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Assessment of perceived traumatic injury hazards during drywall taping and sanding

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Abstract

The objective of this study was to identify the drywall finishing tasks which are directly perceived as hazardous by workers. A questionnaire survey was conducted to evaluate workers' perceived injury hazards (physical stress, fall potential, and struck by/against an object) for six finishing tasks (4 taping and 2 sanding tasks) and three items of elevated support equipment. Thirty experienced drywall finishers participated in this study. The ratings of perceived physical stress and fall potential varied significantly among the six tasks (both p values < 0.05). Subjects perceived greater physical stress for the two drywall sanding tasks than the four taping tasks. Sanding skimmed drywall without the use of pole sanders, in particular sanding ceiling joints, nails, and corners was rated most stressful. Wrists/hands and shoulders were identified as the most affected body part subject to physical stress during drywall taping and sanding. Tasks performed with the use of stilts were rated as having greater fall potential than those without using stilts. The activity of putting on stilts and getting up on them was most likely to cause loss of balance. Results from this study provide information directly from experienced workers to help identify hazardous tasks and activities associated with drywall finishing. The findings will assist in focusing future research efforts on the most hazardous tasks and activities of drywall finishing.

Relevance to industry

Construction workers who perform drywall installation, including taping and sanding drywall sheets, have the highest incidence/injury rate compared to any other workforce. Taping and sanding drywall sheets increases the potential for physical stress, falls and struck by and against objects. A questionnaire was designed to collect injury information directly from painters who performed drywall taping/sanding and to identify perceived hazards associated with drywall taping and sanding. Prior to this study, there has been little substantive research to ergonomically evaluate the excessive stresses and potential injuries imposed on this workforce. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Drywall installation; Drywall taping and sanding; Physical stress; Fall injury; Struck by and against objects; Traumatic injuries

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1. Introduction

Generally, the primary concern with drywall installation is the overhead-material-handling process which is associated with ergonomic-related hazards (Pan and Chiou, 1999a). Drywall installation is a several-step process. Once the drywall sheets have been hung, the finishing process starts. Drywall finishing can be divided into two tasks: taping and sanding. First, finishers conduct taping tasks. They fill joints between panels with a joint compound. Using a wide and flat tip trowel, finishers spread joint compound onto and along each side of the joint with brushlike strokes. The trowel is then used to press a paper tape into the wet compound and smooth away excess material. This is done to cover the joints and to conceal imperfections. Finishers complete the final taping tasks by applying second and third coats. Secondly, finishers sand the treated areas after each coat to make them as smooth as the rest of the wall surface. This results in a very smooth and almost perfect surface. Because of the use of elevated equipment and repetitive motions, finishing drywall sheets on lower and upper halves of the walls and ceilings exposes workers to several ergonomic-related hazards. Currently, very little research has been conducted to examine these hazards associated with drywall finishing.

Recently, the National Institute for Occupational Safety and Health (NIOSH) issued a hazard evaluation report of drywall-sanding-dust exposures (NIOSH, 1999). In this report, health concerns regarding drywall sanding were identified and evaluated, and further control strategies were proposed. NIOSH also initiated a comprehensive research project in 1996 which focuses on safety and injury issues associated with drywall installation, including both hanging and finishing tasks. This ongoing drywall study has systematically evaluated drywall lifting tasks and activities in a field setting (Pan et al., 1999a,b) as well as within a simulated drywall workstation in a laboratory (Pan and Chiou, 1998). In addition, beginning in fiscal year 2000, NIOSH is planning to conduct a drywall-intervention study to evaluate current drywall intervention techniques and assistive devices (Pan, 1999). The findings of these studies will provide

feasible safety strategies for controlling injury hazards in drywall-installation work, thereby promoting the safety and health of this sector of the construction population.

In the construction industry, drywall installation appears to mean drywall hanging, which is conducted by drywall installers and carpenters (Pan and Chiou, 1999a). Drywall finishing is usually carried out by a different group of workers – the painters. Drywall finishing tasks and associated activities are among the most hazardous in terms of potential for traumatic injury, and in terms of the ergonomic stresses imposed on workers (NIOSH, 1995; Chiou et al., 1997). Drywall finishing tasks (i.e., taping and sanding) are highly dynamic, unstructured, and often require workers to handle materials and large-sized tools repetitively, and perform jobs in a confined space. These unique characteristics of the work environment – constantly changing tasks, materials, and work site layout – make it difficult to apply objective ergonomic assessment tools at construction sites. Therefore, information taken directly from experienced workers is valuable to help identify problems and high-risk tasks and activities. The objective of this study was to conduct a questionnaire survey for identifying the hazardous tasks and activities of drywall taping and sanding which were directly perceived as stressful activities by the workers. Tasks and activities with high risks for traumatic injuries can then be identified, so that ergonomic principles can be applied to modify the work methods and environment or to select appropriate assistive devices.

