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Comparison of Self-Reported and Expert-Observed Physical Activities at Work in a General Population

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Concerns about exposure assessment quality have impeded research to identify risk factors for ergonomic disorders. We compared self-reported and expert-observed estimates of work-related physical factors for participants in a study of carpal tunnel syndrome (CTS). We analyzed data from 61 subjects, including 28 CTS cases and 33 controls randomly sampled from a case-control study with 417 participants. For 11 posture and manual materials handling factors, the median difference in mean exposure between self-reported and expert-observed exposure at work was less than 1/2 hour a day. Measurements by the two methods in this study agreed more often than expected by chance (median kappa 0.31 in cases and 0.28 in controls). Kappa differed significantly by case-control status for two factors: bending at the waist (kappa 0.79 in cases versus 0.28 in controls, P = 0.01) and twisting of the forearm (kappa 0.45 in cases versus −0.02 in controls, P = 0.02). Although imperfect, exposure information collected from workers' self-reports is useful for many ergonomic epidemiology studies. Am. J. Ind. Med. 34:29–35, 1998. *© 1998 Wiley-Liss, Inc.*

KEY WORDS: data collection; interviews; task performance and analysis; questionnaires; reproducibility of results; occupational exposures; posture; time perception; carpal tunnel syndrome

INTRODUCTION

In the field of epidemiologic research, it is important to improve methods of exposure measurement [Armstrong et al., 1994]. This is especially critical in ''ergonomic epidemiology,'' the subfield of study of the distribution and causes of work-related musculoskeletal disorders [Hagberg, 1992; Winkel and Mathiassen, 1994; Punnett and Keyserling, 1987]. As noted by Wiktorin et al., [1993], ''Physical workload exposures have generally been classified indirectly from job titles'' [Burdorf, 1992; Winkel and Westgaard, 1992]. Assessment of exposure on the basis of job title leads to misclassification of exposure, which can mask an existing health effect [Van der Beek et al., 1994].

In other branches of occupational health research, such as radiation and cancer, special devices have been developed to measure exposure to the environmental agent of interest. In contrast, no standardized exposure measurement rating exists for musculoskeletal disorders such as carpal tunnel syndrome (CTS). A condition associated with the longest periods of work-related disability among workers' compensation claims [Cheadle et al., 1994], CTS has been self-reported by about 1.5% of adult workers in the United States [Tanaka et al., 1995]. A major review found no CTS study that directly measured workplace exposure of all participants [Hagberg et al., 1992]. With the issue of musculoskeletal disorder causation unresolved, the Occupational Safety and Health Administration has not been able to issue an ergonomic rule for public comments [Scalia, 1994].

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There is little documented evidence that questionnaire or interview information regarding occupational exposure is inadequate [Axelson, 1985]. Few studies have been done on the validity of self-reported quantitative data on work postures and manual materials handling, and the findings are inconsistent [Wiktorin et al., 1993]. Individuals with musculoskeletal disorders may overestimate or underestimate their exposure to certain physical activities differently than persons without such symptoms [Wiktorin et al., 1993]. To assess whether exposure information collected from workers' self-reports is acceptable for ergonomic epidemiology, we compared the work-related information obtained by telephone interview of participants in an etiologic case-control study of CTS with the findings of an ergonomist's observations of the participants at their workplaces.

METHODS

Many of the questions in our case-control study of CTS in a general population, described previously in detail [Nordstrom et al., 1997], came from the Occupational Health Supplement of the National Health Interview Survey [Park et al., 1993]. In brief, from May to December 1995 we conducted case-control study interviews averaging 35 minutes. Cases (n = 206) were persons aged 18–69 living in a study area, the Marshfield Epidemiologic Study Area (MESA) comprised of 14 adjacent zip codes in Wisconsin, and having a first-ever diagnosis of CTS. We have shown that Marshfield Clinic databases capture 94% of hospital discharges and 92% of outpatient visits of MESA residents [DeStefano et al., 1996]. Controls (n = 211) were persons from the same age and area chosen randomly from a population registry of individuals without a diagnosis of CTS. Neither current nor prior employment was required of case-control study participants.

