2014

Natural history of upper extremity musculoskeletal symptoms and resulting work limitations over 3 years in a newly hired working population

Bethany T. Gardner
Washington University School of Medicine in St. Louis

Ann Marie Dale
Washington University School of Medicine in St. Louis

Alexis Descatha
Inserm, Occupational Health Unit

Bradley A. Evanoff
Washington University School of Medicine in St. Louis

Recommended Citation

Gardner, Bethany T.; Dale, Ann Marie; Descatha, Alexis; and Evanoff, Bradley A., "Natural history of upper extremity musculoskeletal symptoms and resulting work limitations over 3 years in a newly hired working population". *Journal of Occupational and Environmental Medicine*, 56, 6, 588-594. 2014.

Natural History of Upper Extremity Musculoskeletal Symptoms and Resulting Work Limitations Over 3 Years in a Newly Hired Working Population

Bethany T. Gardner, OTD, OTR/L, Ann Marie Dale, PhD, OTR/L, Alexis Descatha, MD, and Bradley Evanoff, MD, MPH

Objective: To describe the proportions of workers with upper extremity (UE) symptoms and work limitations because of symptoms in a newly hired working population over a 3-year study period and to describe transitions between various outcome states. **Methods:** A total of 827 subjects completed repeat self-reported questionnaires including demographics, medical and work history, symptoms, and work status. Outcomes of interest were UE symptoms and work limitations because of symptoms. **Results:** Up to 72% of workers reported symptoms at least once during the study, with 12% reporting persistent symptoms and 27% reporting fluctuating symptoms; 31% reported work limitations at least once, with 3% reporting consistent work limitations and 8% reporting fluctuating limitations. **Conclusions:** UE symptoms and work limitations are common among workers and dynamic in their course. A better understanding of the natural course of symptoms is necessary for targeted interventions.

Learning Objectives

- Summarize the new findings on rates of upper extremity symptoms and associated work limitations in a population of newly hired workers over 3 years.
- Identify patterns of variations in the study findings over time, including rates of persistent versus fluctuating upper extremity symptoms and work limitations.
- Discuss the implications for understanding the natural course of symptoms and work limitations, toward developing more effective strategies to improve workers' health.

Transiency of symptoms is a characteristic of many health conditions such as rheumatoid arthritis and multiple sclerosis, such that there are periods of increased disease activity alternating with remission or abatement of symptoms. Previous studies have hypothesized that the course of work-related musculoskeletal disorders (MSDs) may be similar, with several stages of symptom severity from mild discomfort to functionally disabling pain.[1–3] The transience of MSD symptoms may be due either to the nature of the disorder[1,2] or to cyclical or seasonal variance in physical work exposures.[4]

Evanoff et al[5] recently described the complex and multifactorial nature of MSDs in a simple conceptual model showing a pyramid of disability (Fig. 1). As Evanoff outlined, epidemiological studies of MSDs have used a wide variety of case definitions with varying degrees of disease severity and related work disability. Yet, the factors influencing progression of MSD, and thus potential targets for intervention, may be different at different stages of disease or disability.[2,5,6] Traditionally, duration of lost work has been the primary measure of work disability because of musculoskeletal injuries. Lost time as the primary measure of work disability largely underestimates the cost of MSDs to employers, individual workers, and to society as a whole and misses the earliest opportunity for prevention and intervention efforts.

Most lost productivity, and thus cost, is due to workers who are able to continue working but at less than full ability, rather than from workers who are on lost time.[7–11] This phenomenon, of decreased work performance because of a health condition, is sometimes known as "presenteeism."[12–15] Previous studies showing links between employee health and presenteeism have focused on chronic health conditions including migraines, allergic rhinitis, gastrointestinal disorders, arthritis, and depression in single-employer studies, clinical populations, or national telephone surveys.[16–28]

Despite the breadth of epidemiological studies of the development, prevention, and treatment of MSDs, and return to work interventions, relatively few studies have examined productivity and functional abilities of workers who remain at work while experiencing musculoskeletal pain.[8,29–32] Most existing studies on presenteeism in workers with MSDs have been conducted with clinical populations who were treatment seeking rather than working populations. These studies have focused on the impact of presenteeism in terms of the cost to employers rather than exploring its causes and the experience of the worker.[33]

Because of the high prevalence of upper extremity (UE) symptoms and the transient nature of both symptoms and resulting disability, studies of the natural history of UE symptoms and work limitations are necessary to understand the experience of individual workers and the individual and occupational characteristics associated with these limitations. Better understanding of the natural course of symptoms and work limitations can lead to more effective preventive and treatment strategies to improve workers' functional abilities and provide cost savings for employers. The aims of this study were to describe the proportions of workers with UE symptoms and work limitations because of symptoms in a newly hired working population during repeated follow-ups over a 3-year study period and to

From the Department of General Medical Sciences (Drs Gardner, Dale, and Evanoff), Washington University School of Medicine, St Louis, Mo; and Occupational Health Unit (Dr Descatha), the Inserm U1018-AP-HP, Garches, France.