2. Method

A questionnaire, which was designed by NIOSH for this study, was used to identify perceived hazardous tasks and activities associated with drywall taping and sanding. This questionnaire was developed using direct observations and videotape of construction workers performing drywall taping and sanding. The taping and sanding operations were divided into six tasks, which were further divided into 3 to 7 constituent activities as listed in Table 1. The tasks and activities were verified with the help of experienced drywall workers.

Table 1
Perceived physical stress for drywall finishing activities ($n = 30$)

Task	Activity	Mean rating \pm standard errors
1. Apply tape to joints and corners (w/o stilts)	Assemble tools and materials at the work site	3.0 \pm 0.45
	Open joint compound bucket and fill tray with compound	2.7 \pm 0.38
	Apply a layer of compound to corner or joint	3.2 \pm 0.38
	Lay paper tape over joint	2.7 \pm 0.36
	Work tape into compound	3.4 \pm 0.40
	Smooth tape and joint compound	3.3 \pm 0.38
2. Apply tape to joints and corners (w/ stilts)	Assemble tools and materials at the work site	3.3 \pm 0.46
	Put on stilts and get up on them	3.3 \pm 0.38
	Open joint compound bucket and fill tray with compound	3.3 \pm 0.40
	Apply a layer of compound to corner or joint	3.2 \pm 0.40
	Lay paper tape over joint	2.9 \pm 0.37
	Work tape into compound	3.6 \pm 0.39
3. Apply skim coats of joint compound (w/o stilts)	Smooth tape and joint compound	3.5 \pm 0.39
	Assemble tools and materials at the work site	2.9 \pm 0.44
	Open joint compound bucket and fill tray with compound	3.1 \pm 0.38
4. Apply skim coats of joint compound (w/ stilts)	Apply a layer of compound to corner or joint	3.7 \pm 0.40
	Smooth joint compound	3.8 \pm 0.40
	Assemble tools and materials at the work site	3.1 \pm 0.58
	Put on stilts and get up on them	4.2 \pm 0.57
5. Sand skimmed drywall (w/o pole sanders)	Open joint compound bucket and fill tray with compound	3.7 \pm 0.45
	Apply a layer of compound to corner or joint	3.5 \pm 0.42
	Smooth tape and joint compound	3.6 \pm 0.40
	Assemble tools and scaffold at the work site	2.5 \pm 0.42
	Ascend or descend scaffold	4.0 \pm 0.41
	Sand ceiling joints, nails and corners	5.1 \pm 0.42
6. Sand skimmed drywall (w/ pole sanders)	Move scaffold	4.1 \pm 0.39
	Sand wall joints, nails and corners	4.5 \pm 0.42
	Assemble tools at work site	2.7 \pm 0.47
	Sand ceiling joints, nails and corners	5.1 \pm 0.38
	Sand wall joints, nails and corners	4.2 \pm 0.39

The questionnaire contained three sections. The first section of this questionnaire consisted of demographic data including gender, weight, height, years of experience taping and sanding drywall and injury history (frequency of past injuries).

The second section of the questionnaire addressed issues associated with six sanding and taping tasks: (1) applying tape to joints and corners without stilts; (2) applying tape to joints and corners with stilts; (3) applying skim coats of joint compound without stilts; (4) applying skim coats of joint compound with stilts; (5) sanding skimmed

drywall without pole sanders; and (6) sanding skimmed drywall with pole sanders. The construction workers were asked to characterize each of the six tasks and the constituent activities in terms of fall potential, perceived physical stress, and risk of being struck by or against objects. A seven-point scale was used, where:

1 = hardly at all; The task or activity has very low physical demand, propensity for loss of balance leading to a possible fall incident, or risks of getting struck by or against an object.

7 = a great deal; The task or activity is highly and physically demanding, likely to cause loss of balance leading to a fall incident, and can easily involve being struck by or against an object.

