Chapter

The Importance of Exposure Assessment in Blue Collar Jobs: Construction as an Example

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Abstract

Exposure to musculoskeletal disorder (MSDs) risk factors are not only common but also omnipresent in almost every workplace. The purpose of this chapter is to describe how we can attempt to reduce the exposure to the risk factor in order to attain a reduction in negative physiological outcomes (like injuries and illnesses). Blue collar jobs are often subject to heavy manual handling and intervening these jobs with any new technique is burdensome. This chapter gives the example of construction job as a blue collar and hard to reach job in which an intervention was implemented in a systematic way.

Keywords: construction, intervention, exposure, physical, ceiling, installation, hazards

1. Introduction

The construction sector is dynamic and usually follows a rigid work schedule. The high number of acute and chronic injuries and illnesses put construction sector as one of the most dangerous workplaces in the United States. Due to the production-oriented nature of the job, exposure to the risk factors is not uncommon in construction related jobs. Opportunity of using the personal protective equipment (PPEs) is not scarce but high production pressure necessitates the workers to focus more on the outcome than a safe procedure.

The author of this chapter has carried out several focus groups in different construction sectors in greater Boston area. In the author's experience, the workers most of the time, discussed on the issues of the weight of the panels. It is noteworthy that in any focus groups, the workers did not participate well if the facilitator used words like 'safety', 'problem', 'research' or 'solution'. However, the workers spontaneously participated while they were asked about 'any concern they can share' with the facilitator. In such focus groups, the workers were supposed to brainstorm with any possible ideas of implementing or using an assistive device for ceiling installation. Before we learn about the possible solutions, let us have a look at the problems associated with ceiling installation in the following.

2. Drywall panel installation

The main operation of drywall carpentry is installation of the drywall panels onto the walls and ceilings. Installation of drywall panels is faster and cheaper than plaster walls. The drywall installers lay out the whole interior wall system and ceiling with studs and hang large drywall panels to the ceiling and sidewalls.

Drywall panels consist of a layer of gypsum (often used as building material) between two layers of heavy paper. In commercial applications, the standard sizes are 4 ft. X 8 ft. and 4 ft. X 12 ft. with a 5/8 inch thickness. The usual weight of a 4 ft. X 8 ft. panel is 70 lbs. and that of a 4 ft. X 12 ft. is 105 lb. [1]. The panels used in residential carpentry are 4 ft. X 8 ft. with a thickness of ½ inch.

The main difference between residential and commercial drywall installation is the use of wood studs in residential carpentry instead of lighter metal studs in commercial carpentry. As far as the hanging of the drywall itself is concerned, there are no other significant differences between the two settings.

In the case of ceiling installation, usually a pair of installers lifts the panels to the ceiling while standing on separate ladders. One of the installers continues to hold the panel to the ceiling while the other installer uses the screw gun and affixes the panel permanently on his side. The first installer then releases one of his hands to use the screw gun until the panel becomes attached to the ceiling (**Figure 1**). In the case of smaller drywall pieces, one installer instead of two carries out the process.

For wall installation, the entire 4 ft. X 8 ft. or 4 ft. X 12′ pieces are attached vertically to the wall; this is often carried out by a single installer. For walls more than 12′ high, wall installation might include horizontal attachment of more than one panel.

The main tasks of the drywall installation process, which the workers carry out in a routine sequential order, are as follows [2]:

- **Stacking:** After getting unloaded from the truck, the drywall panels are stacked at the site on different floors. Generally the panels are put on each floor by a crane and then pulled through the window of the respective floors. In absence of an elevator, the workers carry the drywall panels through the stairs.

- **Carrying:** Carrying is required to bring the panels from the place of stacking to the place of installation. Workers also need to carry the panels for housekeeping and fitting (both described below).

- **Measuring:** The panels are measured according to the dimensions needed. This is done before cutting and installing them in the desired place.

Figure 1.
Holding the panel, being on ladder.

Figure 2.
Lifting the panel.

- **Cutting:** The panels are cut into the necessary dimensions. There are two main cutting operations: a) cutting of whole panels into two or more pieces, b) selective cutting of smaller parts to fit them around doors, windows, electrical and plumbing outlets.

- **Fitting:** Cut panels are measured several times before installing them.

- **Lifting:** In the case of lifting the panels to the ceiling, the workers might stand on a ladder or scissor lift based on the height of the wall, as shown in **Figure 2**.

- **Attaching:** Attachment of the panels is done with a screw gun. In case of attachment to the ceiling, workers might work in pairs. One of them holds the panel while the other one screws it into the studs (**Figure 1**).