This study was supported by CDC/NIOSH (grant number R01OH008017-01) and by the Washington University Institute of Clinical and Translational Sciences Award (CTSA) (grant # UL1 TR000448) from the National Center for Advancing Translational Sciences (NCATS) of the National Institutes of Health (NIH). Its contents are solely the responsibility of the authors and do not necessarily represent the official view of NIOSH, NCATS, or NIH.

Authors Gardner, Dale, Descatha, and Evanoff have no relationships/conditions/circumstances that present potential conflict of interest.

The JOEM editorial board and planners have no financial interest related to this research.

Supplemental digital content is available for this article. Direct URL citation appears in the printed text and is provided in the HTML and PDF versions of this article on the journal's Web site (www.joem.org).

Address correspondence to: Bethany T. Gardner, OTD, OTR/L, Division of General Medical Sciences, Washington University School of Medicine, Campus Box 8005, 660 S. Euclid Ave, Saint Louis, MO 63110 (bgardner@dom.wustl.edu).

DOI: 10.1097/JOM.0000000000000179

describe the transitions between different states of symptoms and work limitations.

METHODS

This study was conducted within an ongoing prospective, longitudinal study of carpal tunnel syndrome and UE MSDs, the Predictors of Carpal Tunnel Syndrome study (PrediCTS). From July 2004 to October 2006, 1107 newly hired workers were recruited from various high and low hand-intensive industries. Inclusion criteria included a minimum age of 18 years, newly hired or becoming benefits eligible within the last 30 days, working at least 30 hours per week, and English-speaking. Exclusion criteria included having a prior diagnosis of carpal tunnel syndrome or peripheral neuropathy, being pregnant during study recruitment, or having a contraindication to nerve conduction testing. All subjects provided written informed consent to participate and were compensated for the participation. The Washington University School of Medicine Institutional Review Board approved this study.

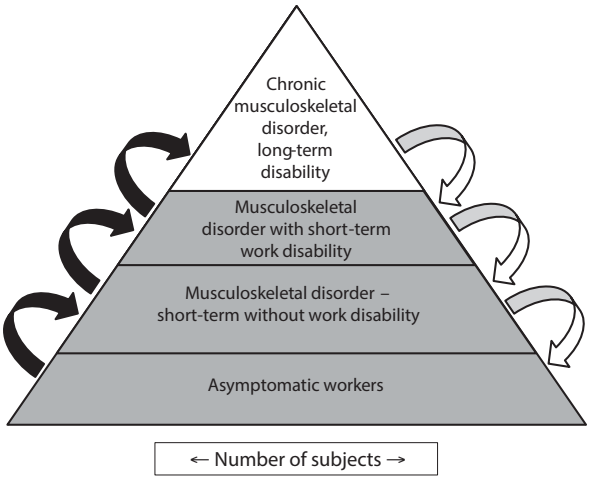


FIGURE 1. Pyramid of disability. Reused with permission: Evanoff BA, Dale AM, Descatha A. A conceptual model on musculoskeletal disorders for occupational health practitioners. *Int J Occup Med Environ Health.* 2014;27(1):145–148.

Data Collection and Study Population

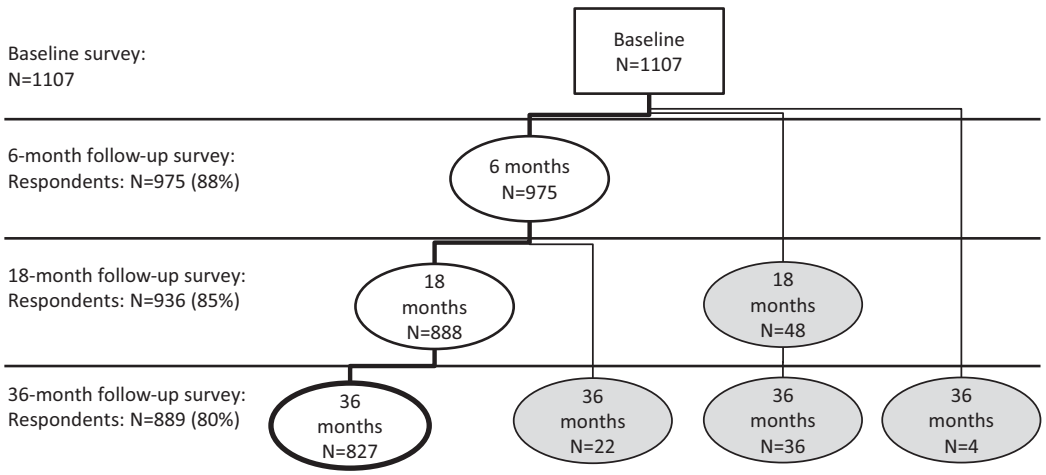
At baseline all subjects completed a self-reported questionnaire including demographics, medical and work history, and current symptom status, nerve conduction studies of the bilateral median and ulnar nerves, and a physical examination of the UE. Questionnaires were repeated at 6, 18, and 36 months after enrollment to collect information on physical and psychosocial work exposures, symptom status, and work and activities of daily living limitations. When follow-up questionnaires were not returned, a second questionnaire was mailed. Subjects who did not return mailed questionnaires were called to complete the survey by phone. Subjects were pursued for up to 6 months after the due date of an unreturned questionnaire.

