The XXIXth Annual Occupational Ergonomics and Safety Conference
Seattle, Washington, USA
June 1-2, 2017

Evaluating the Effectiveness of Innovative Ceiling Installation Techniques Among Drywall Installers

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Abstract: The study attempted to assess the effectiveness of a ceiling installation assistive device (hanger's helper) based on its evidence to reduce the musculoskeletal disorder (MSD) injury risk factors of ceiling installation (Dasgupta, 2015). This assistive tool ('hanger's helper') is based on the idea of using a 'deadman' (Dasgupta, 2016) that supports the ceiling while being held by workers during its installation. 'Hanger's helper' is an advanced version of 'deadman' as it can be placed on its own and does not need to be held. 'Hanger's helper' is cost-effective, has a tiltable top portion and adjustable button for changing length. The benefits associated with the use of 'hanger's helper' can become significant to bring a desired reduction in musculoskeletal injury illness risks in the drywall installers. Hence, it was worth to evaluate its adoption and effectiveness within the drywall installers' community. Hanger's helper was introduced to three different construction sites in Huntington, West Virginia. A total of three participatory groups were planned to be held at each site. The aim of these groups was to identify specific explanations behind permanent adoption or rejection of 'hanger's helper'. During the meetings, workers at each site received information on its risk reduction evidence and they were encouraged to experience its use. A total of three focus groups and six participatory groups were carried out at three construction sites. While the installers perceived hanger's helper to be worth an addition to their toolbox, discussions often emerged on willingness of construction companies to pay for it. Workers also suggested some physical changes of the tool, one such as making a foldable pole that will potentially lead to its permanent adoption. Moreover, their suggestions on further modification of the tool gave an insight to its future evolution. The installers' as a group agreed that 'hanger's helper' will be a valuable addition for the residential installation in case it is marketed. Such positive factors increase the chances of the tool getting adopted in the community. Hence this research is an important addition in the long run for the marketing aspects of 'hanger's helper'.

Keywords: assistive tool; ergonomics, residential construction

1. Introduction

The drywall installation task has a number of physical ergonomic exposures (overhead arm postures, awkward trunk posture and heavy manual handling) that may lead to musculoskeletal injuries and illnesses in the installers (Lemasters, 1998; Lipscomb 2003). The weight of typical 4' X 8' drywall panels is 70 lbs and that of the 4' X 12' panels is 105 lbs. The installers are most exposed while they are lifting and attaching the heavy drywall panels to the ceiling (Chiou 2000; Dasgupta, 2014). The task of ceiling installation is done typically by installers working in pairs and using ladders to reach the ceiling. The installers must maintain an overhead arm posture to hold the panels against the ceiling while the panels are permanently attached with screws.

1.1 Pilot studies on 'deadman' and its prototype

A pilot study by Dasgupta et al. (2013), showed a reduction of the physical ergonomic exposures for ceiling drywall installation with the use of a 'deadman', a narrow piece of scrap drywall, which supported the ceiling drywall panel during its installation (Figure 1). Based on the 'deadman' concept, a prototype tool with adjustable length

for 8' – 12' ceiling heights was constructed and was implemented as an intervention in a commercial-residential construction site (Figure 2). The tool was used as an assistive device for ceiling installation for a total of seven months. PATH (Posture, Activity, Tools, Handling; Buchholz, 1996) analysis explored changes in overhead arm postures (48% reduction), awkward trunk posture (53% reduction) and heavy load handling (37% reduction) after implementation of the intervention when the installers used the tool while being on a ladder. 3DSSPP (Three Dimensional Static Strength Prediction Program) analysis showed significant reduction of lowback compressive force ($p=0.005$) and right shoulder moment ($p=0.01$) after implementation of the assistive tool (Dasgupta, 2016). The workers' perception of the tool's usability, stability, drywall supporting strength and effect on production speed were positive.

