NIOSH Research Success Using Extramural Partnerships and Collaborations

Chris Pan, Ph.D., CPE

July 28, 2022

Agenda

- Presentation Objectives
- Primary Projects and Partnerships
  - Helmet Project
  - Mast Climber Project
  - Exoskeleton Project
  - Truck Driver Project

Objectives

- The presentation will address three NIOSH ongoing project activities and partnerships in the construction sector, and a previous NIOSH project in the transportation sector.

- The presentation will focus on various collaborative experiences with industrial partners, manufacturers, academic institutions, researchers, and other research and governmental institutes.

Partner Involvement

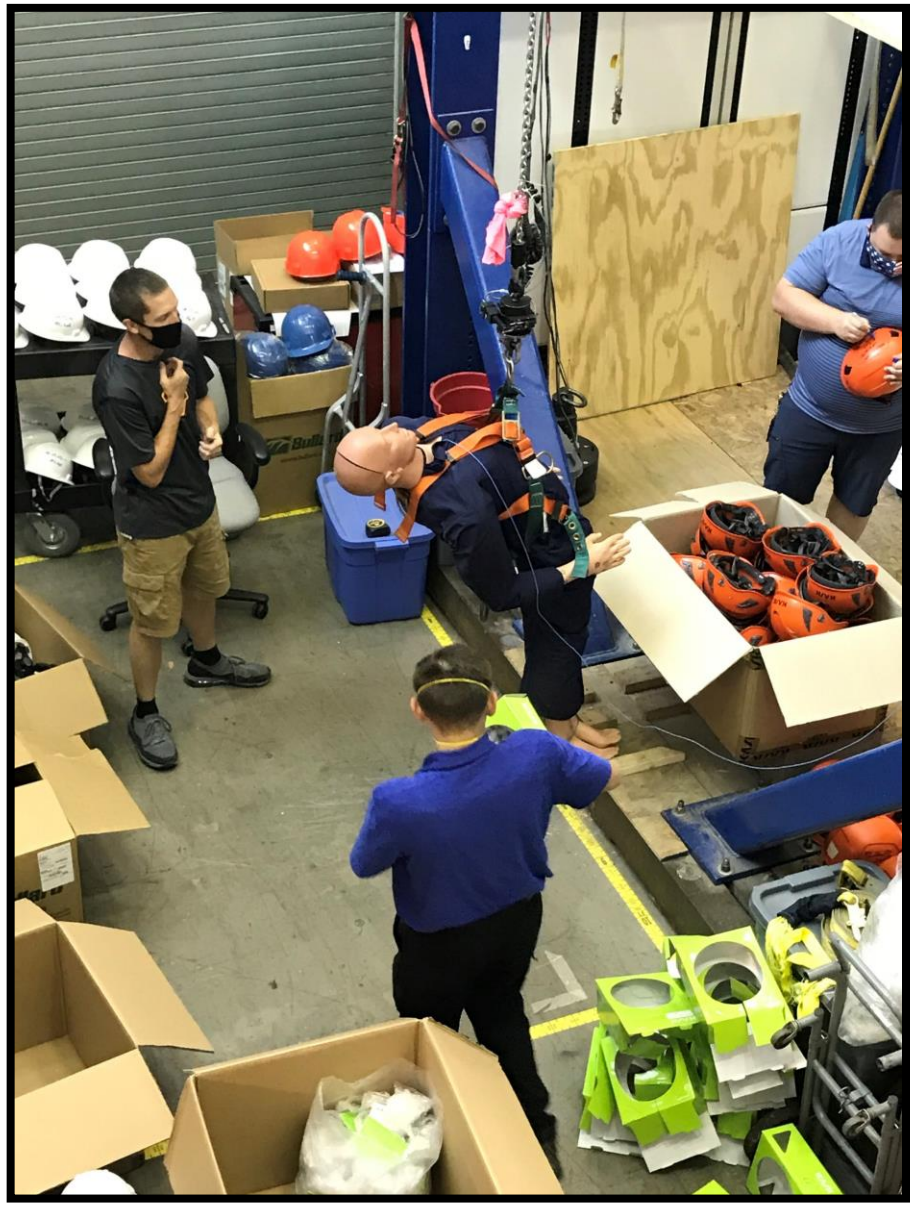
	Helmet	Mast Climber	Exoskeleton	Truck Driver
Project Conception	√	√	√	
Planner	√			√
Research Collaboration	√	√	√	√
Funding Source	√	√	√	√
Research Translation	√	√	√	
Research Dissemination	√	√	√	
Evaluator	√			