- **Housekeeping:** At the end of a work day, the workers remove rejected pieces to the trash and keep the unused pieces back at designated places for the next day's use.

3. Handling and carrying heavy drywall panels as sources of exposure

Handling and carrying the heavy and bulky drywall panels have been cited as exposure sources for the high amount of back and shoulder muscle injuries of drywall carpenters. Handling of heavy drywall pieces was reported by [3], to be associated with more than 40 percent of the overexertion injuries of drywall workers. In this study, more than 15% of total traumatic injuries were muscle overexertion due to lifting of the heavy drywall panels, whereas 37.2% of total traumatic injuries were injuries due to bodily reaction while handling the drywall panels.

4. Biomechanical stress exerted on back when lifting panels as a source of exposure

Ref. [4] analyzed the four most common techniques (three horizontal and one vertical) used to lift a drywall panel and showed that each lifting technique exerted a minimum of 655 lb. disc compression force on the low back (L5/S1 region) of the workers whether for a 60 lb., 80 lb. or 100 lb. drywall panel. The same study found that low back loading while lifting a 100 lb. drywall panel exceeds 760 lb., the maximum value recommended by NIOSH in the Work Practices Guide for Manual Lifting. All four lifting techniques also involved risk of perturbation in postural balance [5].

Yuan et. Al., [2] found that the average disc compression force during installation of drywall panels exceeded value of 760 lb. (3400 N) disc compression force, set by NIOSH as the recommended action limit. The highest value of disc compression force in this study was found to be 1721 lb. (7748.8 N) and was sustained for an average of 8.5% of the total 8 hour work shift, or around 41 minutes.

5. PATH (posture, activities, tools, and handling) data collection

PATH method [6, 7], was used to code posture, activities, tools used and materials handled at every moment for at least 3–4 hours every day with a hierarchical taxonomy. Since the drywall installation task is cyclical in nature, we collected data for a week that is absolutely representative of the whole task. We used fixed intervals to make direct observations and coded postures into a PDA.

6. 3DSSPP (three dimensional static strength prediction program)

3DSSPP (3 Dimensional Static Strength Prediction Program) was utilized in order to find out the compressive forces generated at low back and shoulder moments generated in the ceiling installers.

The sequence of static postures was selected while performing the task of ceiling drywall installation. The selected static postures from the task videos were not made at a defined interval of seconds or minutes. Instead, the postures were selected corresponding to the main set of activities. For example, the task of installing the drywall to the ceiling at the intervention phase comprised the following six activities, i) loading the panels to the electrical lift, ii) lifting the panels while being on the lift, iii) raising the panels to the ceiling, iv) holding the panels to the ceiling, v) attaching the panes to the ceiling.

7. Research design

This intervention study was designed as a quasi-experimental study with no control group. The only experimental group consisted of the five drywall installers.

Baseline PHASE	Intervention PHASE
Static frame description	
Lifting the drywall in overhead arm posture	Sliding the drywall panel to the electrical lift, both arms down
Carrying the drywall panel in overhead arm posture and stepping on the ladder	Keeping the hands on the drywall panel being raise by the electrical lift
One feet in air, maintaining the previous posture	The arms are down, maintaining the previous posture
Holding the drywall panel (overhead arms) to the ceiling, drywall in air	Overhead arms, drywall being lifted to the ceiling and supported by 'deadman'

Table 1.
The selected static frames from the videos for 3DSSPP analysis.

To find out a change of exposure **for ceiling installation at the intervention phase compared to the baseline phase**, a before- after comparison protocol (for PATH and 3DSSPP) was followed.

Table 1 summarizes the overall description of the main postural activities which were selected as the static frames for baseline and intervention analysis in 3DSSPP method.

8. Prior ergonomic interventions in drywall installation that was discussed with the installers

As mentioned earlier, the idea of having the focus groups was to engage the workers to brainstorming sessions in order to find out a solution to their concerns of ceiling/sidewall installation. Some of the ideas that the facilitator of those focus groups brought to the discussion are as follows:

A. Coupling devices for carrying the panel were already introduced by [8] in order to reduce awkward trunk postures while carrying the drywall panels. Installers were of the opinion that the coupling tools would be suitable for carrying, but could not be used as a help during installation of the panels simply because they lost time for removing the coupling tools from the panel before the installation process.

B. Although stilts have not been tested as an alternative to the ladders for drywall installers, workers tend to put extra efforts on their lower extremity to balance their gait, which results in limiting their joint mobility and increasing the risk for falling over objects [1, 3, 4, 9]. However, a 2009 study by Pan [5] concluded that if stilts are kept at low height, it enables the workers to maintain a good postural balance. The facilitator made it an open question to be answered by the installers.

