Forearm Muscle Oxygenation Decreases During Low Levels of Brief, Isometric Contraction—Murthy G, Hargens AR, Kahan NJ, Bach JM, Rempel DM

Introduction. Regional muscle pain syndromes can be caused by repeated and sustained exertion of a specific muscle. Such exertion may elevate local tissue fluid pressure, reduce blood flow and tissue oxygenation (TO_2), and cause fatigue, pain and functional deficits of the involved muscle. Low levels (less than 20% maximum voluntary contraction (MVC)) of prolonged static contraction of the upper extremity are common in many occupational settings and may cause fatigue (1). The purpose of our investigation was to determine whether TO_2 decreases significantly at low levels of static contraction of the extensor carpi radialis brevis (ECRB).

Methods. Healthy male and female subjects (n=9) participated in the study after providing written informed consent. The protocol was approved by the University Human Research Institutional Review Board. Each subject was seated, right arm was abducted to 45°, elbow was flexed to 85°, right forearm was pronated 45°, and wrist and forearm were supported on an arm rest throughout the protocol. Altered TO_2 was measured noninvasively using near infrared (NIR) spectroscopy (2). This technique has been validated previously (3). The NIR probe was placed over the ECRB muscle and gently secured with an ace wrap. MVC was determined initially and the subject rested for an hour prior to subsequent tests. After one minute of relaxed, baseline measurements, four different loads (randomly ordered) were placed just proximal to the metacarpalphalangeal joint such that subjects isometrically contracted the ECRB at 5, 10, 15, and 50% of MVC for 1 minute each. A 3 minute recovery period followed each contraction level. At the end of the protocol, with the NIR probe still in place, an ischemic TO_2 was obtained to establish a zero level for each subject. NIR data were normalized to a relative scale between the physiologic minimum (0%) established during ischemia and the spectrophotometer output at baseline (100%).

Results. After 35 and 40 seconds of contraction, TO_2 plateaued at below baseline levels and remained at that level throughout the contraction period. Mean TO_2 decreased from resting baseline (100% TO_2) to 89 ± 4% (SE), 81 ± 8%, 78 ± 8%, and 47 ± 8% at 5, 10, 15, and 50% MVC, respectively. TO_2 levels at 10, 15, and 50% MVC were significantly lower ($p < 0.05$; RANOVA and Tukey's follow-up) than baseline values. TO_2 recovered to baseline values within 3 minutes following contraction.

Discussion. This study demonstrates a significant reduction in TO_2 even at sustained contraction levels as low as 10% MVC. Tissue deoxygenation during prolonged isometric muscle contraction may play an important role in the development of work-related muscle fatigue and pain. Static or dynamic contraction with inadequate recovery time may sustain elevated intramuscular pressures, and reduce blood flow and TO_2, and cause muscle fatigue and pain. Although the duration of static contraction in our study was only 1 minute, the observation that recovery to baseline TO_2 took between 30 seconds to 3 minutes indicates that a low contraction level even for a brief period is sufficient to reduce TO_2 significantly. Therefore, sustained tissue hypoxemia associated with low levels of sustained contraction may provide a mechanism to explain work-related muscle dysfunction.

References

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Session 13: Intervention Evaluation

Preventing Drownings in Alaska's Commercial Fishing Industry—Conway GA, Lincoln JM

Introduction. The Arctic and subarctic waters of Alaska provide a very hazardous work setting, with great distances, seasonal darkness, cold waters, high winds, brief fishing seasons, and icing. Deaths have been inordinately common in Alaska's commercial fishing industry. Over 90% of these deaths have been due to drowning or drowning plus hypothermia, following vessel capsizings and sinkings. During 1991 through 1994, the U.S. Commercial Fishing Vessel Safety Act of 1988 (USCFVSA) required the implementation of comprehensive prevention measures for all fishing vessels in offshore cold waters, including immersion suits, survival craft (life rafts), EPIRBs and crew training in emergency response and first aid.

Purpose. To examine the effectiveness of the measures instituted under the USCFVSA in reducing the high occupational fatality rate (200/100,000/year in 1991-1992) among Alaska's commercial fishermen

Method. Comprehensive surveillance for commercial fishing occupational fatalities was established by our office during 1991 and 1992 in Alaska. Demographic, risk factor, and incident data for 1991 through 1996 were compiled and analyzed for trend.

Findings. During 1991-1996, there was a significant (p=.002) decrease in Alaskan commercial fishing-related deaths, from 36 in 1991 to 35 in 1992, 22 in 1993, 11 in 1994 (artificially reduced number due to closure of crab fisheries that year), 18 in 1995, and 24 in 1996. While man-overboard drownings and vessel-related events in crabbing (often conducted far offshore and in winter) have continued to occur, marked progress (significant downward trend, p<0.0002) has been made in saving lives of those involved in vessel-related events:

Year	Vessels Lost	Persons on Board	Persons Killed	Case Fatality Rate*
1991	39	93	25	27%
1992	44	113	26	23%
1993	24	83	14	17%
1994	36	131	4	3%
1995	26	106	11	10%
1996	38	114	13	11%

**Case Fatality Rate = (number killed/number at risk) x 100 percent*

Conclusions. Specific measures tailored to prevent drowning in vessel capsizings and sinkings in Alaska's commercial fishing industry have been very successful so far. However, these events continue to occur, placing fishermen and rescue personnel at substantial risk. Additional efforts must be made to reduce the frequency of vessel events, enable similar progress in crabbing fisheries, and to prevent man-overboard events and drownings associated with them.