The construction workers were also asked to identify the body part(s) affected for each of the six taping and sanding tasks and the constituent activities in terms of perceived physical stress and risk of being struck by or against objects. The body parts affected in the survey included: neck, shoulder, elbow, wrists/hands, upper back, lower back, hips/thighs, knee, and ankles/feet.

The third section of the questionnaire addressed the physical stress, fall potential, and risks of being struck by or against an object associated with the use of three common assistive elevated devices during drywall taping and sanding – step ladders, stilts, and scaffolds. Ratings for each of the elevated devices were also made on a seven-point scale, as described earlier.

Thirty painters with drywall taping/sanding experience, from the painters' unions located in Wheeling, Fairmont, and Huntington, West Virginia, volunteered to participate in this study. Questionnaires were distributed to groups of volunteer workers by trained data-collection contractors, and instructions were given for completing the questionnaire. A pilot study of nine workers was conducted using the exact procedures planned for the actual survey to refine the questionnaire. Access to volunteer workers for questionnaire administration was obtained by the contractor (the Construction Program of West Virginia University). Included in the instructional session for the painters was practice in filling out a portion of the questionnaire. Experienced data collection contractors remained throughout the session to answer questions and assist in completion of the questionnaire. All of the participants completed the survey.

The statistical analyses were performed using the Statistical Analysis System (SAS, 1996). The ratings of physical stress, fall potential and risk of being struck by or against objects were analyzed by repeated measure analyses of variance (ANOVA). For any significant results, multiple comparisons were performed to further compare the six tasks.

Similar procedures were used to determine the effect of different elevated devices on the three ratings. Pearson correlation analyses were used to explore possible associations among the study variables (i.e., subject age, experience and ratings of physical stress, fall potential, struck by/against) in each of the six tasks. These analyses were carried out to determine whether changes in the ratings of perceived physical stress, fall potential, and risks of being struck by or against an object were associated with subjects' age and number of years of experience.

3. Results

Thirty subjects (mean age = 40.5 yr \pm 8.6 standard deviation [SD]) participated in this study. These subjects possessed an average drywall taping and sanding experiences of 17 yr \pm 7.8 SD. Subjects had mean body weight of 85.8 kg \pm 13.4 SD and mean body height of 178 cm \pm 7.9 SD. Their mean working hours per week was 35.7 h \pm 12 SD. More than one third of the subjects had suffered injuries associated with drywall taping and sanding. Sixty percent of the injuries were falls and overexertion.

3.1. Evaluation of drywall taping/sanding tasks and activities

Analyses of variance (ANOVA) with pairwise contrast were performed to determine the effect of task on the ratings of physical stress, fall potential, and risk of being struck by or against objects. Fig. 1 illustrates the mean ratings and standard errors for the six drywall taping and sanding tasks. The effect of task was found to be significant on ratings of fall potential and physical stress (both p values $<$ 0.05). Pairwise contrast comparisons revealed that the perceived physical stress while sanding drywall without pole sanders was significantly greater than that while applying tapes to joints and corners, with or without stilts (both p values $<$ 0.05). The perceived stress for sanding drywall without pole sanders was also greater than that of applying skim coats of joint compound without stilts ($p <$ 0.05). Subjects perceived greater fall potential while

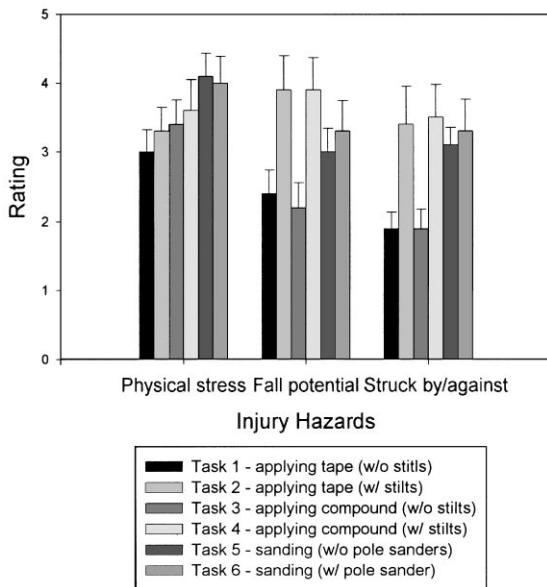


Fig. 1. Mean perceived injury hazards and standard error for six drywall finishing tasks ($n = 30$).

applying tape to joints and corners with stilts than for tasks performed without stilts ($p < 0.01$). The task of applying coats of joint compound with stilts was also perceived to have greater fall potential than without stilts ($p < 0.05$).