The prototype, which was shown to help reduce the ergonomic and musculoskeletal exposures during ceiling installation in the commercial residential sector, can be important for bringing a desired reduction in musculoskeletal injury illness risks in drywall installers. Evaluation of the quantitative efficacy of the prototype tool established its ability to reduce the physical ergonomic exposures of the ceiling installation task. Hence, it will be worthwhile to evaluate the tool's adoption as an innovation more broadly within the drywall construction community.

Also, workers preference and opinion to use the tool in a daily basis will give an insight on its marketability. Thus, both the quantitative and qualitative efficacy evaluation results will be used as an evidence to implement the tool as part of the ceiling installation process in the drywall community. Therefore, to popularize the tool's adoption and to introduce it in the construction market (as a viable option to get rid of the daily exposures of ceiling installation), this study aimed to investigate the perception of the ceiling drywall installers, their foreman and the safety management on the characteristics of the tool that will facilitate its adoption as an innovation.

1.2 Literature on Focus group with Construction workers

There are common challenges faced at the management and contractors' levels that oppose an intervention to be implemented in a real work setting (Buchholz & Moir, 1996). Contractors often worry about the production being slowed and then pressure the workers to produce expected deliverables on time. The benefits of qualitative research such as circulating questionnaires to construction workers and their supervisors in order to collect their opinion have been demonstrated in many realms. Researchers have found that engaging workers in focus groups or participatory meetings were useful for understanding workers' perceptions on different ways of using new tools or techniques (DeJong, 2002; Hess, 2004). Additionally, qualitative methods provide an opportunity for workers to speak about their work concerns, to collectively discuss advantages or disadvantages of tools or techniques and to brainstorm for solutions against existing work hazards. On the other hand, the researchers receive a deeper understanding of reasons for why a field practice would be accepted or rejected based on different fundamental conceptions (Gittleman, 2010). Although the challenges associated with the supervisors, contractors and other hierarchy are mentioned in the literature, too little research on diffusion or adoption of an innovative tool or technique appears to have been conducted in the area of construction intervention. Also, no study to date appears to have been conducted evaluating the factors that have potential to encourage or discourage the company executives or supervisors for providing assistive tools to the construction workers.

2. Methods

2.1 Study setting

The study was carried out across three construction sites in Huntington, West Virginia, USA between January, 2016 and February, 2016. The worksites were in close proximity to the Marshall University, Huntington area.

2.2 Sample selection

The author has briefly introduced the tool in the construction worksites and did three focus groups (one on each) with the drywall installers and their foreman. The researcher discussed the pilot studies carried out in the past and the evidenced advantages of reducing exposures to the hazards. A convenience sample of interested participants was attempted. The following criteria were applicable in order to be a participant of the focus groups:

- Only drywall installers (either male or female)
- Atleast 6 months of experience in ceiling drywall installation
- Aged within 18-65.

- Only English speaking (focus group discussion were in English)

2.3 Focus group discussions

The study attempted to understand perception of workers, foremen and safety management for resisting or facilitating the use of hanger's helper. Reasons behind adoption/rejection, like/dislike, buy/no-buy were strategized to be explored in detail with the participants. A discussion board with markers was provided to the participants in order to solicit a topic related to the following points that they can brainstorm on:

Theme 1:Why or why no hanger's helper can be adopted for the drywall installation task
Subtheme: If any modifications are needed in the tool which would facilitate the adoption

Theme 2:Why hanger's helper can get rejected despite the evidence of exposure reduction

Theme 3: What feature(s) of hanger's helper is liked the most

Theme 4: What feature(s) of hanger's helper is disliked

Theme 5: Under what circumstances the workers/company can buy 'hanger's helper' if it is marketed

The appropriateness of the questions and flow of the discussion themes were discussed with an University educator who had prior experience as being a construction contractor. The choice of topics were related to the identified hazards of drywall installation that are in the public domain and the concern of the drywall installers in the efficacy study on 'hanger's helper' (Dasgupta, 2015).

2.4 Data Analysis

For each topics of discussion, each idea or statement of the participants were coded as a 'motivation factor' or 'turn-off factor' depending on the relevancy of the statement in light of the research aim. Also, for each theme, a summary explaining the concerns in favor of or opposing adoption of 'hanger's helper' was prepared at the end, which is presented in the results section of this paper.