After completing the case-control study, we selected a limited number of exposure variables to be simultaneously observed by an ergonomist to minimize loss of precision [Kilbom, 1994]. Each physical activity (for the corresponding complete questions from the case-control study, see Appendix) was assessed by the ergonomist in up to three different ways: did the subject ever perform the activity while observed on the job; if so, was the activity performed almost all the time or only sometimes; and how many minutes or hours was this activity performed on a typical work day? To promote the same interpretation of the exposure questions as in the case-control study, we showed the ergonomist the same visual aids for posture that we mailed to the case-control study participants before their interviews. These depicted two hand movements, hand bending and pinch grip (see Appendix). The ergonomist, a former physical therapist, had 10 years of experience in job analysis consulting.

The expense of workplace visits precluded observation of all 417 case-control study participants. For the worksite study of intermethod reliability of exposure assessment, our budget allowed us to observe 60 persons. Our worksite sample was stratified by CTS case-control status and farm residency as determined in the case-control study. We restricted worksite study participation to cases who had only one job during the 12 months before their first-ever CTS diagnosis and to controls who had only one job during the 12 months before their case-control study interview. Only persons who were still doing that same job at the time of the worksite study, January to February 1996, were eligible to participate. Long-distance truck drivers were deemed ineligible because it was not feasible to observe them.

Information from our case-control study indicated that 306 participants met the ''one job'' criterion described above. We originally had 8 farm cases, 13 farm controls, 140 nonfarm cases, and 145 nonfarm controls who were eligible for enrollment in the worksite study. Since farm residency originally was a variable of interest for our analysis, we decided to sample all farmers and a random subset of nonfarmers from the case-control study. First, we sent a letter to the potential participant, and then the case-control study interviewer of each participant telephoned that participant to obtain informed consent to conduct an observation at work. If the worker agreed, we called the worker's employer to get consent (except for self-employed). The worksite study was approved by the Institutional Review Board of Marshfield Clinic. To see whether occupations differed between worksite study participants and case-control study participants, we compared the distributions by U.S. government standard white collar, service, agriculture, and blue collar occupational groups [Park et al., 1993, p. 41].

An ergonomist observed each selected person at work for about 1 hour and recorded the worker's exposure to 11 physical activities (see Appendix) on a standard form. Each of the activities was included in our case-control study because it was deemed a potential risk factor for CTS. Cases were observed on average 12 months after their CTS diagnosis, and controls were observed on average 6 months after their interview in the case-control study. The observer was blinded to case-control and exposure status of the worker as classified in the case-control study. Before observation began, the ergonomist asked the subject to name the duties of the job and the usual percentage of time for each duty. Simpler jobs were observed for shorter periods, and complex jobs for longer ones at the ergonomist's discretion. To estimate how long a worker performed an activity on a typical day, we determined how long they worked on a typical work day, which we then multiplied by the proportion of time they performed the task of interest while being observed.

To assess agreement between the worker's and the ergonomist's assessment of physical activities, we used the kappa coefficient [Fleiss, 1981] with all dichotomous variables (e.g., ''Do you ever perform the activity on the job?''). Requiring no assumption about which rating is true [Fritschi et al., 1996], kappa estimates the observed agreement beyond chance divided by the maximum possible agreement beyond chance [Van der Beek et al., 1994]. Byrt [1996] has proposed this description of kappa: 0.00 or less, no agreement; 0.01–0.20, poor agreement; 0.21–0.40, slight agreement; 0.41–0.60, fair agreement; 0.61–0.80, good agreement; 0.81–0.92, very good agreement; 0.93–1.00, excellent agreement. Kappa is negative when the measurements agree less than expected by chance. Because workers' self-reports and the ergonomist's observations were based on different time periods (1 day vs. 1 hour), data from the latter were extrapolated to 1 day to permit comparison in minutes per day. We used a test of equality for independently derived kappa statistics [Fleiss and Cicchetti, 1978] to determine whether the discrepancy between self-reported and observed assessments differs across case-control status or gender. Because kappa depends on the prevalence of exposure, we also determined the percentage of full agreement for all dichotomous variables.

We also wanted to evaluate agreement for the number of hours or minutes spent performing each task. We categorized the ergonomist's extrapolated measurements to reflect the same detailed level of information as collected in the case-control study interviews: daily exposure of less than 5 minutes, 5–29 minutes, 30–59 minutes, or 1 hour or more. In this instance, we could not use kappa due to small sample size, so instead we used Spearman's correlation coefficient (r_s). All analyses were performed using the SAS System, version 6.11 [SAS Institute, Inc., Cary, NC].