Among the 5 activities associated with sanding drywall without the use of pole sanders, sanding ceiling joints, nails, and corners was perceived as producing the most physical stress (mean rating = 5.1), followed by the activity of sanding wall joints, nails, and corners (mean rating = 4.5) as listed in Table 1. The mean rating of sanding ceiling joints, nails, and corners was significantly higher than those of all other activities for sanding skimmed drywall without the use of pole sanders ($p < 0.05$). Similar findings were found for sanding drywall with the use of pole sanders. The activities of sanding ceiling joints, nails, and corners was perceived to be most stressful. The mean rating of sanding ceiling joints, nails, and corners was significantly greater than the rest of two activities ($p < 0.01$).

For both tasks of applying tape and skimmed coats of joint compound with the use of stilts (Tasks

#2 and #4), the activity of putting on stilts and getting up on them was rated to have greatest fall potential (Table 2). The rating of this activity was also significantly greater than that of all other activities among Tasks #2 and #4 (all p values < 0.05). One of the activities while sanding skimmed drywall without the use of pole sanders – ascending or descending a scaffold – was also noted to have high fall potential rating (mean rating = 4.2). The mean rating of ascending or descending the scaffold was significantly greater than those of all other activities among sanding skimmed drywall without the use of pole sanders ($p < 0.001$).

Among all the activities (Table 3) performed during drywall finishing, the mean perceived risk of being struck by or against an object was greatest for sanding ceiling joints, nails and corners with the use of pole sanders (mean rating = 4.0). The mean perceived risks for sanding ceiling joints, nails, and corners was significantly greater than that of assembling tools at work site (mean rating = 2.5, $p < 0.05$) or sanding wall joints, nails and corners (mean rating = 3.7, $p < 0.05$).

3.2. Evaluation of three supportive elevated equipment (stilts, step ladders, and scaffolds)

Fig. 2 presents the mean ratings and standard errors for the three elevated equipment devices used for performing taping/sanding tasks. ANOVA was performed to determine the effect of elevated equipment on all 3 ratings. The effect of elevated equipment was only found to be significant on the risks of being struck by/against objects ($p < 0.05$). The mean struck by/against rating associated with the use of stilts (4.0) was greater than those of step ladders (3.6) and scaffolds (3.5).

3.3. Body parts affected during drywall taping and sanding

Figs. 3 and 4 present the most affected body parts subject to physical stress for drywall taping and sanding, respectively. For drywall taping tasks, subjects identified physical stress primarily in their wrists/hands, shoulders, and lower back (Fig. 3). More than 13% of the subjects reported that multiple body parts were affected while performing the

Table 2
Perceived fall potential for drywall finishing activities ($n = 30$)

Task	Activity	Mean rating \pm standard errors
1. Apply tape to joints and corners (w/o stilts)	Assemble tools and materials at the work site	2.3 \pm 0.38
	Open joint compound bucket and fill tray with compound	1.5 \pm 0.24
	Apply a layer of compound to corner or joint	2.5 \pm 0.35
	Lay paper tape over joint	2.2 \pm 0.35
	Work tape into compound	2.1 \pm 0.28
	Smooth tape and joint compound	2.5 \pm 0.36
2. Apply tape to joints and corners (w/ stilts)	Assemble tools and materials at the work site	3.6 \pm 0.62
	Put on stilts and get up on them	5.4 \pm 0.64
	Open joint compound bucket and fill tray with compound	3.8 \pm 0.68
	Apply a layer of compound to corner or joint	3.7 \pm 0.61
	Lay paper tape over joint	3.7 \pm 0.61
	Work tape into compound	3.6 \pm 0.59
3. Apply skim coats of joint compound (w/o stilts)	Smooth tape and joint compound	3.8 \pm 0.63
	Assemble tools and materials at the work site	2.1 \pm 0.39
	Open joint compound bucket and fill tray with compound	1.9 \pm 0.35
4. Apply skim coats of joint compound (w/ stilts)	Apply a layer of compound to corner or joint	2.2 \pm 0.35
	Smooth joint compound	2.5 \pm 0.37
	Assemble tools and materials at the work site	2.9 \pm 0.48
	Put on stilts and get up on them	4.5 \pm 0.49
5. Sand skimmed drywall (w/o pole sanders)	Open joint compound bucket and fill tray with compound	3.5 \pm 0.53
	Apply a layer of compound to corner or joint	3.6 \pm 0.57
	Smooth tape and joint compound	3.8 \pm 0.53
	Assemble tools and scaffold at the work site	1.5 \pm 0.19
	Ascend or descend scaffold	4.2 \pm 0.49
	Sand ceiling joints, nails and corners	3.6 \pm 0.52
6. Sand skimmed drywall (w/ pole sanders)	Move scaffold	2.6 \pm 0.42
	Sand wall joints, nails and corners	3.1 \pm 0.57
	Assemble tools at work site	2.5 \pm 0.47
	Sand ceiling joints, nails and corners	3.9 \pm 0.52
	Sand wall joints, nails and corners	3.6 \pm 0.50