Methodological Criteria for Evaluating the Effectiveness of Accident Prevention Programs—Shannon HS, Robson LS, Guastello SJ

Despite the large volume of occupational safety literature, which is often descriptive or examines physical risk factors, accident prevention programs are often not evaluated. Moreover, the quality of evaluations that do take place has been criticized. Commonly occurring methodological weaknesses include: not taking into account length of exposure when calculating accident rates; the use of proxy measures for outcome measures, without validating the use of the proxy; not monitoring large workplace/societal changes which could influence accident rates, especially in the case of before-after designs. There are, no doubt, many reasons for this situation - among them is a lack of training in evaluation in those responsible for occupational safety within organizations. Yet rigorous assessments of our efforts in promoting safety are essential if we are to avoid using limited human and financial resources on ineffective (or even harmful) measures.

In the following, we describe a set of methodological criteria, derived in order to assess the quality of reported evaluations of safety interventions. These criteria can also serve as a reference for those planning such evaluations. Identification of the criteria was based on an examination of the safety, health promotion, program evaluation and research design literatures. Eight areas were deemed relevant:

1. Program objectives—e.g., Did the program objectives provide a measure against which outcomes could be compared? 2. Program design—e.g., Was experimental, quasi-experimental or non-experimental design used? 3. Program participants—e.g., Was selection bias considered? 4. Description of the safety intervention(s)—e.g., Was exposure to additional societal/workplace factors considered? 5. Measurement of program implementation—e.g., Was description/measures of compliance of program recipients provided? 6. Measurement of program outcome—e.g., Were true outcome measures provided? 7. Analysis of results—e.g., Was sample size/statistical power considered? 8. Conclusions—e.g., Were conclusions supported by the analysis?

Some of the criteria are applicable to field experimentation in general, but emphasis has been given to issues in the safety field.

Baseline Safety Measures in the First Year of the New England Safety Project—Halperin K

In the fall of 1996 the United Brotherhood of Carpenters Health and Safety Fund (UBCHSF), working with researchers from the Johns Hopkins School of Public Health, was awarded a three year grant from NIOSH in injury prevention among union carpenter contractors in New England. The aim of this project is to demonstrate that injuries to carpenters can be measurably reduced by the implementation of written health and safety programs by small construction contractors. The methodology is a controlled prospective trial among small firms employing unionized carpenters. Twenty-two small-to-medium sized carpenter contractors (with average annual employment approximating 10 to 50 carpenters) in the Boston, MA, Hartford, CT and Providence, RI areas were recruited into the treatment group. The control group consists of 50 similar (in size and types of work) contractors in upstate New York. The geographical separation should minimize contamination. The treatment group will implement, with UBCHSF help, a written health and safety program. Using OSHA-required injury logs and workers' compensation data, this project seeks to demonstrate how the implementation of written health and safety programs by such contractors can lead to a measurable reduction in the rate of occupational injuries. Implementing this intervention over a two-year period is expected to result in a reduction in OSHA-recordable injuries, lost workday injuries, and days lost from work due to injuries, and in reduced workers' compensation experience modification rates.This project will also seek to demonstrate that the implementation of health and safety programs will result in measurable changes in workplace safety and health practices by participating contractors. Four "sentinel" safety and health practices are being measured through direct observation in actual workplaces: use of eye protection, use of ground fault circuit interrupters, use of hearing protection, and fall protection. Contractor and worker interviews are being used to gather information about the implementation of the intervention, and particularly about the perceptions of these two groups regarding the degree of acceptance of the intervention.The control group will be given an initial workplace visit with occupational safety and health advice (comparable to the baseline visit for the treatment group) and the promise of help in installing health and safety programs in their companies at the end of the two year period. Periodic measures of the sentinel practices will occur for both the control and treatment groups throughout the period, and the OSHA logs and experience modification rates collected before and after the period.Baseline information about workers' compensation experience modification rates, OSHA recordable injury rates, and occupational safety and health practices as represented by observation of the four "sentinel" practices will be presented for both the treatment and control groups. The next steps of the project will be outlined.

A Meta-Analysis of Long-Term Results for a Behavior-Based Method to Reduce Workplace Injuries—Krause TR, Sloat KCM, Seymour KJ

Research and applications of behavioral principles have established behavior-based safety initiatives as effective, proactive, and long-term solutions to occupational health and safety challenges. This study adds to the existing literature a longitudinal evaluation of an injury prevention process implemented in real-world industrial settings where the behavioral causes of injury varied from one site to the next. These highly individual initiativesshared 4 components: specification of critical behavior, observation/data collection, feedback, and problem-solving. Up to four years' injury data from sixty companies representing the chemical, petroleum, paper, lumber, electronics, transportation, food, and other industries who implemented this behavior-based safety process were examined. The average reduction from baseline amounted to 29% after 1 year of observation and feedback, 46% from baseline after 2 years, 50% after 3 years, and 59% after 4 years. Results did not depend on union status, industry, or baseline recordable rates and perceptions of success within the organizations concurredwith these findings.