3. Results

3.1 Participants

The three sites had seven, four, and three participants respectively who confirmed the author of their participation. Number of workers, foremen and safety management is mentioned below:

Table 1: Number of participants

Site 1	Site 2	Site 3
5 workers	2 workers	2 workers
1 foreman	1 foreman	NA
1 safety officer	1 safety supervisor	NA

Focus groups were done after the lunch break for approximately forty minutes. The workers, foreman and the safety supervisor all were present at the meeting. The discussion that took place under each theme are illustrated in the following:

3.2 Adoption of hanger's helper

The workers in all three sites majorly favored an adoption of the tool. The reasons behind were mostly related to the burden on shoulders and neck that 'hanger's helper' will save. Some of the comments were "*I will adopt it, it will make my life easier*", "*The tool ensures that one of my hands become free and that is enough for me to adopt this tool*". The foreman

seemed to be positive towards the adoption and recognized it to be worth of trying by the installers. One of the foreman quoted " *The pole is strong enough and it is strong enough to support the ceiling, I guess the workers will use it*". The safety officers preferred that workers shall work in pairs while using 'hanger's helper' to ensure that the panel never stays alone on top of it.

3.3 Modifications needed in 'hanger's helper'

A total of six workers (out of nine) strongly suggested a minimum of two feet length of the top portion of the tool. The foreman explained that this should safeguard any inadvertent or accidental breakage of the panel in the middle portion.

3.4 Rejection of hanger's helper

Despite the evidence of exposure reduction, both the foremen and one safety officer (at one site) disinclined to the idea that the tool can be marketed at its present status. They persuaded with the idea of longer top portion of 'hanger's helper' which promisingly will prevent accidental or inadvertent breakage of the ceiling panel. One of the foreman told "*If we want that the workers continue with the tool for the rest of their life, you have to give a stronger and longer top portion*".

3.5 Most liked feature of 'hanger helper'

The pole press button was the mostly liked feature among the installers as well as the foreman. The experienced workers compared 'hanger's helper' with 3D extension and concluded that the former one saves time than the later.

3.6 Most disliked feature of hanger's helper

The length of the top portion of 'hanger's helper' was the least appreciated part of the prototype. Although the workers, their foreman and the safety supervisor agreed that the existing length (7'') was comparable to the length of a palm of an adult men in the US, they expressed a feeling of dilemma on its strength to hold the ceiling. One of the foreman said that "*With a 7" length of the top portion, the pressure rests on one part. With a longer top portion, pressure would get distributed better and thus ideally should reduce a chance of crack or breakage at the middle portion of the pole*". The workers agreed to this fact emphasizing that this would increase the chances of marketing for the tool itself. A foreman at one site postulated a comparison with manual handling tool while one installer raised the issue of space for such lifts. His exact words were "*The manual lifts are so much space, we can not use them for residential construction. This tool will be perfect for that*".

Overall, the outcomes of the focus groups on 'hanger's helper' were positive at all of the three sites. The concern and perceptions of the drywall installers and foreman are summarized in the following:

4. Discussion and Conclusion

This study used qualitative method to explore an "in-depth-understanding" of several perceptual factors responsible for adoption or rejection of 'hanger's helper' in the drywall construction community for the ceiling installation task. In the bureaucratic environment at construction sector, scarce or insignificant opportunities exist that gives a chance to workers to demand or configure necessary assistive tools. Most of the workers are under high work pressure with minimal or no control of their job which worsens the situation.

Dasgupta et. al., showed use of 'deadman' (2013) and use of 'hanger's helper' (2015) were evidenced to reduce the musculoskeletal exposure of ceiling installation task (Dasgupta, 2014). Much of this goes back to the burden of handling and holding heavy drywall panels with overhead arm postures (2014) which simultaneously assault the neck and or back musculature of the installers. The workers are aware of it and they acknowledged the advantages of using 'hanger's helper' in reducing most of their concern of ceiling installation task (Dasgupta, 2015). However, the drywall installers of this study showed a clear preference for adopting 'hanger's helper'.