tasks of applying joint compound without stilts. Multiple body were also affected when performing drywall sanding with (13.4%) or without (19.4%) the use of pole sanders. Physical stress was most often reported for wrists/hands, shoulders, and neck when sanding the drywall (Fig. 4).

Figs. 5 and 6 illustrate the most affected body parts subject to the risk of being struck by or against an object. The head was the target body part for both drywall taping and sanding tasks, reported by more than 30% of the subjects. Risks of

being struck by or against an object were also often reported in wrists/hands and multiple body parts. Thirty-one percent and 23.4% of the subjects perceived that multiple body parts were subject to risks of being struck by or against an object when sanding drywall without or with the use of pole sanders, respectively. Subjects identified risks of being struck by or against an object in wrists/hands at 22.3%, 22.7%, and 23.2% for applying tape with stilts, applying joint compound without stilts, and applying joint compound with stilts, respectively.

Table 3
Perceived risk of being struck by or against an object for drywall finishing activities ($n = 30$)

Task	Activity	Mean rating \pm standard errors
1. Apply tape to joints and corners (w/o stilts)	Assemble tools and materials at the work site	2.0 \pm 0.27
	Open joint compound bucket and fill tray with compound	1.7 \pm 0.31
	Apply a layer of compound to corner or joint	2.0 \pm 0.29
	Lay paper tape over joint	1.8 \pm 0.24
	Work tape into compound	2.0 \pm 0.27
	Smooth tape and joint compound	1.8 \pm 0.27
2. Apply tape to joints and corners (w/ stilts)	Assemble tools and materials at the work site	3.8 \pm 0.73
	Put on stilts and get up on them	4.2 \pm 0.70
	Open joint compound bucket and fill tray with compound	3.5 \pm 0.68
	Apply a layer of compound to corner or joint	3.3 \pm 0.68
	Lay paper tape over joint	3.3 \pm 0.70
	Work tape into compound	3.3 \pm 0.65
3. Apply skim coats of joint compound (w/o stilts)	Smooth tape and joint compound	3.1 \pm 0.66
	Assemble tools and materials at the work site	1.8 \pm 0.28
	Open joint compound bucket and fill tray with compound	1.9 \pm 0.31
	Apply a layer of compound to corner or joint	2.0 \pm 0.31
4. Apply skim coats of joint compound (w/ stilts)	Smooth joint compound	2.1 \pm 0.33
	Assemble tools and materials at the work site	3.4 \pm 0.53
	Put on stilts and get up on them	3.8 \pm 0.53
	Open joint compound bucket and fill tray with compound	3.3 \pm 0.53
5. Sand skimmed drywall (w/o pole sanders)	Apply a layer of compound to corner or joint	3.2 \pm 0.55
	Smooth tape and joint compound	3.5 \pm 0.55
	Assemble tools and scaffold at the work site	2.3 \pm 0.39
	Ascend or descend scaffold	3.5 \pm 0.53
	Sand ceiling joints, nails and corners	3.0 \pm 0.53
	Move scaffold	3.1 \pm 0.53
6. Sand skimmed drywall (w/ pole sanders)	Sand wall joints, nails and corners	3.3 \pm 0.62
	Assemble tools at work site	2.5 \pm 0.50
	Sand ceiling joints, nails and corners	4.0 \pm 0.60
	Sand wall joints, nails and corners	3.7 \pm 0.59

3.4. Correlation analysis

Table 4 presents the correlation matrix of age and experience with mean ratings of physical stress. There were significant positive correlations between age and perceived physical stress, and between working experience and perceived physical stress while performing Tasks #1 and #5 (both p values < 0.05). Table 5 shows the correlation matrix of age and experience with mean ratings of

fall potential. There was a significant positive correlation between age and work experience with the ratings of fall potential while performing the tasks of applying tape to joints and corners without stilts (both p values < 0.05).

