**Fan ZJ, Silverstein BA, et al. The Association Between Combination of Hand Force and Forearm Posture and Incidence of Lateral Epicondylitis in a Working Population. Human Factors 2014;56:151-165.**

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Design: cohort study

Purpose of study: to follow a population of workers at risk of lateral epicondylitis (LE) and to measure the association of risk factors with the incidence of new cases of epicondylitis over a period of 3.5 years of followup

Population/sample size/setting:

* 611 workers (299 women, 312 men, mean age 40) in 12 different manufacturing and service sector settings in Washington State
* Eligibility criteria required only that the worker not have LE

Ascertainment of potential exposures:

* Data was obtained from three sources: from trained interviewers, from a self-administered questionnaire, and from observation in the workplace by ergonomists
	+ Trained interviews collected information on several personal factors such as age, gender, gender, education, previous health history, sports/hobbies, job history, and musculoskeletal symptoms
		- Symptom variables included any pain or discomfort in the past 7 days or in the past 12 months, duration, frequency, severity, and interference with the pace and quality of work
		- An occupational health physician, a registered nurse, or a physical therapist, blinded to self-reported health status, completed a brief physical examination of the neck and upper extremities on all study participants
	+ The self-administered questionnaire assessed work organization factors such as job demands, decision latitude, job security, job satisfaction, job rotation, and social support factors such as team coordination
	+ The observation of work factors was done through video filming of sampled short-cycle and routine task performances and through measured estimation of forceful exertions
	+ Workers were videotaped from two different angles as they performed their usual tasks; a minimum of 15 minutes of videotape was collected
	+ Forceful exertion was measured through force gauges and grip dynamometers, as well as through estimation by the ergonomists and the workers
	+ Force workload factors were broken down into categories based on levels of force in previously published ergonomic literature, and were measured in terms of pinch force, power grip force, lifting/lowering force, and pushing/pulling force
	+ Posture analysis was estimated from the video frames in different positions to analyze the percentage of time spent in wrist flexion/extension, forearm supination, forearm pronation, and forearm rotation
	+ A total of 30 physical exposure variables were created: 5 for postures, 5 for different types of frequency, and 20 for various posture/force combinations

Ascertainment of outcomes:

* Assessments of health status were carried out every four months after baseline, so that the presence or absence of LE could be determined and any changes in job tasks could be determined; because the study lasted for 3.5 years, a maximum of 10 assessments was possible for any one worker during the entire study period
* A case was defined as (1) pain, aching, stiffness, burning, numbness, or tingling in the elbow or forearm in the past 7 days AND (2) symptoms that lasted more than one week or occurred more than three times in the previous 12 months AND (3) no previous sudden injury at the elbow/forearm area at the time of the onset of symptoms AND (4) a positive physi9cal exam with pain at the lateral epicondyle o resisted wrist extension
	+ Only pain on the dominant side was eligible for consideration as an incident case of LE

Results:

* During the course of up to 3.5 years of followup, 57 new cases of LE arose among the 611 workers who had contributed person-time data to the study
	+ This represented an incidence rate of LE of 4.91 per 100 person-years
* Because data were available for the occurrence of LE at different times during followup, the authors elected to calculate hazard ratios for LE (which allow the researcher to consider the time it takes for a new case of LE to occur rather than only whether or not the LE occurred at all)
* Numerous factors were tested for their association with the incidence of LE; age and gender were associated with LE and therefore were adjusted for in the physical factor analyses
	+ Compared with the age group 18-35, the age group 36-50 had a hazard ratio of 4.55 (95% confidence interval 1.77 to 11.7), and the age group older than 51 had a hazard ratio of 5.20 (95% CI 1.93 to 14.0)
	+ Compared to men, women had a hazard ratio of 1.67 (95% CI 0.97 to 2.86)
* The final models, adjusted for age and gender, included the combination of awkward posture and time spent with different types of forceful exertions
	+ Forearm pronation of >= 45° more than 40% of the time was associated with LE when any level of power grip was involved in the job; the hazard ratio was 2.80 ( 95% CI 1.35 to 5.77)
	+ Forearm pronation of >= 45° more than 40% of the time was also associated with LE when more than 3% of the work time was spent lifting any load; the hazard ratio was 2.50 ( 95% CI 1.19 to 5.24)
	+ Finally, forearm pronation of >= 45° more than 40% of the time was associated with LE when the duty cycle entailed forceful exertion at least 10% of the time; the hazard ratio was 2.25 ( 95% CI 1.09 to 4.66)
	+ Neither forceful exertion nor awkward posture by themselves were associated with LE
	+ Although female gender was associated with LE in the univariate models (were only gender was analyzed), female gender was not associated with LE in any of the adjusted models (where the physical factors were considered)
	+ However, age, which was associated with LE in the univariate models, continued to be associated with LE in the models which were adjusted for physical factors; workers aged 35 to 64 were 4 times more likely to develop LE than workers younger than 35
* Psychosocial and work organizational factors were not found to be predictive of LE
* Wrist posture was also not found to be predictive of LE

Authors’ conclusions:

* Older workers with jobs requiring a high percentage of time working with force in combination with awkward postures of the forearm were at increased risk of developing LE
* The combination of forearm pronation of >= 45° more than 40% of the time was predictive of LE when associated with power grip, lifting, and when the duty cycle required more than 10% of the time to be spent in forceful exertion
* Strenuous manual tasks are therefore likely to lead to LE

Comments:

* A very large number of ergonomic variables were tested; first, they were tested one at a time, and later they were tested in combination with one another
* It might be argued that such a large number of variables would require adjusting the p values for multiple testing; however, this is probably not necessary for several reasons
	+ The original setting in which multiple test adjustment was introduced was in settings where a single sample was tested multiple times (such as when a single large lot of an industrial product was sampled multiple times and each sample was tested for defective products); this kind of multiple testing inflates the likelihood of a Type I error (incorrectly inferring that the lot has more than the allowed number of defects), but that is not the kind of setting for this study
	+ Each of the variables which was observed and measured had been associated with LE in various previous studies with weaker causal designs (such as in cross-sectional studies); the exposure variables were not just a random group selected from a potentially infinite number of irrelevant variables
	+ The universal null hypothesis (that *none* of the variables being tested is significantly associated with the outcome of interest) is appropriate in some settings in which there is no previous information about them and there is no reason to suppose that any of the variables is relevant to the outcome; this is not the case in the current study
	+ Adjusting the p values for a large number of variables which are plausibly associated with the outcome of interest, while decreasing the risk of a Type I error, increases the risk of a Type II error (missing an important association which is in fact relevant to the outcome
* It is often expected that psychosocial and work organization factors are predictive of work-related musculoskeletal disorders; it is not clear why this was not found in the current study, but it is noteworthy that these factors were based on self-report and not on the kind of observation of physical work factors based on videotaping and on force measurements with dynamometers for which the bulk of the tested variables was measured
* The authors acknowledge that it may be a limitation that only LE in the dominant limb was considered to be a new case of LE, and that some tools and tasks may place physical demands on the non-dominant forearm
* The actual measured categories of exposure (forearm pronation of 45° or more for at least 40% of the time) should not be interpreted too literally, and might have been selected with different cutoff points while retaining their association with LE; other combinations of physical factors could still be causally associated with LE
* The cohort design of the study protects against incorrect inferences regarding the temporal association of exposure and outcome and is an important strength of the study

Assessment: high quality cohort study providing good evidence that (1) there is an increased risk of lateral epicondylitis in workers whose job tasks involve forearm pronation of 45° or more for a substantial proportion (40% or more) of the workday, when the job tasks require either power grip or any lifting, and (2) that workers over 35 are more vulnerable to developing lateral epicondylitis than workers younger than 35 who are performing the same job tasks