RESULTS

Observation of participants ranged from 15 to 150 (median 55) minutes, and duration did not differ by case-control status. We achieved the study aim of observing 61 subjects, including 28 CTS cases and 33 controls. (Our analysis excludes one person who was observed whose job was not the same in both studies.) Cases included 10 males and 18 females, and controls included 20 males and 13 females. The median age was 42 years for cases and 45 years for controls. Of the 306 individuals from the case-control study who met the worksite study criterion of having had only one job during the relevant 12 months, we sampled 280 including all of the eligible cases, all of the eligible farm controls, and the majority (119/145) of the eligible nonfarm controls. Worker refusals of worksite observation were high (51 cases, 50 controls), as were worker observation ineligibles due to job or employer changes (29 cases, 40 controls), while employer worksite observation refusals were low (2 cases, 2 controls). (We did not contact 44 other individuals in the sample after we completed observations of 61 persons.)

TABLE I. Distribution of Participants Selected for the Worksite Study in Marshfield Epidemiologic Study Area, 1995–1996, by Gender, Occupational Group, and Observation Status (n = 279)*

	Male[a]		Female[b]	
	Observed	Not observed	Observed	Not observed
White collar	10 (33.3)	30 (26.3)	24 (77.4)	58 (55.8)
Service	1 (3.3)	4 (3.5)	4 (12.9)	25 (24.0)
Agriculture	8 (26.7)	9 (7.9)	0 (0.0)	5 (4.8)
Blue collar	11 (36.7)	71 (62.3)	3 (9.7)	16 (15.4)
All combined	30 (100.0)	114 (100.0)	31 (100.0)	104 (100.0)

*Data are numbers, with percent in parentheses. Table includes only eligible, sampled individuals. It excludes one person who was observed whose job was not the same in both studies.
[a]$P = 0.02$ (Fisher's exact test).
[b]$P = 0.21$ (Fisher's exact test).

TABLE II. Mean Exposure in Minutes per Workday to Selected Physical Factors Estimated by Self-Reported and Expert-Observed Methods in Marshfield Epidemiologic Study Area, 1995–1996

	Carpal tunnel syndrome cases (n = 28)			Controls (n = 33)		
	Self-reported[a]	Expert-observed	Difference[b]	Self-reported[a]	Expert-observed	Difference[b]
Bend at waist	117	37	80	90	18	72
Lift >2 lbs.	201	63	138	146	42	104
Use power tools	106	19	87	51	14	37
Assembly line	34	26	8	44	26	18
Twist forearm	56	76	−20	82	75	7
Twist hand	131	113	18	143	141	2
Press w/finger	75	50	25	62	40	22
Use pinch grip	36	86	−50	77	85	−8
Use ear plugs	80	26	54	57	58	−1
Work in cold	60	32	28	70	32	38
Wear gloves	105	23	82	96	18	78

[a]Interpolated from ordinal data obtained in telephone interviews.
[b]Self-reported minus expert-observed.

The distribution by occupational group in participants versus sampled non-participants differed in men (Fisher's exact test, $P = 0.02$), but not in women ($P = 0.21$) (Table I). Self-reported daily duration of exposure to the 11 physical factors usually exceeded expert-observed duration, but the difference for most factors was less than an hour (Table II). Moreover, the median difference in mean exposure for cases, 28 minutes, was similar to the median difference for

TABLE III. Cohen's Kappa, Percentage of Full Agreement, and Spearman's Correlation Coefficient Between Self-Reported and Expert-Observed Exposure to Selected Physical Factors at Work in Marshfield Epidemiologic Study Area, 1995–1996

	Carpal tunnel syndrome cases (n = 28)			Controls (n = 33)			*P* value for test of equal kappas[a]
	Kappa[a]	Full %[a]	r_s[b]	Kappa[a]	Full %[a]	r_s[b]	
Bend at waist	0.79	89	0.67	0.28	64	0.38	0.01
Lift >2 lbs.	0.41	75	0.58	0.35	70	0.41	0.78
Use power tools	0.28	68	0.45	0.02	67	0.03	0.18
Assembly line	0.46	93	0.46	0.78	97	0.80	0.40
Twist forearm	0.45	71	0.35	−0.02	45	0.05	0.02
Twist hand	0.26	64	0.33	0.09	56	0.01	0.46
Press with finger	0.00	50	0.16	0.11	52	0.08	0.64
Use pinch grip	0.00	43	0.31	−0.06	47	0.24	0.72
Use ear plugs	0.44	86	0.53	0.31	82	0.40	0.67
Work in cold	0.31	71	0.55	0.68	88	0.74	0.08
Wear gloves	0.31	71	0.51	0.39	76	0.51	0.72

[a]Based on dichotomous exposure measurement.
[b]Based on ordinal exposure measurement.

controls, 22 minutes. However, workers reported lifting objects greater than 2 pounds about 2 hours more per workday than estimated by our ergonomist's observation.