An additional analysis was conducted to determine the correlation between worker's age and experience. A significant positive correlation between the age and experience of the study subject ($r = 0.86$, $p < 0.001$) was found.

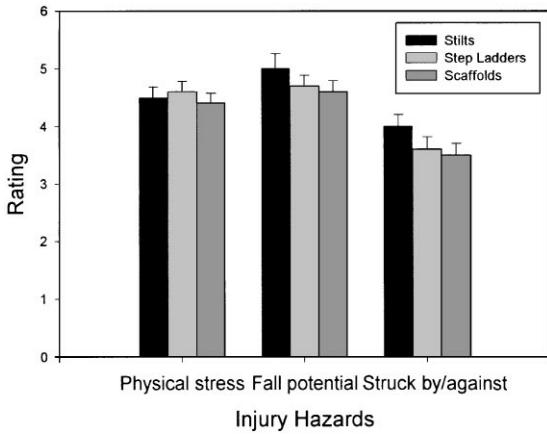


Fig. 2. Mean perceived injury hazards and standard errors for three supportive elevated equipment ($n = 30$).

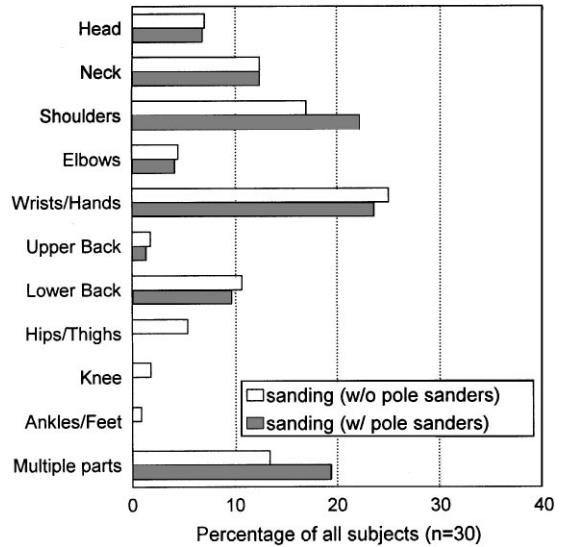


Fig. 4. Affected body parts subject to physical stress in different drywall sanding tasks ($n = 30$).

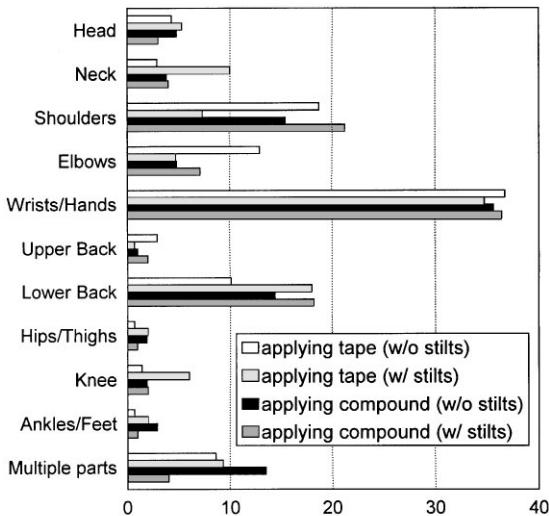


Fig. 3. Affected body parts subject to physical stress in different drywall taping tasks ($n = 30$).

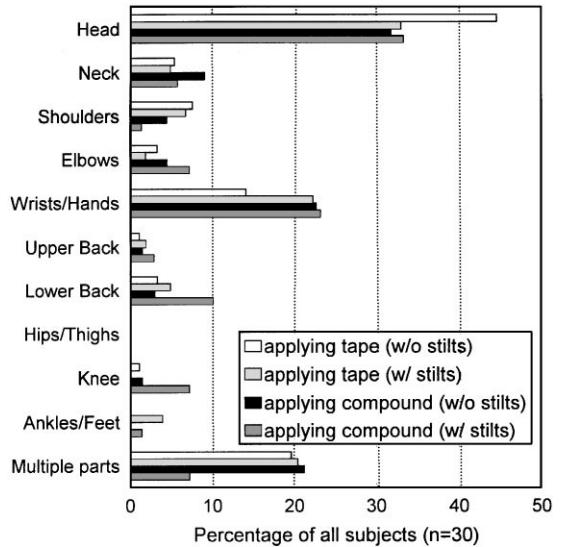


Fig. 5. Affected body parts for risks of being struck by or against an object in different drywall taping tasks ($n = 30$).