Data analyses for this study were limited only to subjects who completed all four surveys between baseline and 36-month follow-up because the primary aim of the study was to describe the dynamic and transient natural course of symptoms and work limitations with repeated follow-ups. Figure 2 shows the study design and follow-up rates at each survey time point. Survey response rates ranged from 80% to 88% at 6-, 18-, and 36-month follow-up. Overall, 827 subjects (75%) completed all four surveys and were included in the present analyses. Mean follow-up times by study survey were as follows: 6-month follow-up: 7.0 months (range, 3.8 to 18.0), 18-month follow-up: 19.2 months (range, 9.1 to 27.0), and 36-month follow-up: 32.5 months (range, 26.6 to 44.8).

Outcome Measures

For this study, we defined two primary outcomes of interest: (1) UE symptoms and (2) work limitations resulting from UE symptoms.

1. *UE symptoms:* At baseline and at each study follow-up, subjects were asked about the presence of UE symptoms in any one of three UE regions: "In the past year, have you had any recurring (repeated) symptoms in your (neck/shoulder/upper arm, elbow/forearm, or hand/wrist/fingers) more than three times or lasting more than 1 week?"
2. *Work limitations because of UE symptoms:* Subjects who reported symptoms were asked to complete additional questions about the effect of their symptoms on their work abilities. Six-questionnaire items pertaining to limitations in work abilities, productivity, job restrictions, lost time, and job or company changes because of UE symptoms were available from the follow-up questionnaires at 6, 18, and 36 months (see supplemental digital content, Appendix,



Note: Excluded subjects represented in grey circles due to missing surveys.

FIGURE 2. Study design and survey response at each follow-up.

http://links.lww.com/JOM/A156). Work ability and productivity questions were similar to items from the University of Michigan Upper Extremity Questionnaire.[34,35] A composite outcome of these items was created such that cases were defined as having any limitations in work ability or productivity or a positive response to any one of the other items.

Statistical Analysis

Differences on demographic and clinical characteristics and presence of UE symptoms at baseline were analyzed between the groups of subjects with completed surveys at all study time points versus subjects with at least one missing survey using the chi-square statistic and *t* tests. To describe the natural history of UE symptoms and work limitations in a working population, the percentage of subjects reporting UE symptoms and work limitations because of UE symptoms were calculated at each study time point as well as the overall percentages of subjects who reported symptoms or work limitations at least once during the study period. We calculated the percentage of workers whose symptom and/or functional status changed between each study time point. We also examined whether workers became symptomatic or experienced work limitations and remained symptomatic or limited throughout the study, whether symptoms and/or work limitations resolved, or whether workers remained asymptomatic for the remaining time in the study. We explored the effects of job change and unemployment on symptoms and future work limitations. We calculated the percentage of subjects who changed jobs during the study period. Then, we stratified subjects by symptom status to determine whether job changes appeared to be more common among subjects who experienced symptoms during the study. Finally, we conducted a sensitivity analysis to determine the effects of unemployment on symptoms and work limitations. Workers with periods of unemployment were included in the study to avoid a unidirectional bias in the data that could have potentially excluded workers who were unable or chose not to work because of their symptoms; we also compared the proportion of subjects with symptoms and work limitations among those without any unemployment with workers reporting periods of unemployment concurrent with follow-up at each study time point. The analyses were performed using SPSS,[36] and $P < 0.05$ was considered as statistically significant.

RESULTS

The demographic characteristics of the study population at baseline are shown in Table 1. Study subjects were young, with a mean age of 30.4 years and predominately male (64%). The largest proportion of subjects was employed in construction (40%). Subjects who were missing at least one follow-up survey were generally less educated and a higher proportion worked in service industry jobs than the study population; however, the proportion of workers reporting UE symptoms at baseline did not differ significantly between workers with missing surveys and the study population ($P = 0.15$).

The natural course of symptoms and work limitations in the study population is graphically displayed in Fig. 3. The pyramid of disability[5] has been modified to reflect the type of data available by time point in this study. At baseline, all subjects reported the presence of UE symptoms, shown as two levels within the pyramid. Because study subjects were newly hired workers and in many cases had not yet begun performing their regular work duties at baseline, work limitation status for the new job was not available until 6 months. From 6-month through 36-month follow-up, symptom and work limitation statuses are shown as three levels, between which workers fluctuated over time. The arrows (Fig. 3) show the proportions of workers reporting changes in symptom status and work limitations that occurred since the previous study time point. The length of the arrow indicates a greater degree of change, with longer arrows indicating the movement of two levels up or down the pyramid of disability.