The measurements by two methods in this study agreed more often than expected by chance (Table III). The median kappa for case participants, 0.31, was similar to the median kappa for control participants, 0.28. Kappa appeared to differ by case-control status for two factors: bending at the waist (kappa 0.79 in cases vs. 0.28 in controls, $P = 0.01$) and twisting of the forearm (kappa 0.45 in cases vs. -0.02 in controls, $P = 0.02$). The median kappa for male participants, 0.18, was lower than the median kappa for female participants, 0.30 (data not shown). In the gender-specific analysis (data not shown), kappa also differed for two factors, assembly line (kappa 0.35 in males vs. 1.00 in females, $P = 0.03$) and use of ear plugs (kappa 0.18 in males vs. 0.78 in females, $P = 0.02$). Only eight farmers were observed, so we could not assess the influence of farmwork on exposure to physical work factors using the kappa coefficient.

For the 11 physical factors, the median percentage of full agreement between the two data collection methods was 71% for case participants and 67% for control participants (Table III). The median correlation between the two methods of classifying exposure in daily time rankings was 0.46 for case participants and 0.38 for control participants.

DISCUSSION

Our comparison of self-reported to expert-observed exposure to physical activities at work in a community study including many industries and occupations found that exposure classification agreed more often than expected by chance, with agreement even fair or good for some activities. Moreover, in the first such study with subjects whose musculoskeletal condition was medically diagnosed, we found little evidence that agreement differed by disease status.

Strengths and Limitations

Differences in questions, modes of data collection, physical activities, and medical disorders make it difficult to compare our findings with the eight prior studies that have assessed information on work postures and manual materials handling obtained from worker self-reports and external observation [Baty et al., 1986; Burdorf and Laan, 1991; Hildebrandt and Bongers, 1992; Rossignol and Baetz, 1987; Van der Beek et al., 1994; Viikari-Juntura et al., 1996; Wiktorin et al., 1993; Wiktorin et al., 1996]. Only two of the 11 physical factors examined in our study, bending at the waist and lifting, were assessed in five prior investigations. Two other factors from our study, use of power tools and twisting of the hand, were each evaluated in one study.

In contrast to our approach, most other investigators collected both observational and self-reported data on the same time period. For example, a worker would be observed for a day; at the end of the day, he or she would be asked to self-report exposure to selected factors that had been measured that day. The difference in frequency distribution of work tasks at the time of observation from that at the time of responding to a questionnaire [Viikari-Juntura et al., 1996] could explain differences in exposure to physical factors,

particularly among individuals with symptoms. Our findings are consistent with other reports that the direction of disagreement between workers' and observers' estimation of exposure to physical work load differs by exposure variable. Burdorf and Laan [1991] found observed exposures to be greater, but Rossignol and Baetz [1987] and Van der Beek et al. [1994] found self-reported exposures to be greater.

A potential threat to causal inference is bias from misclassification of exposure or outcome. Blinded to our prior assessment of exposure and outcome, our ergonomist estimated that he could identify the CTS status of only one-sixth of observed individuals. Although none of the other eight studies required disease-diagnosed subjects, several classified subjects as having or not having current or past year pain symptoms in the neck, shoulder, or back. Wiktorin et al. [1993] reported that people with low back complaints may have overestimated lifting when compared with those without low back pain. Viikari-Juntura et al. [1996] also found that agreement between self-reported and expert-observed estimates of exposure differed between those with and without low back pain. On the other hand, Burdorf and Laan [1991] and Wiktorin et al. [1996] reported that musculoskeletal complaints did not appear to influence the accuracy of self-reports.

Direct measurements of exposure during work tasks may be combined with self-reported task distributions to obtain a proper estimate of the complete individual job exposure, as Winkel et al. [1996] suggest. Also, it may be easier to estimate duration of postures during the preceding workday than to estimate durations in a typical workday [Wiktorin et al., 1996]. We believe the design of the questionnaire is an important influence on the accuracy of self-reported data. Our case-control study instrument resulted from a process of carefully weaving borrowed and original questions together into a format that was pretested twice before its use in a structured way by well-trained, professional interviewers [Nordstrom, 1996]. A systematic interview rather than simple self-report improves the accuracy and precision of exposure considerably [Winkel and Mathiassen, 1994].