4. Discussion

In the current study, the task of sanding skimmed drywall without using a pole sander was rated more stressful than tasks of applying tape to joints and corners (with or without stilts) and applying coats of joint compound without stilts. Among all

sanding activities, sanding ceiling joints, nails, and corners was perceived as most physically demanding, and also as having the greatest risk of being struck by or against an object, when pole sanders

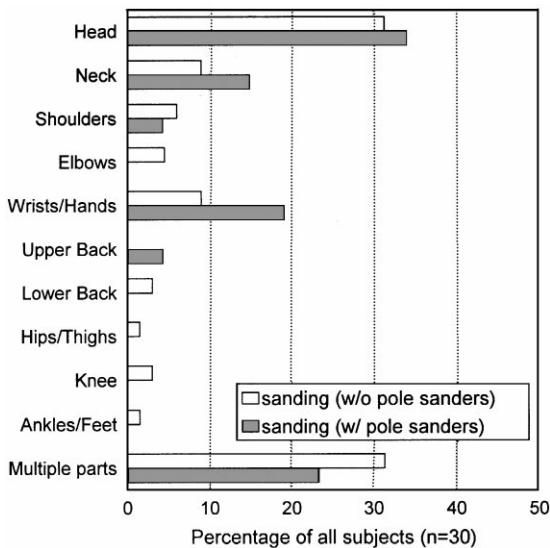


Fig. 6. Affected body parts for risks of being struck by or against an object in different drywall sanding tasks ($n = 30$).

were used. Hand-sanding the drywall joints down to a smooth finish is a stressful process. It is carried out with a hand-held, abrasive-paper-covered, sanding block. Some workers prefer hand sanding to pole sanding because it allows better visual and manual control. Drywall sanding involves numerous repetitive motions, which also places stress on the back, arms, and wrists, since workers have to apply pressure to the paper to create friction for sanding (Schneider and Susie, 1994). In addition, since workers are often paid by the square foot, drywall finishing tasks are often conducted at a high pace. The repetition, forceful exertions, and rapid pacing associated with drywall sanding are also contributing factors to cumulative trauma disorders of the wrists and shoulders. In a study of 522 carpenters, Lemasters et al. (1998) found that work-related musculoskeletal disorders of the upper extremities (e.g. shoulders, hands, wrists) were most prevalent among all carpenters, particularly in the drywall or ceiling and formwork subspecialties.

Table 4

Correlation matrix of subject age and experience with mean ratings of physical stress

Number	Task description	Age		Experience	
		<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
1	Apply tape to joints and corners w/o stilts	0.62	0.001*	0.50	0.003*
2	Apply tape to joints and corners w/ stilts	0.19	0.26	0.8	0.36
3	Apply skim coats of joint compound w/o stilts	0.38	0.06	0.22	0.13
4	Apply skim coats of joint compound w/ stilts	-0.20	0.27	-0.11	0.32
5	Sand skimmed drywall w/o pole sanders	0.51	0.02*	0.61	0.001*
6	Sand skimmed drywall w/ pole sanders	0.26	0.17	0.20	0.17

* $p < 0.05$, one-tailed test.

Table 5

Correlation matrix of subject age and experience with mean ratings of fall potential

Number	Task description	Age		Experience	
		<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
1	Apply tape to joints and corners w/o stilts	0.44	0.04*	0.37	0.03*
2	Apply tape to joints and corners w/ stilts	-0.13	0.34	-0.30	0.10
3	Apply skim coats of joint compound w/o stilts	-0.06	0.41	0.02	0.46
4	Apply skim coats of joint compound w/ stilts	-0.12	0.36	-0.13	0.30
5	Sand skimmed drywall w/o pole sanders	-0.01	0.45	0.27	0.12
6	Sand skimmed drywall w/ pole sanders	-0.14	0.32	-0.12	0.28

* $p < 0.05$, one-tailed test

Results from the current study are consistent with Lemasters' study. Subjects perceived most physical stress in their wrists, hands, and shoulders for both drywall taping and sanding tasks.