At baseline, 31% of subjects reported having UE symptoms in the past year. At 6-month follow-up, the proportion of subjects with UE symptoms increased to 44%, but then remained relatively

TABLE 1. Demographic Characteristics of the Study Population at Baseline

Characteristic	All Participants at Baseline ($n = 1107$) Mean (SD)	Participants with Complete Surveys at All Time Points ($n = 827$) Mean (SD)	Participants Missing At Least One Survey ($n = 280$) Mean (SD)	*P* Value[a]
Age, yrs	30.3 (10.3)	30.4 (10.4)	30.1 (9.9)	0.664
Body mass index, kg/m^2	28.5 (6.5)	28.3 (6.2)	29.0 (7.4)	0.116
	***n* (%)**	***n* (%)**	***n* (%)**	
Male sex	719 (65)	530 (64)	189 (68)	0.301
Job category				0.000*
Construction	450 (41)	334 (40)	116 (42)	
Service	301 (27)	186 (23)	115 (41)	
Technical	146 (13)	123 (15)	23 (8)	
Office/clerical	210 (19)	184 (22)	26 (9)	
Upper extremity symptoms at baseline	334 (30)	259 (31)	75 (27)	0.150
With at least high school education	1,022 (92)	779 (94)	243 (87)	0.000*
Comorbid health condition[b]	58 (5)	46 (6)	12 (4)	0.407
Prior musculoskeletal disorder diagnosis[c]	114 (10)	91 (11)	23 (8)	0.205

[a]Comparing participants with complete surveys at all time points and those missing at least one survey.
[b]Diabetes mellitus, osteoarthritis, rheumatoid arthritis, or hypertension.
[c]Tendonitis in the fingers, hands, wrists, forearms, or elbows, rotator cuff disorder, ganglion cyst, tendonitis in the shoulders, carpal tunnel syndrome, or ulnar neuropathy.
*$P < 0.05$ (statistically significant).
SD, standard deviation.

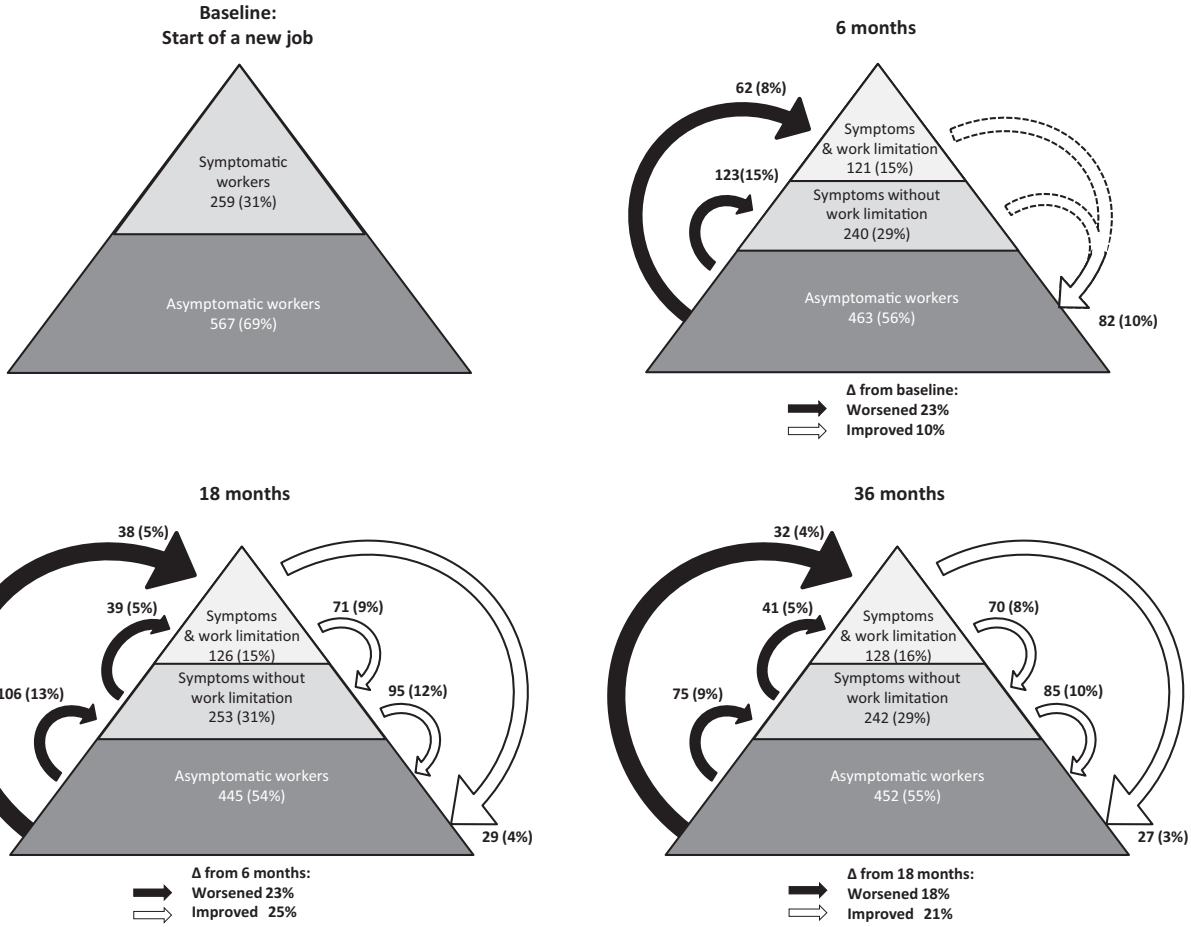


FIGURE 3. Natural course of symptoms and work limitations in the study population.

