*AL*	*MD*	*SS*	*ST*	*VS*	*ES*
	0	1	2	3	4	5	6	7
Did you feel at any time that you would slip while walking/working?								
Did you feel at any time that you would trip while walking/working?								
Did you feel at any time that you would lose your balance or become unsteady while walking/working?								
Did you feel at any time that you would fall while walking/working?								
What would you say was the overall difficulty of this task in terms of maintaining balance?								

NT = Nothing; JN = Just Noticeable; AL = A little; MD = Moderate; SS = Somewhat Strong; ST = Strong; VS = Very Strong; ES = Extremely Strong

3. Preliminary Findings and Discussion

3.1 Subjects

Six male volunteers, average 22.3 years old (SD: 2.3 years), participated in the study/lab experiment (i.e., simulated roof shingling operations). The average height and weight of the participants were 68.5 inches (SD: 1.5 inches) and 153.7 lbs (SD: 12.0 lbs). The participants were all right-handed and their average handgrip strength was 82.5 lbs (SD: 11.0 lbs). These

volunteers needed not have any experience in roofing because they were trained for the task. Each participant was screened for any history of medical complications.

3.1 Working Postures and Roofing Shingles

Each simulated roofing (asphalt shingling) task was performed in a random order for 20 minutes in three different working postures (i.e., bending, kneeling, and side sitting), respectively. The average number of roof shingles completed/laid by the participants was bending (74 sheets), kneeling (66 sheets), and side sitting (63 sheets), respectively (Figure 2).

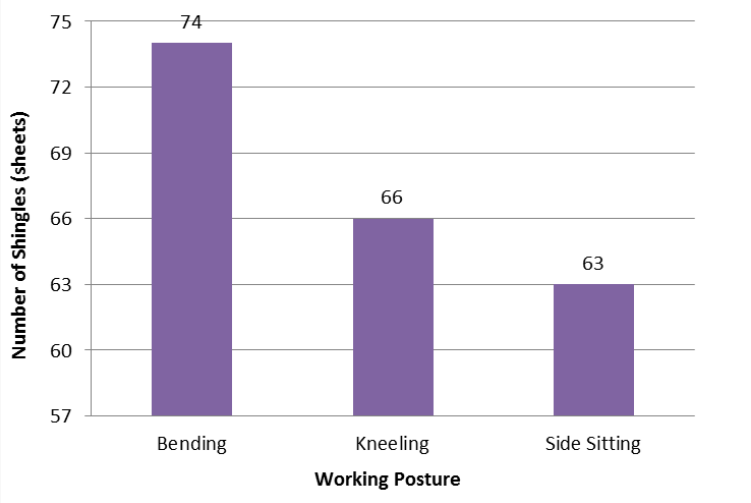

Figure 2. Number of Roof Shingles Completed at Three Different Working Postures

3.2 Working Heart Rates (HR) and Ratings of Perceived Loss of Balance (RPLB)

Figure 3 depicts the physiological measure (working heart rate) in the three different working postures (bending, kneeling, and side sitting) respectively. Kneeling posture induced the highest physiological workload (141 bpm) (SD: 8.2 bpm) followed by bending working posture (132 bpm) (SD: 12.2 bpm) and side sitting working posture (128 bpm) (16.1 bpm). Similarly, on the average Ratings of Perceived Loss of Balance (RPLB), kneeling working posture recorded the highest score of 12.5 (SD: 5.2) followed by side-sitting (8.5) (SD: 6.1) and bending posture (8.0) (SD: 4.9).

Figure 3. Working HR at Three Different Postures

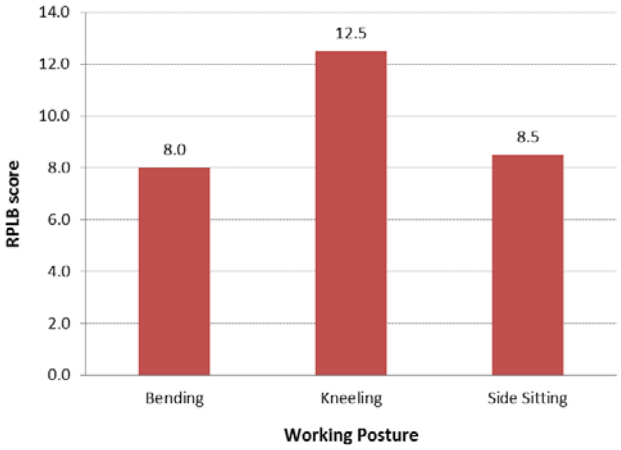

Figure 4. RPLB Score at Three Different Postures

3.3 Body Discomfort

Regarding to *"Bending"* working posture, the participants reported their body discomfort in *Mid-to-Lower Back* ranging *Moderate discomfort to Very uncomfortable*. Other uncomfortable body parts in bending working posture included Right Upper Arm, Left and Right Forearm, Buttocks, Left and Right Knees, Left and Right Lower Legs, and Left and Right Ankles/Feet. In the *"Kneeling"* working posture, the participants reported their *Mid-to-Lower Back*, raging *Fairly comfortable to Moderate discomfort*, while *Knees and Ankles/Feet* were ranging *Moderate Discomfort to Very Uncomfortable*. In regards to the *"Side Sitting"* posture, the participants reported *Moderate Discomfort* in their *Right Upper Arm*, and *Fairly comfortable to Moderate discomfort* in their *Mid-to-Lower Back*.

4. Acknowledgement

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