In our previous study of non-fatal traumatic injuries associated with drywall hanging, drywall hangers were found to be at a high risk of overexertion and falls to a lower level (Chiou et al., 1997). In contrast, Suruda (1992) found that 50% of painter fatalities resulted from a fall from height. Because drywall hanging and finishing tasks constantly require workers to reach the upper half of the wall and ceiling, balancing on ladders, stilts, or scaffolds to perform tasks is a part of the characteristics of this workforce. Results from ANOVA and pairwise contrast indicate that workers' perceived fall potential for tasks of applying tape and skim coats to joints and corners with the use of stilts was significantly greater than for those without stilts. The activity of putting on stilts and getting up on them was rated most hazardous in terms of fall potential. In our previous study of drywall hangers, stilts were rated as the most hazardous among three items of elevated equipment (stilts, scaffolds, step ladders) in terms of fall potential and physical stress for drywall installation tasks (Pan et al., 1999b). This study also confirmed the potential fall hazard for using stilts during drywall sanding. However, in the current study, when the subjects were asked about the overall tasks they performed (not limited to applying tapes and skim coats), stilts did not present significantly greater physical stress or fall potential than two other elevated devices. The different findings between the two studies can be attributed to the differences in sampling groups and the tasks and activities they performed. Compared with hanging/lifting tasks (Pan et al., 1999b), sanding and taping tasks are less physically demanding, and fewer awkward postures are imposed. Since workers are not required to constantly extend their upper extremities and upper trunks as compared to hanging heavy and bulky drywall sheets at elevations, drywall finishing tasks are less likely to shift the workers' center of mass away from the body. Workers are also more likely to respond to any possible momentary loss of balance more effectively.

There were significant positive correlations between the subjects' age and the ratings of physical

stress, and between experience and ratings of physical stress for Tasks #1 and #5 (see Table 4). The older and more experienced subjects perceived greater physical stress while performing Tasks #1 and #5. Applying tape to joints and corners requires considerable amounts of wrist flexion and work over shoulder height. This work is usually performed on stilts to increase mobility. Applying tape to joints and corners without the use of stilts may reduce the fall potential, but it may increase physical stress, in that workers have to move the ladder or scaffold and other equipment from the location of one joint to another, or from one room to another. Sanding skimmed drywall without pole sanders is very repetitive and stressful for wrists, hands, and back. As muscle strength appears to deteriorate after the ages of late 20s and early 30s (Chaffin and Andersson, 1991), older workers perceived greater stress. Another possible explanation is that older workers may have been experiencing effects from cumulative trauma disorders on different body parts. As the duration of employment in carpentry increased, the work-related musculoskeletal disorders for most body areas increased (Lemasters et al., 1998). The significant correlation between experience and perceived physical stress for Tasks #1 and #5 might be due to the age effect – the more experienced the subject is, the older the subject is.

There was no significant correlation between age and physical stress or experience and physical stress in any of the other tasks. Reasons for this lack of correlation may include the belief of all the workers, regardless of their age and experience, that tasks involving stilts or pole sanders are inherently stressful. Other possible explanations of these correlations may include the perception of older, more experienced workers, that tasks not involving stilts or pole sanders may require the use of other elevated work devices (scaffolds, stepladders, buckets, boxes, etc.), and that the use of these other devices to perform the tasks is also stressful.

Table 5 indicates that there was a significant positive correlation between the subjects' age and the number of years of experience, with the ratings for fall potential in Task #1. To apply tapes to joints and corners, workers have to extend their arms to reach the top of the wall. These activities

are stressful and likely to move the body's center of mass away from the body. Deterioration in muscle strength, neurological systems, and vision in older workers may make it more difficult for them to maintain balance while stretching their upper extremities or bending down to perform taping of drywall. There were no significant correlations found between age, experience and the ratings for fall potential in any of the other tasks. Reasons for this lack of correlation may include the belief of all workers, regardless of age or experience, that the use of stilts produced a high risk of falling.

Findings from this survey allowed us to determine the workers' perceptions of what tasks in drywall finishing are, in their experience, seen to contain serious potential injury hazards. They also provide further understanding, and research focus, for future preventive studies on drywall-finishing work. Four issues are suggested for future studies. First, a survey of a larger sample size and geographical area should be considered. This survey was performed in a small area in West Virginia, using only 30 subjects. Second, future studies can be extended to examine the relationship between the worker's age and perceived hazards. Surveys that evaluate the effect of age may find that workers over a certain age experience significantly different levels of perceived physical stress and fall potential compared to their younger counterparts. Third, a longitudinal study is also needed to examine risk factors, from the entry into the job through the remainder of the career span. Finally, the findings from this study suggest the need to develop better work practices and assistive devices for this workforce.

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