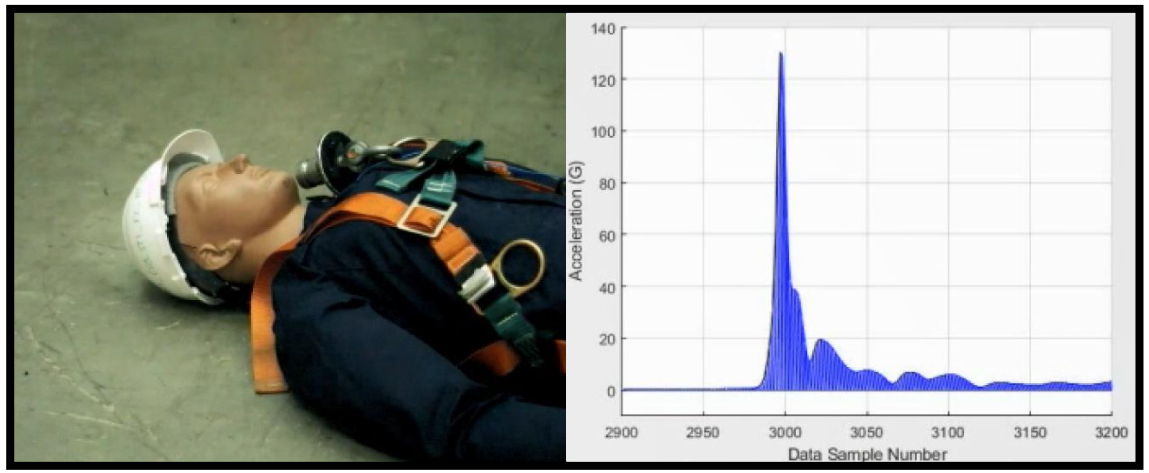
Helmet Project

***Project Objective*:**

To optimize helmet design to reduce severity of head injuries based on head injury mechanisms

Partnerships





Partnerships

ISEA INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION

ANSI/ISEA Z89.1-2014 Industrial Head Protection

WV SCHOOL OF MEDICINE

Sponsors

CHUBB®

Liberty Mutual®

Turner Building the Future

ZURICH®

CDC NIOSH

Evaluation of the Fall Protection of Type I Industrial Helmets

John Z. Wu, Christopher S. Pan, Clayton Cobb, Andrew Moorehead, Tsui-Ying Kau, and Bryan M. Wimer

National Institute for Occupational Safety and Health, Morgantown, WV, USA

(Received 12 October 2021; accepted 17 January 2022)

Associate Editor Stefan M. Duma oversaw the review of this article.

Abstract—The performance of Type I industrial helmets for fall protection is not required to be tested in standardized tests. The current study analyzed the fall protection performance of Type I industrial helmets and evaluated if the use of a chin strap and the suspension system tightness have any effect on protection performance. Head impact tests were performed using an instrumented manikin. There were 12 combinations of test conditions: with or without chin strap usage, three levels of suspension system tightness, and two impact surfaces. Four representative helmet models (two basic and two advanced models) were selected for the study. Impact tests without a helmet under all other applicable test conditions were used as a control group. There were four replicates for each test condition—a total of 192 impact tests with helmets and eight impact tests for the control group. The peak acceleration and the calculated head impact criteria (HIC) were used to evaluate shock absorption performance of the helmets. The results showed that all four helmet models demonstrated excellent performance for fall protection compared to the barehead control group. The fall protection performance of the advanced helmet models was substantially better than the basic helmet models. However, the effects of the use of chin straps and suspension system tightness on the helmets' fall protection performance were statistically not significant.

Keywords—Industrial helmet, Manikin, Fall impact, Head impact criteria (HIC), Abbreviated injury scale (AIS).

INTRODUCTION

Many epidemiological studies indicate that work-related traumatic brain injury (WrTBI) is one of the most serious occupational injuries among construction workers, resulting in extensive medical care, multiple days away from work, permanent disability, and sometimes death.[15,19,21,22,32,33] Approximately 15.6% of the WrTBIs were the results of being struck on the head by objects.[5,17,21] In the United States, over 30% of crane accidents were due to being struck by loads or objects.[36] The risk of head injuries in struck-by incidents could potentially be reduced when wearing protective helmets. Wearing an industrial helmet is recognized as one of the important prevention strategies in construction sites to reduce WrTBIs.[18,33] Occupational Safety and Health Administration (OSHA) regulations require workers to wear a helmet to reduce the risk of head injury from falling objects.[27]

Industrial helmets are categorized as Type I or Type II according to ANSI Z89.1 standard.[3] These two helmet types have different purposes: Type I helmets are designed for top impact to protect against falling objects, whereas Type II helmets are designed for both lateral and top impacts. Type I helmets are the most popularly used in construction sites and by manufacturers as "general purpose" helmets for workers' safety protection. Besides the hazard of being struck by falling objects, slips, and trips, falls are another major hazards that are associated with high rates of accidents in typical construction sites.[20] A surveillance study of Nigerian construction workers showed that the hazards of falling from low heights (such as falling from a ladder, slips, trips, and other low falls) are ranked second out of 11 types of identified hazards.[6] The performance of Type I industrial helmets for fall protection has not been tested, since Type I helmets are not required to be tested for lateral impacts in standardized tests.[3,4]

The retention system is an important component to keep a helmet on the wearer's head. The retention system of a construction helmet typically consists of a

Address correspondence to Christopher S. Pan, National Institute for Occupational Safety and Health, Morgantown, WV, USA. Electronic mail: cpan@cdc.gov