C. Reducing the weight of drywall panels by cutting it into two pieces would increase the task of fastening additional boards and taping additional joints [1]. The facilitator made it an open question for the installers.

The idea of engaging workers in these focus groups were to receive suggestions from them is a useful way to find a solution for a reduction in exposure(s) [10, 11]. These groups gave the workers an opportunity to speak on their work concerns, to collectively discuss advantages or disadvantages of tools and techniques, and to brainstorm solutions to problems.

8.1 What did the workers suggested from the focus groups

In two different sites, the workers approached the outcome of the focus group quite differently:

a. In site 1, the workers wanted to use a narrow piece of panel that is called a 'deadman' as evidenced by [12].

b. In site B, the workers wanted to give a try with the prototype 'hanger's helper' [13] that was fabricated with the idea of the 'deadman'. We named the prototype 'hanger's helper'.

In both of these sites, the workers took the trial and error method, i.e., they would continue with the devices if they like it and they would stop the trial immediately if they do not like it.

Efficacy studies, usually, are those that proves the accuracy of an instrument or assistive devices to the degree it says it will. By that definition, both ‘deadman’ and ‘hanger’s helper’ were ready to be assessed for their efficaciousness in the real field. Effectiveness studies, in construction are those that will prove whether any instrument/assistive device would be effective in making a permanent place in the construction trade. This study did not evaluate the effectiveness.

9. The success behind the implementation: some precipitating factors

There were precipitating factors behind the success of implementing the ‘deadman’ and electrical lift as an intervention. The participants of the intervention or the ‘users’ had suggested the ‘deadman’ after perceiving its beneficial use in reducing their overhead arm postures to hold drywall panels to the ceiling. Nevertheless, a brief yet imperative role was played by the safety management crew who gave substantial amount of importance on the safety features of the drywall job at this site. The management was dissatisfied with the potential hazards of the ‘bucketing’ or ‘laddering activities and perceived the electrical lift and ‘deadman’ to be more stable and therefore safer. The spontaneously yielded to provide one of the two electrical lifts (that were present at the site for some electrical work) for ceiling installation and thus, offered a pivotal support to the ‘deadman’ use (**Figure 3**).

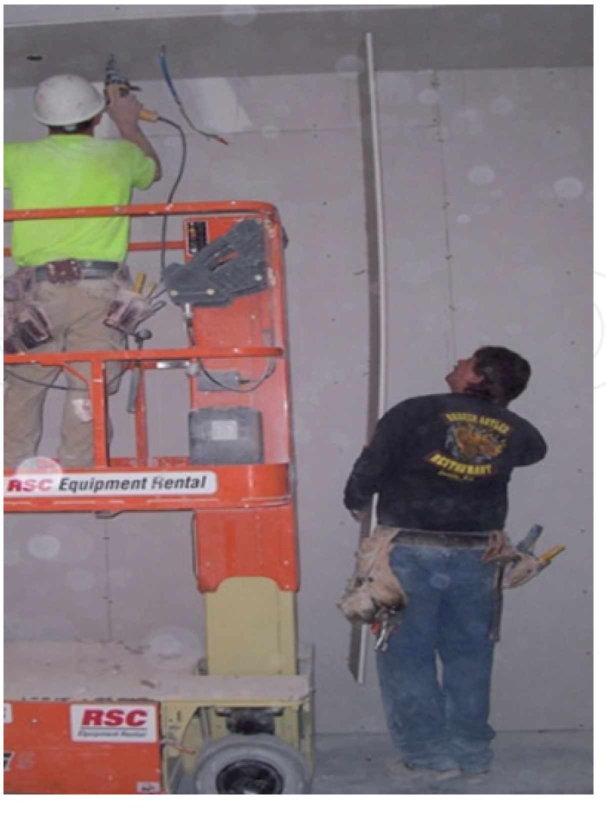

Figure 3.
Use of ‘Deadman: narrow piece of panel’.

10. Why exposure assessment is important

The ceiling installation task have many physical exposures that are discussed under sections 3 and 4. These physical exposures are present throughout each cycle in case of a cyclical task or throughout all day (in case it is a non-cyclical task). For example, a ceiling drywall installer will go through the same physical exposures (such as heavy handling, overhead arm postures, back and neck stress) for each ceiling panel installation. Assessment of these exposures will give the opportunity to fix parts of the task. These parts would get fixated by modifying different activities. By doing thus, only a small part of the tasks can get rectified, however, the result oftentimes is a huge reduction in the physical exposure level. If exposure to MSD risk factor is reduced by modifying a task or activity, then usually the modified task or activity gets adopted by all the workers in the organization [14–16]. The next section will describe how and why the exposure was reduced.

