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Musculoskeletal Discomfort Surveys Used at NIOSH

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4.1 Background

Self-report measures of musculoskeletal discomfort are widely used and generally accepted as a proxy or risk factor for musculoskeletal disorders in epidemiologic research and workplace health surveillance. Discomfort measures are also commonly used to evaluate ergonomic interventions, or as a screening tool in the context of hazard surveillance to detect exposures to workplace physical stressors.

As popularized by the classic work of Corlett and Bishop (1976), the most familiar forms of musculoskeletal discomfort surveys employ body maps together with rating scales for assessing attributes of discomfort in multiple regions of the body. Cameron (1996) and Straker (1999) provide excellent reviews of the literature on measurement of body part discomfort, including the wide range of methods employed.

Of the many methods for surveying musculoskeletal discomfort, few have been used repeatedly in a standardized fashion. Exceptions include the Standardized Nordic Questionnaire (SNQ) (Kourinka et al., 1987) and the University of Michigan Upper Extremity Questionnaire (UMUEQ) (Franzblau et al., 1997). These two instruments are similar in many respects to the discomfort surveys used by the National Institute for Occupational Safety and Health (NIOSH).

Table 4.1 describes characteristics of major NIOSH studies of musculoskeletal discomfort that have been conducted in the last decade, including laboratory and epidemiologic investigations and workplace health hazard evaluations. Most of these studies (all but 8, 10, 20) were conducted in actual workplaces and involved work with video display terminals, meat processing, and the handling of grocery products. Nine studies were prospective in nature (8, 10, 13, 16, 17, 19, 20, 22, 23) and featured various interventions with follow-up, primarily in field settings. Physical demands and task design were examined in all of the studies. Broader psychosocial aspects of the job (e.g., participation in decision making, social support, job satisfaction) were also investigated in ten studies (3, 7, 9, 11, 12, 14, 15, 18, 19, 21), and in three of these studies (3, 7, 11), multiple regression models were able to discern unique effects of psychosocial

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TABLE 4.1 Representative NIOSH Studies Employing Body-Part Discomfort Measures

Studies[a]	Type of Work Investigated	Factors Studied[b]	Study Design[c]	Body Regions Targeted[d]	Severity Measures[e]
1. NIOSH (1989a)	poultry processing	pt	c	ue	d, f
2. NIOSH (1989b)	beef processing	pt	c	ue	d, f
3. NIOSH (1990a)	newspaper/VDT	pt, ps	c	ue, b	d, f
4. NIOSH (1990b)	poultry processing	pt	c	ue	d, f
5. Sauter, Schleifer, and Knutson (1991)	data processing/VDT	pt	c	ue, le	d, f
6. NIOSH (1991); Baron and Habes (1992)	grocery scanning	pt	c	ue, b	f
7. NIOSH (1992); Hales, Sauter, Petersen, Fine, Putz-Anderson, and Schleifer (1994)	telecommunications/VDT	pt, ps	c	ue	d, f , i
8. Sauter and Swanson (1992)	data processing/VDT (lab)	pt	pi	ue, le, b	i
9. NIOSH (1993a)	grocery warehouse	pt, ps	c	ue, le, b	i
10. Swanson and Sauter (1993)	data processing/VDT (lab)	pt	pi	ue, le, b	i
11. NIOSH (1993b); Bernard, Sauter, Fine, Petersen, and Hales (1994)	newspaper/VDT	pt, ps	c	ue, b	d, f , i
12. NIOSH (1994); Hoekstra, Hurrell, Swanson, and Tepper (1996)	customer service/VDT	pt, ps	c	ue, b	d, f, i
13. Becker, Swanson, Sauter, and Galinsky (1995)	data processing/VDT	pt	pi	ue, le, b	i
14. NIOSH (1995)	grocery warehouse	pt, ps	c	ue, le, b	i
15. NIOSH (1996a)	medical laboratory	pt, ps	c	ue, b	d, f, i
16. NIOSH (1996b)	beverage distribution	pt	pi	ue, le, b	i
17. Galinsky, Swanson, Sauter, Hurrell, and Dunkin (1997)	data processing/VDT	pt	pi	ue, le, b	i
18. NIOSH (1997)	small appliance manufacturing	pt, ps	c	ue, le, b	d, f, i
19. Sauter, Swanson, Conway, Lim, and Galinsky (1997)	data processing/VDT	pt, ps	pi	ue, le, b	d, f, i
20. Swanson, Galinsky, Cole, Pan, and Sauter (1997)	data processing/VDT (lab)	pt	pi	ue, le, b	i
21. NIOSH (1998)	textile manufacturing	pt, ps	c	ue, le, b	i
22. Galinsky, Swanson, Sauter, Hurrell, and Schleifer (2000)	data processing/VDT	pt	pi	ue, le, b	i
23. Lowe, Moore, Swanson, Perez, and Alderson (2001)	clerical/VDT	pt	pi	ue, b	d, f, i