Published online: 05 February 2022

CDC NIOSH

Industrial helmet injury protection from falls

Study highlight from Liberty Mutual Insurance

Liberty Mutual INSURANCE

Let's explore the practical implications of this research study:

Evaluation of the fall protection of type I industrial helmets[1]

Falls from height and falls on the same level are the #1 and #4 most costly workplace injuries for construction in the United States (approximately $4.25 billion per year).[2]

Type I helmets are designed to protect workers from objects that fall from above. This NIOSH study, partially supported by Liberty Mutual, sought to test whether type I helmets could offer protection against head injury due to falls. By dropping manikins in a controlled backward fall of 5-feet, with and without helmets, researchers found:

- All tested helmet models **significantly reduced** head impact forces and their likelihood to cause serious or severe injury
- More advanced helmets (think safety helmet designs over classic hardhats) offered **significantly more protection** than basic hardhat designs, reducing the probability of serious injury to 28% or less

How you can help

Employers can do their part to help prevent injuries from falls in the construction industry.

Provide appropriate safety equipment

- Supply and enforce wearing industrial helmets on the jobsite, and consider supplying more advanced safety helmet designs
- Implement fall protection systems
- Utilize ladders and step stools of appropriate height

Plan ahead

- Know what needs to be done and the path that will be traveled
- Eliminate slip and trip hazards
- Create designated pedestrian pathways in high traffic areas
- Calculate total fall clearance distance to prevent workers from hitting a lower level in the event of a harnessed fall

Keep jobsites organized

- Keep tools, trash, and supplies in designated areas to keep pathways clear
- Tape cords or hoses to the surface and make them clearly identifiable with cord corrals
- Illuminate the job site to make sure the slip and trip risks can be seen; utilize diffuse lighting to help prevent shadows

Study limitations

Manikins were tested at one height for a fall in a single direction under controlled laboratory conditions. Impact and injury reduction on human workers may differ during actual jobsite use.

Risk Control resources to get you started

As a policyholder, you have exclusive access to Risk Control tools and resources through Liberty Mutual SafetyNet™ — visit **lmi.co/safetynet**

- Guidelines for selecting a fall arrest anchorage system, RC 5442
- Portable ladders, RC 858

References

1. Wu JZ, Pan CS, Cobb C, Moorehead A, Kau TY, Wimer BM. Evaluation of the fall protection of type I industrial helmets. Annals of biomedical engineering. 2022 Feb 5:1-4.
2. Liberty Mutual Insurance (2022). 2022 Liberty Mutual workplace safety index. Retrieved from https://business.libertymutual.com/wp-content/uploads/2022/06/WSI-1002_2022.pdf

Collaborating Helmet Manufacturers

Bullard®

KASK

MSA

CDC NIOSH

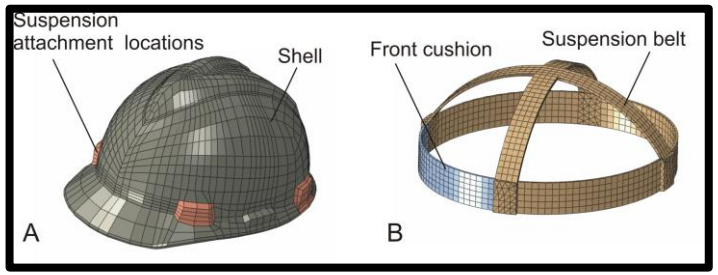
Partnerships (Cont.)

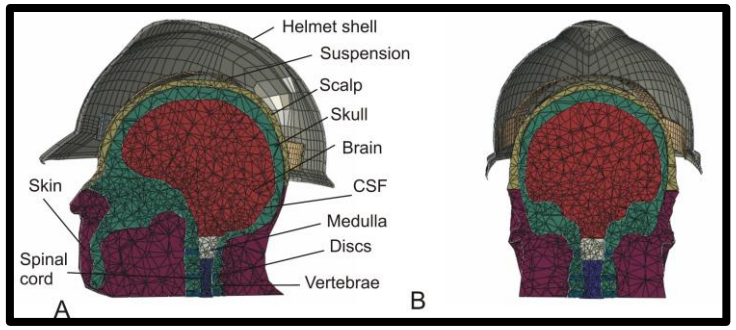
Partners from Industries and Academic Institutes