11. The reduction in exposure

The physical exposures and risk factors of drywall installation task were handling and holding more than 50 lbs in air with overhead arm postures while being on a ladder and continuously handling and handling such load. The idea of deadman did reduce some part of the exposure such as holding it with overstretched arm posture while raising it towards the ceiling. However, it is noteworthy that the worker standing on the floor still needed to hold the narrow 'deadman' piece with his hand. Deadman is 14 pounds in weight, that is much lighter than the panel weight. As a continuation to this intervention technique, the author was able to implement 'hanger's helper' (**Figure 4**) which was much stable in its base and could be placed on its own to hold the ceiling. These studies were conducted in real field and through the analysis of ergonomic observations at the pre and post intervention phases in real construction workplace settings, evaluated the efficacy of an assistive device for ceiling installation. Detailed analysis of the panel load effect on low back and shoulder joints of the installers were possible due to direct observation of the ceiling installation task at the real construction sites, through video analysis of the task and a clear picture of the shoulder and low back workload of the installers could be drawn. Prior biomechanical studies conducted in simulated laboratory environment did not

Figure 4.
Use of 'hanger's helper'.

evaluate other biomechanical variables such as shoulder moments while holding the drywall panels to the ceiling, placing the panels to the ceiling, using the neck and head while holding the ceiling or while using the screwgun to attach those panels.

To assess the workers' perception about any reduction in the exposure of ceiling installation, they were anonymously asked questions about their perception on it. Moreover, workers' suggestions on further modification of the tool gave an insight to its future evolution. Hence these exposure assessment methods are an important addition in the long run research on future possibilities on marketing stronger and more stable version of the prototype.

12. The perception of the workers on the interventions

The ceiling installers from the beginning of the study, accepted the idea of participatory research. To them it was something that can simultaneously change their work while they are also doing research. Also, they believed that as a workers' community they could identify what was an important concern, when it became an important concern and what was needed to address the concern. Throughout the installers were of opinion that they loved the interventions, they stated that release of panel loads from their shoulders and neck was the main reason that they liked it. Also, they felt much energetic at work.

13. Summary of the study

The work has examined the physical ergonomic exposures in the ceiling drywall installation task and has established the ergonomic advantage of working with an assistive device during this task. Finding a solution to reduce the exposures in the ceiling installation task was the focus of the study. The initial results were consistent with previous literature that also showed presence of physical exposures such as handling and lifting heavy drywall panels and suggested the high workload as the reason behind the musculoskeletal injury and illness rates of drywall workers. This is the first study that has evaluated the reduction of these exposures of ceiling drywall installation by implementing the ceiling assistive tool as an intervention.

To date, research on drywall carpentry has mostly focused on the workers in simulated working conditions that either analyzed ideal lifting position of the panels or evaluated tools to assist in carrying the panels. This study, through the analysis of ergonomic observations at the on pre and post intervention phases in real construction workplace settings, evaluated the efficacy of an assistive device for ceiling installation and focused on the drywall installers' during real working conditions at the construction fields, which is rare in drywall installation research.

14. Limitations of the study

The main limitation of this dissertation was associated with convenience sampling of sites. As discussed in the introduction section of this dissertation, the difficulty of gaining access to sites did not give much choice other than to focus on a sample of convenience. Thus, the study sites were the only ones tested with the research hypothesis. However, due to high consistency in ceiling installation work, the efficacy results of this study should be reproducible at other sites too.

15. Recommendations for future research

Participatory involvement continues to be a preferred intervention method to reduce the exposure to musculoskeletal risk factors. The workers feel that they are 'empowered' to choose a way of doing the job which makes them more comfortable [17]. This process also makes them able to compare the productivity of the task with the proposed method.

Participatory research can change the lives of the communities as opposed to the academic research. The latter will have a long term effect which can be far away from us. Participatory research has an effect on us while we are doing it. If the research obtains a meaningful data, then an immediate change can be made. The researcher can see the trend and react when community research is obtaining some results and then we can label the change they are having, you can do some permanent changes with it.

Little research on diffusion or adoption of an innovative tool or technique appears to have been conducted in the area of construction intervention. The relative advantage, observability, complexity and compatibility are four of five important criteria that are perceived by the workers in order to decide if an innovation will be adopted by the workers. Despite the explanatory power of perceived attributes, the reason for the scarcity of an investigation might be related to the pre-test phase of an innovation which is kept in confidence for the sake of market research. Future research could bridge this gap by carrying out a thorough qualitative analysis in measuring the five attributes of perception of the relative advantage of an innovation.

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