International Journal of Industrial Ergonomics 41 (2011) 481–487

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

Ergonomic interventions for commercial crab fishermen

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ARTICLE INFO

Article history:
Received 21 June 2010
Received in revised form
17 February 2011
Accepted 29 March 2011
Available online 17 May 2011

Keywords:
Commercial fishing
Ergonomic intervention

ABSTRACT

Work tasks in the commercial fishing industry require strength, endurance and coordination and these tasks expose fishermen to many of the recognized risk factors for the development of work-related musculoskeletal disorders. The focus of the current study was the design, development and testing of two simple ergonomic interventions to reduce exposure to these risk factors in small-scale commercial crab fishermen. In a laboratory study of these interventions, EMG and motion analysis systems were used to quantify changes in muscle force and body postures. The results of laboratory evaluation of the intervention designed to reduce the low back stress associated with hoisting the crab pots onboard showed significant reductions in muscle force requirements (erector spinae activity reduced by 25%) and peak sagittal trunk angle (reduced by 34%), while the results of the intervention designed to reduce shoulder stress during the process of shaking the crabs from the pots showed significant reductions in peak deltoid activity (reduced by 24%). A field test of these interventions provided a more subjective "usability" evaluation of the interventions. These responses were cautiously positive, providing insights into when these interventions would be most appropriate and under what conditions they would be more of a hindrance than a help.

Relevance to industry: Engineering controls are recognized as the most effective methods of reducing exposure to risk factors for musculoskeletal injury. Engineering controls were developed for small-scale commercial crab fishermen and these interventions were tested in the laboratory and in the field.

1. Introduction

The commercial fishing industry is vital to the economy of many coastal communities in the United States. In North Carolina alone there were 5947 commercial fishermen with the necessary licensure (North Carolina License and Statistics Section: Summary Statistics of License and Permit Program, 2008). The number of individuals actively engaged in commercial fishing work activities is considerably larger than this figure because commercial licenses are not required for crewmembers on fishing vessels or for those individuals that perform other support activities for the fishermen. These fishermen work long hours in a dynamic natural environment that can include excessive heat, frigid cold, high winds, precipitation of all sorts, and a wet, moving standing worksurface that creates unusual, three-dimensional inertial forces on loads. The physical demands of the work tasks require strength and endurance as well as high levels of coordination due the dynamic standing surface and expose these workers to many of the recognized risk factors for the development of work-related musculoskeletal disorders. These risk factors include repetitive bending and lifting, static/awkward postures, high force lifting exertions, repetitive motion and exertions of the upper extremity (including the shoulder and elbow and hand/wrist), slip and fall risks, and high levels of muscular fatigue.

The epidemiology literature supports the view that commercial fishing jobs pose significant challenges to the musculoskeletal system – particularly the low back region. In 1996, Jensen (1996) found that 10 percent of injuries in a Danish fisherman cohort were sprains and strains and 10 percent of the injuries involved the back. In a study of New Zealand commercial deep sea fishermen, Norrish and Cryer (1990) found that 39% of the compensated injury cases were recorded as having occurred during lifting, lowering, loading and unloading boxes. They further showed that back strains accounted for almost two-thirds of the strain or sprain injuries and 36% of the total costs. Recent studies indicate that back injuries remain an important outcome associated with accidents (Chauvin and Le Bouar, 2007; Antão et al., 2008) and hospitalizations (Kaerlev et al., 2008) among commercial fishermen. Two questionnaire-based studies of commercial fishermen from Sweden

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doi:10.1016/j.ergon.2011.03.006

and the Southeastern US found that 74% and 84% reported musculoskeletal symptoms for any body region in the previous 12 months, with over half experiencing low back pain symptoms (Törner et al., 1988a; Lipscomb et al., 2004). Symptoms were also prevalent in the hand/wrist (21% Swedish fishermen and 40% Southeastern US), elbow and forearm (13% and 27%), shoulder (30% and 25%), and knees (25% and 29%). Of fishermen that reported symptoms, 25% of Swedish and 39% of Southeastern US fishermen indicated that these symptoms were at a level sufficient to limit their work activity in the last year, indicating a real economic cost associated with these symptoms.