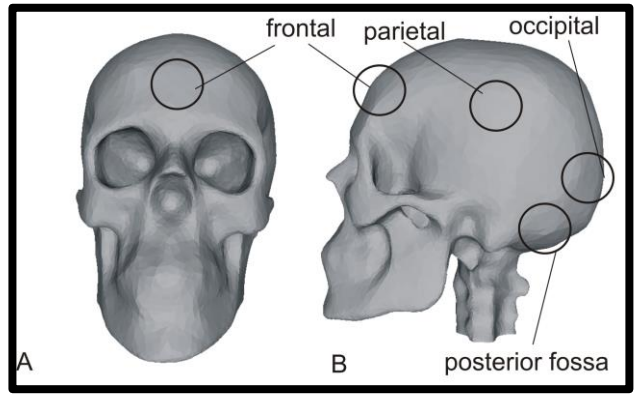
SCHOOL OF MEDICINE

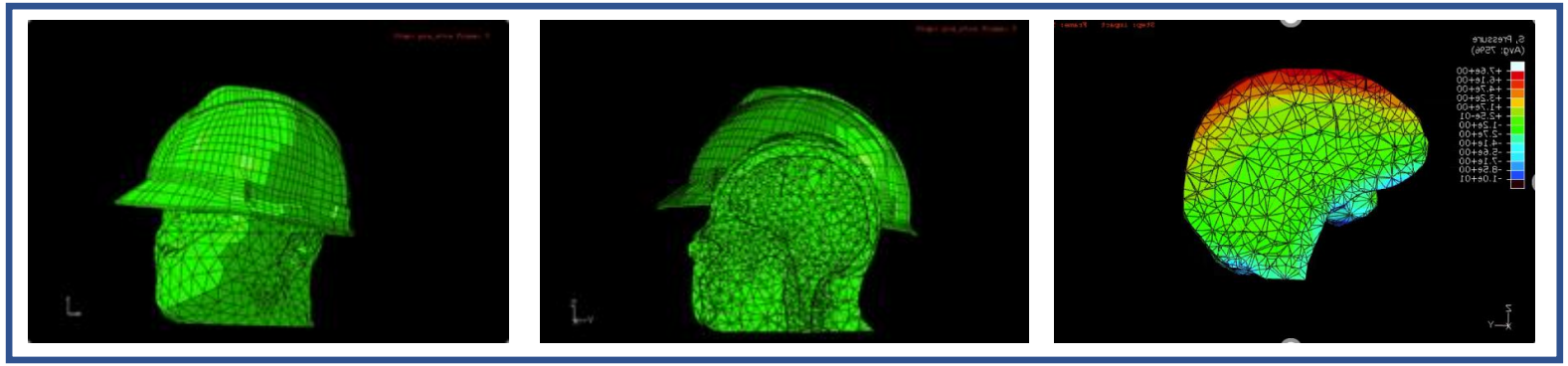
UC San Diego School of Medicine

MSA









CDC NIOSH

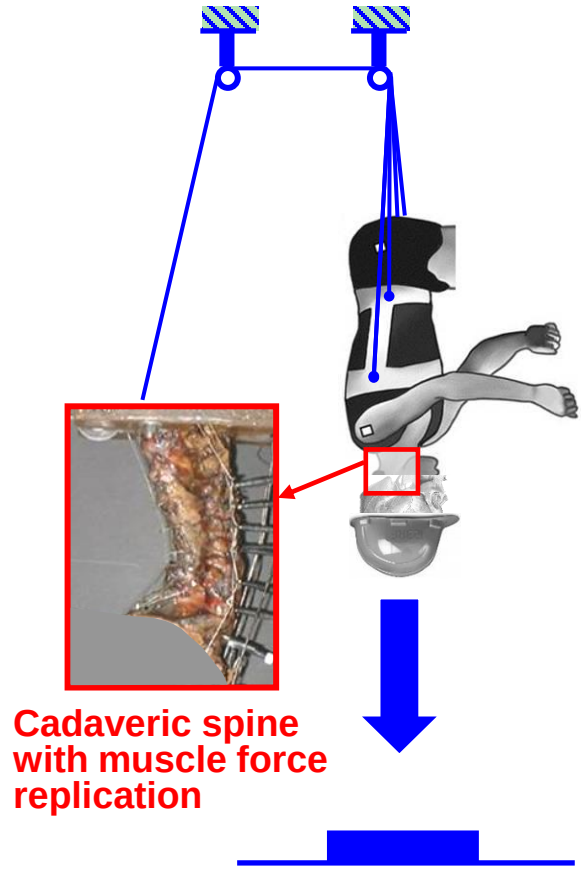
Partnerships (Cont.)

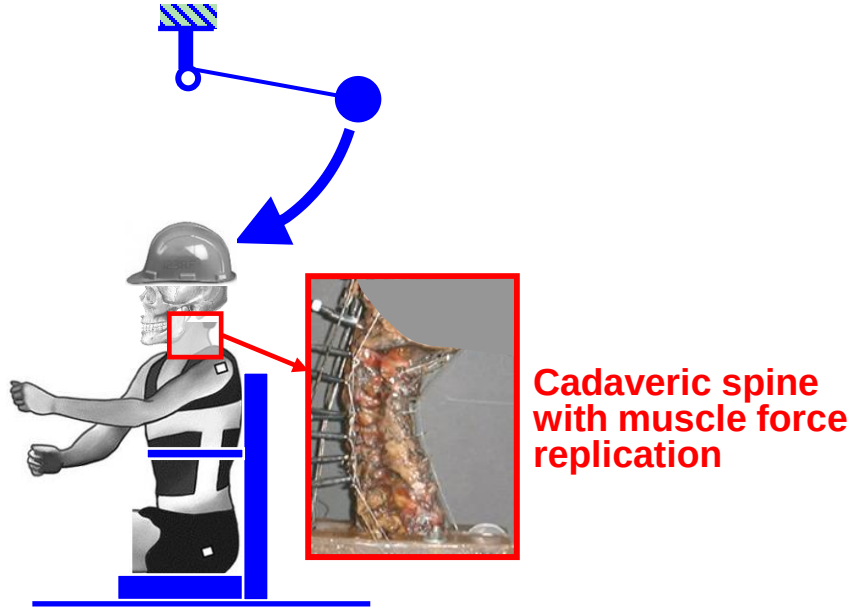
Yale University
School of Medicine

Proposed Cadaveric Studies not Funded

NIOSH and NIH grant applications in 2015 and 2016:

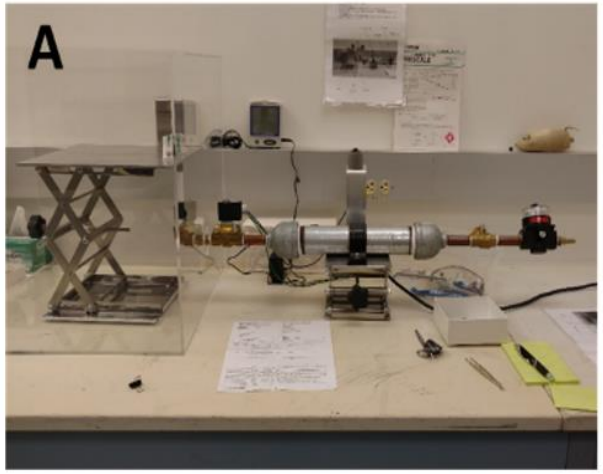
- Title: *"Optimized construction helmet for prevention of brain and spinal cord injuries"*
- PI and collaboration partner: Dept. of Orthopedics & Rehabilitation, Yale University School of Medicine
- Radiopaque surrogate brain & spinal cord imaged using high-speed cineradiography

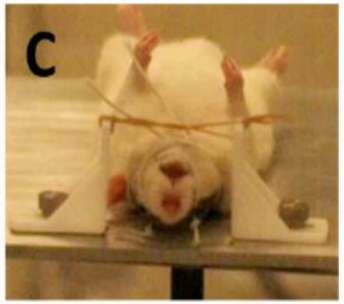


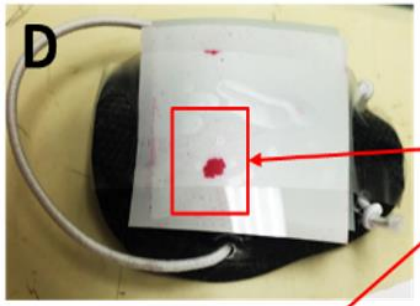


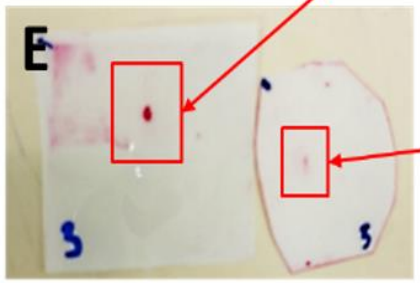
Partnership with WRAIR: Animal Model Development

Partnership with WRAIR: Animal Model Development
using Projectile Concussive Impact (PCI)









Impact force, outside of helmet (dark red indicates ↑ force)

Impact force, **INSIDE** of helmet (note pressure film spot is much lighter, indicating helmet absorbed majority of the force when comparing outside helmet reading)

Looking Ahead
Additional Partnerships Are Expected

- A new NORA IFR was recently approved: Air-Bubble Cushioning Liners to Improve Construction Helmet Shock Absorption Performance (FY23-FY26).

- NIOSH study team is expected to work with helmet manufacturers to fabricate safety helmets using this patentable technology.

Mast Climber Project

***Project Objectives*:**

- To evaluate production (mason) table effectiveness
- To identify possible safety gaps in anchored MCWP configurations

Partnerships

CPWR
THE CENTER FOR CONSTRUCTION
RESEARCH AND TRAINING

ABC FRACO
A division of Chinook Scaffold Systems Ltd

SKYJACK
simply reliable

ANSI
ANSI A92
Mobile Elevating Work
Platform (MEWP) Standards

Sponsor

JSI
Job-Site Safety Institute℠

CDC NIOSH

Partnerships (Cont.)

Partnerships Involving with Training and Testing

CDC NIOSH

Production Tables on Mast Climbers

Applied Ergonomics 90 (2021) 103276

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: http://www.elsevier.com/locate/apergo

Biomechanical assessment while using production tables on mast climbing work platforms

Christopher S. Pan *, Xiaopeng Ning, Bryan Wimer, Joyce Zwiener, Tsui-Ying Kau

Division of Safety Research, National Institute for Occupational Safety and Health, 1095 Willowdale Road, Morgantown, WV, 26505, USA

ARTICLE INFO

Keywords:
Mast climbing work platform
Production table
Back injury
Postural stability

ABSTRACT

The objective of this study was to assess the impact of using alternative mast climbing work platform (MCWP) designs on trunk motion and postural stability with masonry workers while performing bricklaying and stepping down tasks using a conventional MCWP setting (i.e. with a step deck) as well as two types of production tables (straight- and L-shaped). The trunk angles and postural sway parameters of twenty-five masonry workers were recorded for the following tasks: (1) standing on a simulated MCWP and laying bricks on an adjacent wall, and (2) stepping down onto the step deck to get into position for doing the bricklaying task. Results indicated that the use of the L-shaped production table resulted in the lowest trunk ranges of motion and significantly reduced the workers' trunk angles in all three planes when compared to both the straight-shaped production table and the conventional approach of not using a production table. Data showed that both body sway velocity and area were significantly reduced when using either one of the production tables. The use of production tables significantly reduced impact sway forces when workers stepped from the main platform to the step deck. The use of production tables on MCWPs improved workers' postures and overall stability, which could reduce the risk of injury.