stable throughout the rest of the study period, 46% at 18 months and 45% at 36 months. At 6 months, approximately one third of those who reported UE symptoms also reported a limitation in their work activities because of their symptoms (15% of all study subjects). The proportion of subjects with symptoms and work limitations and symptoms alone remained stable from 6-month through 36-month follow-up, although a proportion of subjects within these categories changed. The arrows (Fig. 3) show that the symptom experience for the individual worker is dynamic, and a considerable percentage of subjects, between 33% and 48%, experienced a change of symptoms or work abilities, either worsening or improving, during each interval between study follow-ups.

Overall, 596 of 827 workers (72%) reported UE symptoms at least once during the study, yet the proportion of subjects with symptoms was less than 50% at each study time point. As shown in Table 2, 40% of subjects consistently reported no change in their symptom status: 28% remained asymptomatic and 12% had persistent symptoms throughout the entire 3-year study period. Thus, the majority of subjects (60%) experienced at least one change in symptom status, either worsening, improving during the study, with a substantial proportion (27%), experiencing symptom fluctuations, defined as two or more changes in symptom status during the study period.

Similarly, 253 of 827 workers (31%) reported work limitations because of UE symptoms at least once during the study; however, the overall proportion of work limitations within a single time point remained stable at 15% throughout the study. Also similar to symptoms, most workers who reported work limitations experienced at least one change in status described as worsened or improved, whereas 8% of workers fluctuated, experiencing two or more changes in their work abilities.

Job Changes and Unemployment During the Study Period

Nearly half of the 827 workers in the study population (n = 399, 48%) reported at least one job change during the 3-year study follow-up. Job changes were defined as a change in either company or job title, which constituted a change in work activities. Table 2 describes the proportion of workers who changed jobs during the study according to symptom and functional work status. Among workers with symptoms at any point during the study, there was a significantly higher proportion of job changes among workers who reported worsening of symptoms over the study period (57%) compared with the asymptomatic workers (47%) whose job changes would have been due to reasons other than symptoms ($P = 0.010$). On the contrary, workers whose symptoms improved during the study made the fewest number of job changes although the difference was not statistically significant ($P = 0.352$). Similarly, among workers who reported work limitations because of their symptoms, workers with worsening work abilities reported the highest percentage of job changes (62%) over the study period compared with workers with no work limitations

TABLE 2. Comparison of Employment Changes Among Workers by Upper Extremity Symptom and Functional Status During the Study Period ($n = 827$)

	%	Job Change Ever,[a] %	P[b]
Symptom status (baseline through 36 mos)			
Remained asymptomatic throughout the study	28	47	—
Symptoms			
Persistent symptoms at all time points	12	47	0.805
Improved from baseline to 36 mos	10	43	0.352
Worsened from baseline to 36 ms	22	57	0.010*
Fluctuated	27	45	0.231
Missing	1	—	—
Total	100		
Functional status (6–36 mos)			
No work limitations at any time point	68	44	—
Work limitations			
Persistent at all time points	3	61	0.181
Progressively improved	10	49	0.855
Progressively worsened	10	62	0.007*
Fluctuated	8	57	0.117
Missing	1	—	—
Total	100		

[a]Defined as a change in the job title or company.
[b]Compared with the proportion of job changes among workers who remained asymptomatic or had no work limitations at any time point during the study.
*$P < 0.05$ (statistically significant).

(44%) ($P = 0.007$), whereas workers with improved work abilities reported the lowest percentage of job changes (49%), although the difference was not statistically significant ($P = 0.855$). Workers who had persistent work limitations (61%, $P = 0.181$) or whose work abilities fluctuated (57%, $P = 0.117$) also made more job changes than workers with no limitations; however, these differences were not statistically significant.

We examined the effects of unemployment on reported symptoms and work limitations over the course of the study. A sizeable proportion of workers in the study population (14%, $n = 113$) reported at least one period of unemployment concurrent with one of the follow-up surveys. The proportion of unemployed workers increased throughout the study period, with 3.3% unemployed at 6-month follow-up, 5.7% at 18 months, and 7.4% at 36 months. The increasing proportion of unemployed workers from 2004 to 2009 followed the upward trend of national unemployment during the recession of 2007 to 2008.