Of course, other data collection methods than interview and observation have their own weaknesses. For example, only 35% of 1,867 Finnish forestry workers completed logbooks on their physical work load on 3 typical workdays [Viikari-Juntura et al., 1996], a low participation rate. Also, efforts to develop techniques to reduce the large amounts of biomechanical data that can be collected directly from electrogoniometers or force sensors are still being tested in laboratory settings and are not ready for large-scale epidemiologic investigations [Radwin et al., 1994].

The contrast in our study between low refusal of workplace observation by employers and high refusal by workers was surprising. In California, a government program of CTS surveillance experienced the reverse, that is, 10% refusal by workers of a standardized follow-up interview and 75% refusal by employers of a free, voluntary, nonenforcement worksite inspection [Maizlish et al., 1995]. There are important differences in the two projects. Ours is a scientific and health care institution and not a government agency. We selected participants from our own recently conducted case-control study, while the California program contacted individuals from occupational disease case reports filed by physicians per state law. Our cases, unlike California's, were not presumed to be work-related. (Less than one-third of incident CTS cases in MESA claim coverage under workers' compensation insurance [Nordstrom et al., 1994]). Also, the time required of employers in our study was minimal versus California's half-hour interview and a worksite investigation lasting up to 4 hours. Finally, our access was aided by the positive experience employers in the study area had previously had with our hospital's Rehabilitation Service. That facility's occupational therapist makes workplace visits for the purposes of assessing work tools and tasks and promoting return to work of injured individuals.

Information on past exposures reported in a personal interview may be difficult or impossible to validate [Schlesselman, 1982]. As an intermethod study of reliability, our study does not assess accuracy because there was no predefined ''gold standard'' of ergonomic exposures [Baty et al., 1986]. A limitation of this study results from the impossibility of measuring psychosocial factors, which may play a role in the etiology of some musculoskeletal disorders, by observation in the workplace [Schierhout et al., 1994]. Also, correlation of exposure estimates would likely have been higher if both the study interview and observation had been repeated, but limited resources prevented this. Finally, our sample size may have been too small to detect all physical factors whose kappas differed between participants with and without carpal tunnel syndrome.

CONCLUSION

In view of the brief and arbitrarily chosen observation period several months after self-report interviews, the levels of agreement we found with self-reported exposure to physical factors were impressive. Although imperfect, exposure information collected from workers' self-reports is useful for many ergonomic epidemiology studies.

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APPENDIX

Did this job require you to do REPEATED bending or twisting at the waist?

1 = YES
2 = NO → GO TO Q 3

A. Almost all the time or only sometimes?

1 = ALMOST ALL THE TIME
2 = ONLY SOMETIMES

B. On a typical work day, how many minutes or hours altogether did you do this?

1 = _____ HOURS
2 = 1/2 HOUR–<1 HOUR

3 = 5 MINUTES–<1/2 HOUR
4 = <5 MINUTES
9 = (DON'T KNOW)

C. During a work day when you did the most, how many minutes or hours?

1 = _____ HOURS
2 = 1/2 HOUR–<1 HOUR
3 = 5 MINUTES–<1/2 HOUR
4 = <5 MINUTES
9 = (DON'T KNOW)

(The following 10 questions used the same A, B, and C answer choices as the first question. The answer choices have been deleted to save space.)

Did you lift, carry, push or pull objects weighing more than 2 lbs?

Did you work with hand-held or hand-operated power tools or machinery?

Did you work on an assembly line?

Did you have a job where there was a twisting, rotating or screwing motion of the forearm, such as when using a manual screwdriver or wringing out wet clothes?

Now look at the card labeled "Page Three—Blue." Did this job require you to BEND or TWIST your hands or wrists MANY TIMES AN HOUR?

Did this job require you to use the tip of a finger or thumb as a pressing or pushing tool?

Now look at the card labeled "Page Four—Green." Did this job require you to use your hand in a finger pinch grip?

Did you work in a noisy area where you wore ear plugs or ear muffs?

Did you work in cold temperatures during the winter?

Did you wear gloves or mittens in this job in the winter?