1. Introduction

Mast climbing work platforms (MCWPs), or mast climbers, are elevating equipment, that have been available in the United States since the 1980s. Due to their advantages, MCWPs have become more common throughout the 1990s and 2000s, and their popularity has continued to increase. An essential factor in all MCWPs designs is a powered drive unit that moves the work platform up and down a vertical mast structure. MCWPs are capable of handling much greater loads (including workers and materials) than traditional scaffolding. They also make reaching greater heights much easier, thereby improving efficiency on construction projects. MCWPs can be configured in many ways, from freestanding models that can be used on shorter working heights to anchored models that can reach heights of over 1000 feet. MCWPs are used as an alternative to traditional pole, tubular and coupler scaffolds. Their use frequently avoids idle time for specialty contractors (e.g., masons and labors) and setup crews thus increasing productivity.

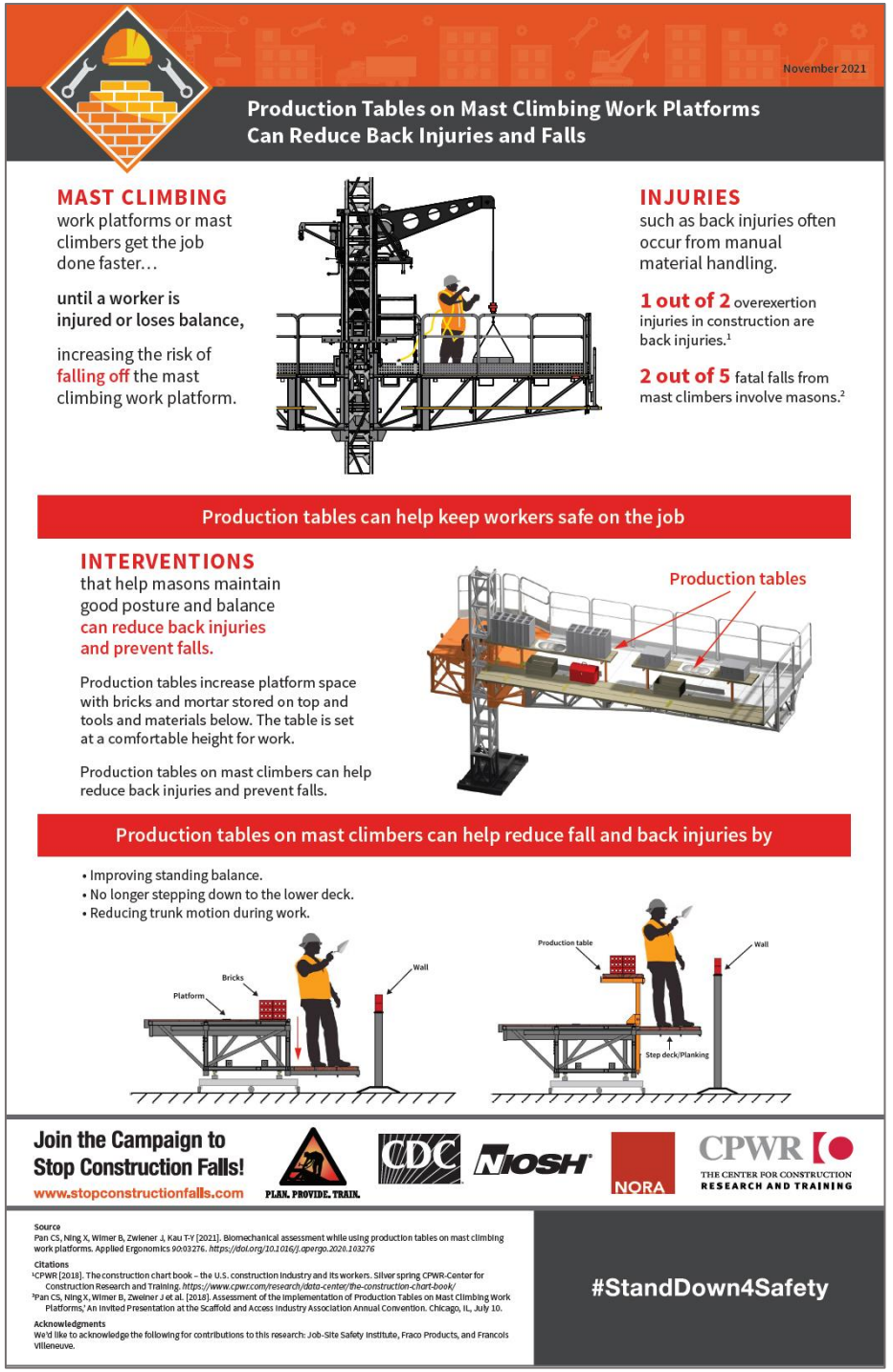
Even though MCWPs have been available since the 1980s, there are limited studies in the occupational safety literature concerning their impact on worker safety and health. Published or peer-reviewed materials elucidating the occupational-hazard component of continued use of MCWPs are difficult to find. Hazards associated with MCWPs are apparent based on the reported incidence of injuries occurring with their use. Concerns of potential hazards have also been raised by users, standards committees, renters and manufacturers (American National Standards Institute, 2011; O'Shea, 2014; Wimer et al., 2017). The basis for this project (O'Shea, 2014) are the hazards currently recognized from input by industrial manufacturers and observations by renters and users of MCWPs.