Of the 113 workers who had a period of unemployment during the study, 45% reported symptoms concurrently. A sensitivity analysis that compared workers who had periods of unemployment versus workers who were employed throughout the study period showed no statistically significant differences in the proportions of workers with symptoms assessed at any time point during the study (6, 18, and 36 months); however, a higher proportion of workers with periods of unemployment reported work limitations because of symptoms at 18 months (22% vs 14%; $P = 0.030$) and 36 months (21% vs 15%; $P = 0.074$) versus workers with no unemployment.

DISCUSSION

This descriptive study showed the natural course of UE symptoms and work limitations because of symptoms in a newly hired working population over a 3-year study period. A considerable majority of workers (72%) reported symptoms at least once during the study, yet less than half of the workers reported symptoms within any single follow-up period. In addition, nearly a third of workers (31%) reported work limitations because of their symptoms at least once during the study, but only 15% within any single follow-up period. These results provide evidence for the dynamic nature of both symptoms and work abilities over time, which has been theorized but not explicitly described in previous studies. A better understanding of the natural history of symptoms could help identify targets for early intervention to prevent progression of symptoms and disability.

The increase in the proportion of workers reporting UE symptoms from 31% at baseline to 44% at first follow-up is not surprising because subjects were enrolled into the PrediCTS study at the time of hire into a new job. Before study enrollment, some subjects had been unemployed or had worked in jobs representing very different physical exposures from their job at enrollment. A significant proportion of study subjects (40%) were just beginning apprenticeship training in the construction trades. Similar associations of musculoskeletal symptoms with increasing job tenure have been observed in other studies.[37] The relatively stable proportion of workers with UE symptoms and work limitations at each subsequent follow-up in this study would suggest that cross-sectional studies of risk factors in active workers would yield similar results at any point in time. Yet, the sizeable proportion of workers whose symptom and work limitation status changed between study follow-ups, ranging from nearly one third (32%) to one half (48%), highlights the need to explore MSDs longitudinally. Cross-sectional studies likely oversample workers whose symptoms are persistent and miss those whose symptoms fluctuate.[38] The result may be differences in the proportions of workers who would meet a clinical case definition and may result in identification of different risk factors. Although we only described the proportions of workers with and without symptoms and not those who progressed to meeting a clinical case definition, musculoskeletal symptoms alone are a precursor of developing a clinical disorder.[2,3,39,40]

Our findings suggest that there could be a nonlinear progression of symptoms to meeting a clinical or epidemiological case definition, as seen in the significant proportion of workers whose symptoms fluctuated (27%). These fluctuating symptoms are important to capture as they may represent an early stage of disease, whereas symptoms that persist over time or cause work limitations may parallel later stages of disease.[41] Longitudinal studies commonly report on outcomes over multiyear follow-up periods, which may underestimate the prevalence of MSDs in working populations.[38,42] Frequency of follow-up is an important consideration in future designs to capture these fluctuations and improve predictive models.

As shown in our findings and in other studies, UE symptoms are common, affecting up to half of the workers at any point in time.[3,43–45] Yet, work ability or productivity has more often been studied in relation to chronic and less common conditions such as rheumatoid arthritis, whereas MSD studies have focused on lost time.[15] Presenteeism, or decreased work performance because of MSD symptoms, likely occurs both during the onset of an MSD and during recovery or return to work. Nevertheless, the factors affecting recovery or disease progression may be different during different stages of disease and for transitions between different stages of impairment. Future studies should examine the natural history and temporal sequence of work ability outcomes related to MSD to identify potential differences in risk and prognostic factors at various stages.

Limitations of this study included a general definition of any recurrent UE symptoms that was based on self-report. The high prevalence of disease in our population using self-reported symptoms as the outcome (up to 46%) likely captured a much wider range of disease severity from mild symptoms to severe disease

than using a more restrictive epidemiological case definition.[38] The prevalence of symptoms in this population is consistent with previous studies[3,34,44,45] but is not a reflection of the proportion of workers who are likely to seek treatment, or whose symptoms will result in an accepted workers' compensation claim. The aim of this study was not to describe prevalence or incidence rates by diagnosis or case definition, but rather to show the transiency of symptoms at the person level. The definition of work limitations was broad and included measures of both presenteeism and absenteeism. Future studies will separate these outcomes to identify differences in predictors of early versus later stages of work disability because of UE symptoms. While we did have nearly complete employment records for all workers with start and end dates of jobs performed during the study period, we did not have an exact date of onset for symptoms and in many cases could not ascertain whether symptoms preceded job changes. Despite this limitation, we could still see an obvious relationship between worsening symptoms and work ability during the study, and significantly higher number of job changes in symptomatic versus asymptomatic workers, whose job changes could not have been due to symptoms. The timing of job changes with relation to symptoms should be explored in greater detail to inform early intervention efforts.