Several recent studies provide deeper insights into the specific activities, exposures and challenges faced in the small-scale commercial crab fishing industry (Kucera et al., 2008, 2009; Kucera and McDonald, 2010; Lipscomb et al., 2004; Marshall et al., 2004; McDonald et al., 2004; Mirka et al., 2005). In 2008, Kucera and colleagues provided a detailed breakdown of the time that commercial crab fishermen spend performing the various work tasks and also documented how these breakdowns varied by position (captain, mate and 3rd man) (Kucera et al., 2008). These results provide a perspective on the exposures and activities and showed that much of the heavy manual materials handling was performed by the mate (hoisting the pots into the boat, shaking crabs from the pots, moving catch and bait around on the boat deck), while the third man often maintained static awkward postures while sorting the catch and the captain operated the controls and hooked the buoys. In a more recent survey-based study of 91 fishermen, Kucera and McDonald (2010) found that the most strenuous tasks identified by this cohort were pulling the crab pots from the water, emptying the catch from the pots, hooking the buoy, and moving boxes of catch and bait around on the boat deck. Supporting these subjective observations are the results of an earlier study (Kucera et al., 2009) that documented the relationship between physical activities of these fishermen and the rate of low back pain. Running the pot-pullers or net reels, sorting catch, and unloading catch were associated with an increased rate of low back pain. More specifically, non-neutral trunk postures combined with a lifting force of greater than 9 kg (>20 lb) showed the strongest relationship to low back pain (Kucera et al., 2009). These results and the epidemiological statistics emphasize the significance of the problems faced in this industry, but also highlight the opportunities for improvement through the development of effective ergonomic interventions.

Engineering controls are generally acknowledged as the most effective way to reduce the incidence and severity of work-related musculoskeletal disorders through the reduction in exposure to recognized risk factors. Interventions employed in the commercial fishing industry have been successful in reducing the risk of entanglement and injury by installing an emergency stop (Lincoln et al., 2008). Two previous studies have considered the development and testing of ergonomic interventions for the commercial fishing industry. In their work investigating the ergonomic exposures of fishermen on Massachusetts fishing vessels, Fulmer and Buchholz (2002) used the PATH ergonomic assessment technique to quantify the postures and work activities of fishermen involved in gillnetting, otter trawling and lobstering. These authors identified a number of work factors (production speed, materials handling, etc.) that had an impact on the exposure to risk factors for these workers and conclude with a number of reasonable engineering control interventions. Unfortunately it was not within the scope of their study to perform a detailed evaluation of the effectiveness of these proposed interventions. Törner and colleagues, performed a practical ergonomic evaluation and intervention study among Swedish professional fishermen (Törner et al., 1988b). Intervention effects were evaluated through changes in muscle oxygen uptake and posture. Suggested interventions to reduce musculoskeletal stress included a modified vertical boat hull and manual winch for eel fishing and a dock-side crane for unloading the catch. The focus of the current study was the development and evaluation of ergonomic interventions designed to reduce exposure to recognized risk factors for the development of musculoskeletal disorders in the commercial crab fishing industry.

Fig. 1. Fisherman lifting the crab pot from the water.

1.1. Introduction to small-scale crab pot fishing

As an introduction to the methods employed in this study, we provide an overview of the sequence of tasks performed in a typical work cycle for a two-man crab pot fishing crew. First the captain of the boat drives up to a buoy floating in the water and reaches out with a long pole with a hook on the end (often called a catch stick and is usually between 4 and 8 feet long and is made of aluminum or wood) and hooks the rope attached to the buoy. The captain then pulls this pole in and feeds the rope into a mechanized device called a pot-puller which is then activated and draws the crab pot (see Fig. 1 for a picture of a crab pot) up from its resting place on the bottom of the ocean or river. After feeding the pot-puller, the captain then sets down the catch stick and drives to the next buoy. Once the pot-puller lifts the pot to the side of the boat, the mate (second man on the team) lifts the pot from outside of the boat (Fig. 2) at about mid-shin level to the interior of the boat. As the mate is lifting the pot into the boat he dumps the old bait from

Fig. 2. The Crab Pot Ramp intervention mounted to the side of the fishing boat.