The rate of adopting MCWPs for use on construction sites is high and increasing, especially among masons and other specialty contractors (Susi et al., 2010). Construction job bidders and planners frequently specify mast climbers in contract proposals. This is due to several reasons: 1) there are productivity and efficiency advantages to using MCWPs; 2) time-to-completion of construction projects is frequently a function of the availability of mechanized elevating equipment (Pan et al., 2012a); 3) equipment technology, like the MCWP, frequently shorten the period of construction; and 4) their use allows for rapid, purposeful scheduling of job activities. However, little research has been conducted on the ergonomics and safety of MCWPs.

Of the 22,000 MCWPs in use in the United States, roughly 70% are used daily (O'Shea, 2014). Potentially as many as 50,000 U.S. workers

* Corresponding author.
E-mail address: cpan@cdc.gov (C.S. Pan).

https://doi.org/10.1016/j.apergo.2020.103276
Received 5 May 2020; Received in revised form 18 September 2020; Accepted 21 September 2020
0003-6870/Published by Elsevier Ltd.



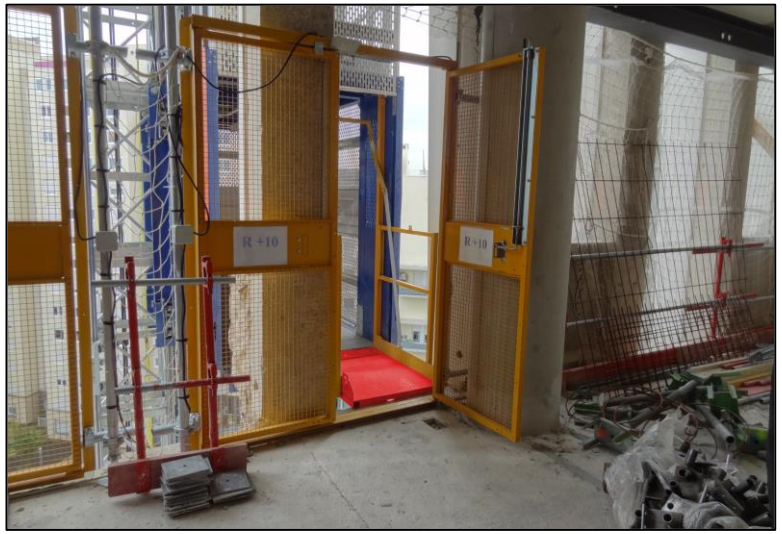
CDC NIOSH

Exoskeleton Project

- Assessing: 1) a cinder block lifting activity by masons using a mast climber; 2) an overhead wire assembly activity by electricians using a scissor lift; and 3) ingress/egress activity by construction laborers using a construction elevator