The major strength of the study is the longitudinal design, which followed a large cohort of workers over a long period of time. We collected repeated measures on several important factors that affect work ability and performance. Our follow-up rates were very good with 93% of subjects completing at least one follow-up survey, and 75% with complete follow-up data for all four surveys during the study period. Limiting study subjects to only those with complete data sets may have eliminated some workers with a high risk of symptoms and work limitations, as those with missing data were less educated and more likely to work in service-oriented jobs such as housekeeping and food service. Nevertheless, there was no difference in study subjects and those with missing data on baseline health indicators such as presence of UE symptoms, prior MSD diagnosis, or comorbid health conditions.

UE symptoms and work limitations because of symptoms are common and dynamic in their course. Our findings suggest that a significant proportion of working adults experience musculoskeletal symptoms at any given time and have difficulty performing their regular work activities. As shown in recent studies, the cost of absenteeism to employers is exceeded by the costs of presenteeism because of workers who continue working but at decreased capacity.[10,11] Most research and social programs target the relatively smaller number of workers with lost time injuries because of the higher individual costs. Although the proportion of workers with symptoms and work limitations seems to be relatively stable over time, a sizeable proportion of workers fluctuate in and out of symptoms and corresponding changes in work ability. Our study population included a range of low and high physical exposure jobs, so the findings are likely to be generalizable across industries. To improve injury and disability prevention programs, it is important to gain a better understanding of the natural course of symptoms to identify better targets for intervention. Subsequent studies should identify the temporal sequence of work limitations and whether there are differences in risk factors for early or later stages of disease and disability and differences in age and social position.

REFERENCES

1. Sluiter JK, Rest KM, Frings-Dresen MH. Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. *Scand J Work Environ Health*. 2001;27(suppl 1):1–102.
2. Miranda H, Viikari-Juntura E, Heistaro S, Heliovaara M, Riihimaki H. A population study on differences in the determinants of a specific shoulder disorder versus nonspecific shoulder pain without clinical findings. *Am J Epidemiol*. 2005;161:847–855.
3. Gold JE, d'Errico A, Katz JN, Gore R, Punnett L. Specific and non-specific upper extremity musculoskeletal disorder syndromes in automobile manufacturing workers. *Am J Ind Med*. 2009;52:124–132.
4. Roquelaure Y, Gabignon Y, Gillant JC, et al. Transient hand paresthesias in champagne vineyard workers. *Am J Ind Med*. 2001;40:639–645.
5. Evanoff BA, Dale AM, Descatha A. A conceptual model on musculoskeletal disorders for occupational health practitioners. *Int J Occup Med Environ Health*. 2014;27:145–148.
6. Gardner BT, Dale AM, Vandillen L, Franzblau A, Evanoff BA. Predictors of upper extremity symptoms and functional impairment among workers employed for 6 months in a new job. *Am J Ind Med*. 2008;51:932–940.
7. Amick BC, Lerner D, Rogers WH, Rooney T, Katz JN. A review of health-related work outcome measures and their uses, and recommended measures. *Spine*. 2000;25:3152–3160.
8. Beaton DE, Kennedy CA. Beyond return to work: testing a measure of at-work disability in workers with musculoskeletal pain. *Qual Life Res*. 2005;14:1869–1879.
9. Lederer V, Loisel P, Rivard M, Champagne F. Exploring the diversity of conceptualizations of work (dis)ability: a scoping review of published definitions. *J Occup Rehabil*. 2013; [Epub ahead of print].
10. Stewart WF, Ricci JA, Chee E, Morganstein D, Lipton R. Lost productive time and cost due to common pain conditions in the US workforce. *JAMA*. 2003;290:2443–2454.
11. Stewart W, Ricci J, Leotta C. Health-related lost productive time (LPT): recall interval and bias in LPT estimates. *J Occup Environ Med*. 2004;46:S12–S22.
12. Aronsson G, Gustafsson K, Dallner M. Sick but yet at work. An empirical study of sickness presenteeism. *J Epidemiol Community Health*. 2000;54:502–509.
13. Hemp P. Presenteeism: at work but out of it. *Harvard Business Rev*. 2004;82:49–58.
14. Dew K, Keefe V, Small K. Choosing to work when sick: workplace presenteeism. *Soc Sci Med*. 2005;60:2273–2282.
15. Schulz A, Edington D. Employee health and presenteeism: a systematic review. *J Occup Rehabil*. 2007;17:547–579.
16. Hu X, Markson L, Lipton R, Stewart W, Berger M. Burden of migraine in the United States. *Arch Intern Med*. 1999;159:813–818.
17. Von Korff M, Stewart W, Simon D, Lipton R. Migraine and reduced work performance. A population-based diary study. *Neurology*. 1998;50:1741–1745.
18. Burton W, Conti D, Chen C, Schultz A, Edington D. The impact of allergies and allergy treatment on worker productivity. *J Occup Environ Med*. 2001: 64–71.
19. Crystal-Peters J, Crown W, Goetzel R, Schutt D. The cost of productivity losses associated with allergic rhinitis. *Am J Manag Care*. 2000;6:373–378.
20. Henke C, Levin T, Henning J, Potter L. Work loss costs due to peptic ulcer disease and gatroesophageal reflux disease in a health maintenance organization. *Am J Gastroenterol*. 2000;95:788–792.
21. Dean B, Aguilar D, Barghout V, et al. Impairment in work productivity and health-related quality of life in patients with IBS. *Am J Manag Care*. 2005;11:S17–S26.
22. Sandler R, Everhart J, Donowitz M, et al. The burden of selected digestive diseases in the United States. *Gastroenterology*. 2002;122:1500–1511.
23. Lerner D, Reed J, Massarotti E, Wester L, Burke T. The work limitations questionnaire's validity and reliability among patients with osteoarthritis. *J Clin Epidemiol*. 2002;55:197–208.
24. Burton W, Morrison A, Maclean R, Ruderman E. Systematic review of studies of productivity loss due to rheumatoid arthritis. *Occup Med*. 2006;56:18–27.
25. Adler D, McLaughlin T, Rogers W, Chang H, Lapitsky L, Lerner D. Job performance deficits due to depression. *Am J Psychiatry*. 2006;163:1569–1576.
26. Lerner D, Adler D, Chang H, et al. Unemployment, job retention, and productivity loss among employees with depression. *Psychiatr Serv*. 2004;55:1371–1378.
27. Collins J, Baase C, Sharda C, et al. The assessment of chronic health conditions on work performance, absence, and total economic impact for employers. *J Occup Environ Med*. 2005;47:547–557.
28. Bunn W, Pikelny D, Paralkar S, Slavin T, Borden S, Allen H. The burden of allergies- and the capacity of medications to reduce this burden in a heavy manufacturing environment. *J Occup Environ Med*. 2003;45:941–955.
29. Hagberg M, Tornquist E, Toomingas A. Self-reported reduced productivity due to musculoskeletal symptoms: associations with workplace and individual factors among white-collar computer users. *J Occup Rehabil*. 2002;12: 151–162.
30. Campo M, Darragh A. Work-related musculoskeletal disorders are associated with impaired presenteeism in allied health care professionals. *J Occup Environ Med*. 2012;54:64–70.