Despite the fact that the workers, their foreman and the safety officer or supervisor wished a stronger top portion, the idea of using 'hanger's helper' were greatly valued. The anticipation of an inadvertent or accidental breakage of the ceiling panel might be related to non-existence of a similar ceiling assistive device. However, suggestion for a modification of the top portion seemed to have a consensus among all installers and the foreman and shows a promising adjustment to bring the tool in market. A stronger top portion conveys a convincing and meaningful impact for the stakeholders to invest in the tool.

Due to scarcity of construction sites, the sites were selected as par convenience. However, the similarity of opinions across the three sites highlights the fact that adoption of 'hanger's helper' is likely in the region and the adoption behavior of the installers can be generalized in case the modifications are made accordingly to their preferences.

'Hanger's helper' and its predecessor 'deadman' were evidenced to reduce the musculoskeletal and ergonomic exposures at construction sites in greater Boston area. The author has briefly discussed the results in the focus group. However it is difficult to conclude whether that evidence had any effect on the perceptions of the participants of the focus groups.

Overall, 'hanger's helper' seemed to be a good choice for the ceiling drywall installers and the foreman. The possibility of its adoption largely, however, depends on the modification of the tool due to the preference of the focus group participants. Nevertheless, the findings of the study strongly suggested that absence of any kind of ceiling assistive device in the construction field does not signify the behavioral constrains of construction sector that opposes adoption of an evidenced based practice. The findings of this study will be used to modify the tool for enhancing its marketability in the near future.

5. References

1.Buchholz B., Moir S., 1996. Emerging Participatory approaches to Ergonomic Interventions in the Construction Industry. American Journal of Industrial Medicine, 29: 425-430.
2. Buchholz B., et al., 1996. PATH: A Work Sampling-Based Approach to Ergonomic Job Analysis for Construction and Other Non-Repetitive Work, Applied Ergonomics, 27:177-87.
3. Chiou S.S., et al., 2000. Traumatic injury among drywall installers, 1992-1995. Journal of Occupational and Environmental Medicine, 42:1101-1108.
4. Dasgupta PS., et al., 2013. Drywall Installers' Innovative Ideas for Reducing the Physical Ergonomic Exposures in Drywall Installation. Proceedings of the Human Factors and Ergonomics Society Annual Meeting September, 57(1) 989-993.
5. Dasgupta PS., Fulmer S., Jing X., Punnett L., Kuhn S., Buchholz B. 2014. Assessing the Ergonomic Exposures for Drywall Workers, International Journal of Industrial Ergonomics, 44(2): 307-315.
6. De Jong A.M., et al., 2003. Reasons for applying innovations for scaffolding work. International Journal of Occupational Safety and Ergonomics, 9(2): 161-175.
7. De Jong A.M., Vink P., 2002. Participatory ergonomics applied in installation work. Applied Ergonomics, 33(5): 439-48.
8. Hess J.A, et al., 2010. Ergonomic evaluation of masons laying concrete masonry units and autoclaved aerated concrete. Applied Ergonomics, 41(3): 477-83.
9. Kramer, D.M., et al., 2010. Searching for needles in a haystack, Identifying innovations to prevent MSDs in the construction sector, Applied Ergonomics, 41(4): 577-584.
10. Lemasters G.K., et al., 1998. Prevalence of work related musculoskeletal disorders in active union carpenters. Occupational Environmental Medicine, 55: 421-427.
11. Lipscomb H.J., et al., 2003. Cameron W. Falls in Residential Carpentry and Drywall Installation: Findings from Active Injury Surveillance with Union Carpenters, Journal of Occupational and Environmental Medicine, 45: 881-890.
12. Vander Molen, H.F., et al., 2004. Efficacy of adjusting working height and mechanizing of transport on physical work demands and local discomfort in construction work. Ergonomics, 47(7): 772-83