Mast Climber

Scissor Lift


Construction Elevator

CDC NIOSH

Partnerships

TEXAS TECH UNIVERSITY

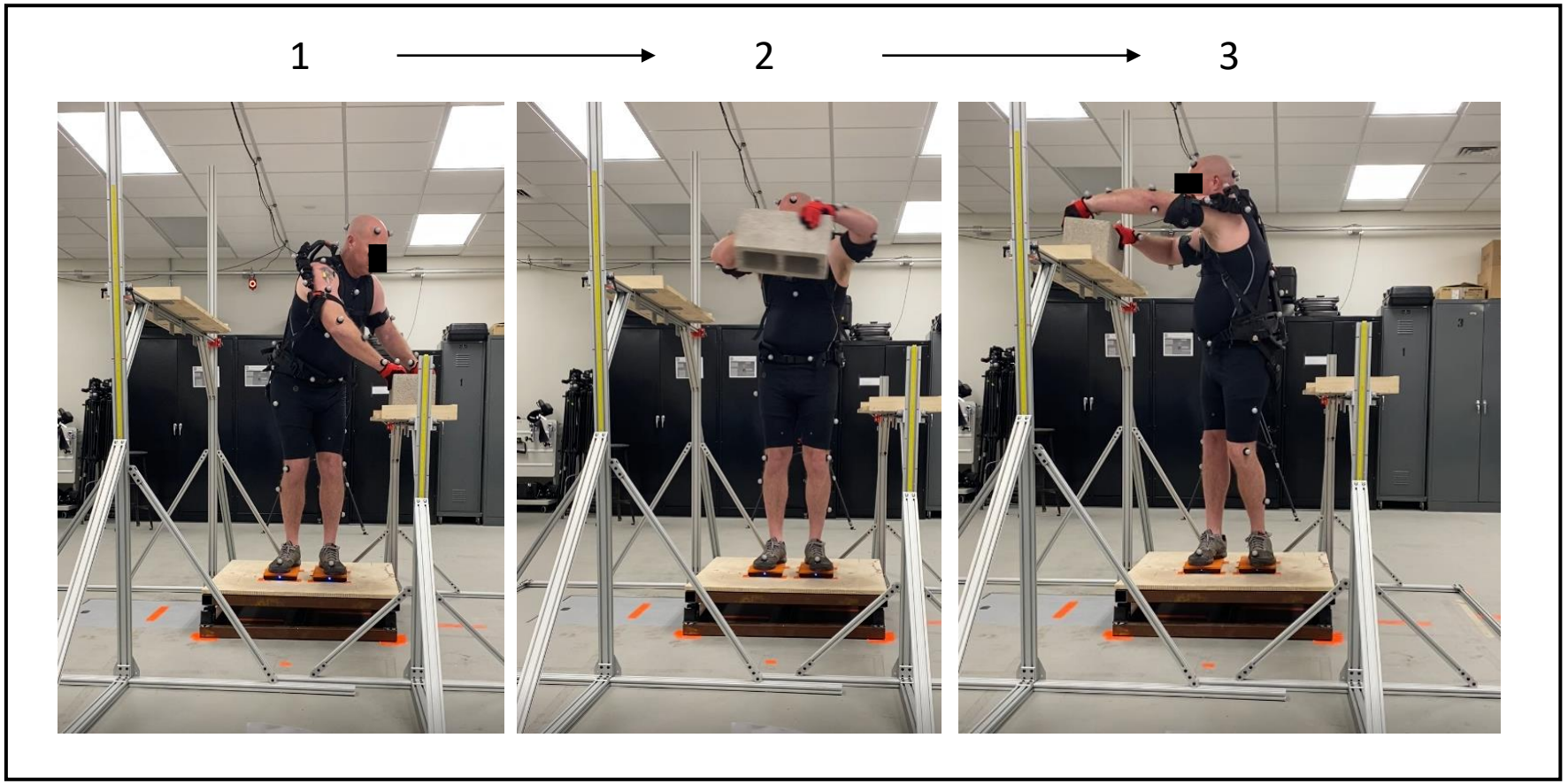
OSU Oregon State UNIVERSITY

TBD

Partnerships (Cont.)

Collaborative Data Collection

- Cinder block lifting exertion
- Simulated wobbling platform level
- Simulated wall (left) in participant shoulder height
- Production table (right) in participant trochanterion height



Truck Driver Project

Project Focus:

- An image-based analysis of gap acceptance behavior of large truck drivers on lane changes using naturalistic driving data*
- Accelerated evaluation of automated vehicles using extracted naturalistic driving data*

*IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS 2015, 2016

Partnerships

NIOSH Project Team Members

Ren Dong, HELD

Mat Hause, DSR

Tim Lutz, PMRD

Diane Miller, HELD

Jim O'Callaghan, HELD

John Powers, NPPTL

Stephanie Pratt, DSR

Mahmood Ronaghi, DSR

Nancy Romano, DSR

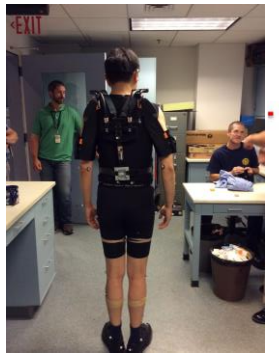
Chris Warren, HELD

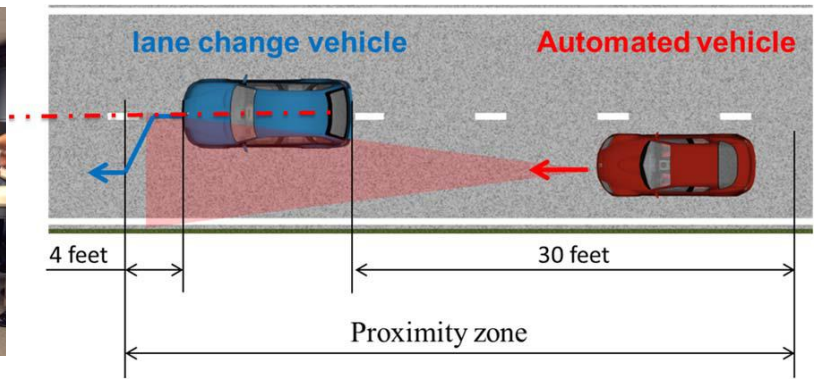
Bryan Wimer, DSR

John Wu, HELD

Liying Zheng, HELD

Joyce Zwiener, DSR





Thank you for your kind attention

Email: cpan@cdc.gov

NIOSH Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.