



Effects of rigid and back-support exoskeletons during simulated shingling

Rigid and soft back-support exoskeletons affect biomechanical and perceptual demands, but in different ways, during simulated shingle installation

Jiwon Choi, Sunwook Kim, Ahmad Raza Usmani, Alan Barr, Carisa Harris-Adamson, Maury A. Nussbaum. Applied Ergonomics, 2026.

Overview

Roofing is among the most physically demanding construction trades, with more than 50% of roofers annually experiencing at least one work-related musculoskeletal disorder (WMSD). They are particularly at risk of back-related WMSDs because the nature of roofing work requires spending over 75% of working hours in strenuous postures such as forward bending from the waist, kneeling, crouching, or crawling. Roofing tasks—especially shingling—present unique ergonomic challenges due to the demands of working on sloped surfaces. Passive exoskeletons are an emerging approach to mitigating occupational physical demands, with back-support exoskeletons (BSEs) potentially reducing physical demands roofers face. In this study, 18 participants performed simulated shingle installation tasks with all combinations of 1) three BSE levels (rigid, soft, and no BSE), 2) two orientations (peak-facing vs. side-facing), and 3) two roof slopes (18° vs. 26°). The researchers used electrodes to measure muscle activation and sensors to measure forward bending, and they asked participants to rate their physical exertion level.

For more information, contact:

Maury Nussbaum: nussbaum@vt.edu

Read the abstract:

bit.ly/4sZBQGi

©2026, CPWR—The Center for Construction Research and Training. All rights reserved. CPWR is the research and training arm of NABTU. Production of this document was supported by cooperative agreement OH 012761 from the National Institute for Occupational Safety and Health (NIOSH). The contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

Key Findings

- The rigid back-support exoskeleton (BSE) significantly reduced lumbar muscle activation (11–17%) compared to no BSE; however, the absolute magnitude of this reduction was small (<3% MVIC).
- The soft BSE reduced trunk flexion (~4%) without altering lumbar muscle activation.
- Both BSEs reduced perceived low back exertion (~16%); however, the rigid BSE increased leg discomfort (~26%), and the soft BSE increased shoulder exertion (~19%).
- BSE effects were similar across roof slopes and orientations.
- The study's results suggest that using BSEs can be beneficial for shingle installation tasks but also highlight the importance of considering device-specific biomechanical benefits and associated trade-offs to ensure effective application.



THE CENTER FOR CONSTRUCTION
RESEARCH AND TRAINING

WWW.CPWR.COM