Svendsen SW, Bonde JP, et al. Work related shoulder disorders: quantitative exposure-response relations with reference to arm posture. Occup Environ Med 2004;61:844–853.

Design: Cross-sectional study

Study question: Is upper arm elevation at work a risk factor for shoulder disorders?

Population/sample size/setting:

- The total study population consisted of men from three trade groups in Denmark: machinists, car mechanics, and house painters who had worked as journeymen for at least one year in their trade
- The total study population had 1866 men, of which there were 1627 in the "currently employed subpopulation"
- Workers who had worked for more than three years in other jobs with high shoulder demands (posture, force, or repetition) were excluded from the study population
- Other inclusion requirements were age 30-65 and at least four schooled working days during the week in which exposure was to be measured
- If a potential participant had current shoulder pain which interfered with performance at work, he was excluded from the study

Exposure assessment:

- From each of the three occupational groups 13 pairs of workers were sampled at random for measurement of upper arm elevation; 26 machinists, 23 car mechanics, and 23 house painters had these measurements completed
- Whole-day measurements of elevation were done for four consecutive working days for these 72 participants
    - Arm elevation was measured with an inclinometer with a sensor attached to each upper arm and a data logger in the belt
    - Upper arm elevation was measured with respect to gravity in of 15° intervals from 0 to 90°, and there was a separate category for arm elevation greater than 90°
- Force requirements were assessed with a torque index using force scores assigned by "experienced tradespeople"
- For each of the three trades, a "reduction factor" was assigned to jobs with special functions: for example, the reduction factor was 0.25 if a car mechanic had a job as a foreman
- Lifetime upper elevation above 90° was assessed by combining the exposure for each job in the worker's history, a reduction factor when necessary, and the total duration of employment across all jobs
    - This led to a single measure of lifetime upper arm elevation as the number of full-time working months with the arm elevated above 90°

- In addition, a questionnaire was used to assess psychosocial working conditions, job demands, and job control

Assessment of outcome:

- A two-item screening questionnaire was used to select workers for a physical examination
    - The first question asked if there had been any pain or discomfort in the shoulder in the past 12 months
    - The second question was asked if the first question was answered affirmatively; it asked how much the worker had been troubled (a little bit, somewhat, quite a bit, much, very much)
        - Screening positive meant that the second question was answered "somewhat" or higher
- A total of 732 workers were examined by examiners who were blinded on work exposure by asking the workers not to wear work clothes, to remove paint stains, and to put on gloves before being examined
- A Constant score was obtained for each examinee, with strength measured by an isometric dynamometer
- Two examiners looked for signs of supraspinatus pathology while excluding cervical radiculopathy, adhesive capsulitis, and shoulder instability

Analysis of causal relationships:

- Generalized estimating equations were used to analyze the relation between upper arm elevation and shoulder disorders (nondominant and dominant shoulders together)
- Logistic regression was used to analyze the relation between upper arm elevation and dominant shoulder disorder
    - Current arm elevation above 90° was categorized in percentage of working hours: 0-3%, 3-6%, and 6-9%
    - Cumulative lifetime arm elevation above 90° was categorized in months of exposure: 0-6 mo, 6-12 mo, 12-24 mo, and >=24 mo
        - For cumulative arm elevation, the odds ratios were adjusted for age and pack-years of smoking
- A separate comparison for unilateral shoulder disorder was made for house painters compared to the other two groups

Results:

- House painters had a higher prevalence of dominant side shoulder complaints compared to the two other groups; 31.8% were at least moderately troubled by shoulder pain in the past 12 months (compared to 15.6% for machinists and 16.8% for car mechanics)

    - High force requirements were actually lower among car mechanics (torque index was highest in this group)
- Current upper arm elevation above 90° for 6-9% of the time increased the odds of shoulder disorder compared to 0-3% of the time
    - For supraspinatus tendinitis, the odds ratio was 4.7; for shoulder pain with disability, the OR was 3.47; for shoulder pain without disability, the OR was 1.84
- Lifetime arm elevation above 90° did not significantly increase the odds of dominant shoulder supraspinatus tendinitis, but did increase the odds of shoulder pain with disability and without disability
    - For pain with disability, more than 24 months of cumulative arm elevation above 90° had an OR of 3.74
    - For pain without disability, more than 24 months of cumulative arm elevation above 90° had an OR of 1.45
- For all three shoulder disorders, a 10 year increase in duration of employment in one of the three trades was not associated with increased odds of shoulder disorder

Authors' conclusions:

- Duration of employment was not associated with shoulder disorders because of the healthy worker survivor effect; healthy workers continue working, while workers with greater disability leave the workforce
- There were exposure-response relations for upper arm elevation above 90° and shoulder disorders which may have been underestimated because of the fact that the use of group averages rather than individual exposures could lead to misclassification of exposure at the individual level
- A cumulative effect of arm elevation is not likely to explain the observed results, since the healthy worker survivor effect suggests that a relatively short induction time leads to shoulder disorders

Comments:

- Not all of the analyses appear to have been very informative or appropriate
    - Generalized estimating equations are used for correlated data (that is, a worker with one bad shoulder is, other things being equal, likely to have the other shoulder affected as well); while these equations were used for the combined shoulder analysis, only the dominant shoulder disorders were analyzed in any detail
    - The exposure data were broken down into categories (0-3%, 3-6%, and 6-9% of the time with shoulder elevation above 90°), which reduces statistical efficiency in the analysis of continuous data

        - In Table 4, this makes it appear that there is no dose-response for supraspinatus tendinitis, with an OR of only 0.94 for the category 3-6% of working hours
        - Fortunately, the trend analysis in Table 4 does show that there was a significant increase in supraspinatus tendinitis for each increment of 1% of working time, and (due to having larger numbers of cases for analysis), this is the more appropriate analysis
    - It appears that a large number of workers in the three trades do continue to work with shoulder pain; even though the authors excluded subjects who were too disabled to work at all, there were a large number of cases of men who had shoulder pain with some degree of disability
    - The force requirements were not measured well enough to infer anything from the fact that car mechanics had the highest torque index; arm elevation above 90° is the only variable measured well enough to measure its association with shoulder disorder

Assessment: Adequate for some evidence that upper arm elevation above 90° increases the odds of shoulder pain with disability, shoulder pain without disability, and supraspinatus tendinitis, with a greater than fourfold increase when the upper arm is elevated at that level for more than 6% of working time (about 30 minutes per day)