31. Roy J, MacDermid J, Amick B III, et al. Validity and responsiveness of presenteeism scales in chronic work-related upper extremity disorders. *Phys Ther*. 2011;91:254–266.
32. Tang K, Pitts S, Solway S, Beaton D. Comparison of the psychometric properties of four at-work disability measures in workers with shoulder or elbow disorders. *J Occup Rehabil*. 2009;19:142–154.
33. Johns G. Presenteeism in the workplace: a review and research agenda. *J Organiz Behav*. 2010;31:519–542.
34. Franzblau A, Salerno DF, Armstrong TJ, Werner RA. Test-retest reliability of an upper-extremity discomfort questionnaire in an industrial population. *Scand J Work Environ Health*. 1997;23:299–307.
35. Salerno DF, Franzblau A, Armstrong TJ, Werner RA, Becker MP. Test-retest reliability of the Upper Extremity Questionnaire among keyboard operators. *Am J Ind Med*. 2001;40:655–666.
36. SPSS. *SPSS Base 20.0*. Chicago, IL: SPSS Inc; 2011
37. Bern SV, Brauer C, Moller KL, et al. Baggage handler seniority and musculoskeletal symptoms: is heavy lifting in awkward positions associated with risk of pain? *BMJ Open*. 2013;3:e004055.
38. Punnett L, Wegman DH. Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *J Electromyogr Kinesiol*. 2004;14:13–23.
39. Silverstein BA, Viikari-Juntura E, Fan ZJ, Bonauto DK, Bao S, Smith C. Natural course of nontraumatic rotator cuff tendinitis and shoulder symptoms in a working population. *Scandinavian J Work Environ Health*. 2006;32:99–108.
40. Descatha A, Dale AM, Franzblau A, Evanoff B. Natural history and predictors of long-term pain and function among workers with hand symptoms. *Arch Phys Med Rehabil*. 2013;94:1293–1299.
41. Riihimäki H. Hands up or back to work: future challenges in epidemiological research on musculoskeletal disorders. *Scand J Work Environ Health*. 1995;21:401–403.
42. National Academy of Sciences and National Research Council. Executive summary: musculoskeletal disorders and the workplace: low back and upper extremities. 2001.
43. Franzblau A, Werner R, Valle J, Johnston E. Workplace surveillance for carpal tunnel syndrome: a comparison of methods. *J Occup Rehabil*. 1993;3:1–14.
44. d'Errico A, Caputo P, Falcone U, et al. Risk factors for upper extremity musculoskeletal symptoms among call center employees. *J Occup Health*. 2010;52:115–124.
45. Douphrate DI, Gimeno D, Nonnenmann MW, Hagevoort R, Rosas-Goulart C, Rosecrance JC. Prevalence of work-related musculoskeletal symptoms among U.S. large-herd dairy parlor workers. *Am J Ind Med*. 2014;57:370–379.