[a] Second entry in rows denotes journal publication of the study.
[b] pt = physical demands and task design; ps = psychosocial factors.
[c] c = cross sectional; pi = prospective with intervention.
[d] ue = upper extremity; le = lower extremity; b = back.
[e] d = duration; f = frequency; i = intensity.

factors on discomfort outcomes. Ten of the studies (1–4, 6, 7, 11, 12, 15, 23) focused on the upper extremities alone or together with back discomfort. All of the remaining studies examined discomfort

in both the upper and lower extremities. In total, musculoskeletal discomfort data have been collected from nearly 6,000 subjects in these studies.

4.2 Discomfort Survey Methods at NIOSH

Nearly all the NIOSH studies listed in Table 4.1 employed surveys that combined body maps and rating scales to assess discomfort in multiple regions of the body. The discomfort survey employed in the NIOSH (1993b) study of newspaper workers illustrates the body maps and rating scales used in many of the NIOSH studies (this report and the study survey can be viewed and printed from http://www.cdc.gov/niosh/hhe/reports/pdfs/1990-0013-2277.pdf). Although most NIOSH studies have shared common survey elements, there have been some variations in the way body regions were mapped and in the measures used for discomfort ratings.

The body maps used in many NIOSH studies are very close to standardized diagrams used to distinguish various upper- and lower-extremity body regions in the SNQ (neck, shoulders, elbow, wrists-hands, upper and lower back, hips/thighs, knees, ankles/feet), in contrast to the UMUEQ, which employs verbal descriptors to distinguish body regions (a diagram is used only to localize discomfort in the hand). However, discomfort in different body regions is characterized in NIOSH surveys using procedures more similar to the UMUEQ, which captures richer information on discomfort attributes (e.g., intensity and temporal aspects) than the SNQ.

Except for four investigations (8, 10, 16, 20), where surveys were self-administered by computer, in all of the studies paper surveys were administered individually or in small groups by a research team.

4.2.1 Defining the Location of Discomfort

Musculoskeletal discomfort surveys collect information on the location of discomfort by reference to specific body regions or by use of partial- or whole-body diagrams that designate specific regions to be assessed. Less commonly, body maps are shaded by respondents to identify regions of discomfort. The number of regions targeted varies in relation to the interests of the study. A general purpose survey proposed by Cameron (1996) targeted over 100 regions, involving permutations of the left, right, front, and back sides of the body.

The ten NIOSH studies that focused mainly on upper-extremity discomfort targeted the same upper-extremity sites as the SNQ (neck, shoulders, elbows, wrists-hands) but, unlike the SNQ and UMUEQ, discomfort assessment did not differentiate the left and right side of the body in nine of these studies. The 13 remaining NIOSH studies that targeted both the upper and lower extremities evaluated discomfort on the left and right sides of the body separately. Except for some small clusters of studies that used identical body maps, these remaining studies exhibited considerable variation in body regions targeted. One NIOSH study (1996b) separately mapped the front and back and left and right sides of the body, similar to Cameron (1996). Differences in regions targeted in NIOSH studies were dictated to some extent by the physical stressors under investigation. For example, the nine studies targeting upper-extremity regions only were focused on food processing and other tasks involving exertions of mainly the arms and hands.

Two different display formats have been used for identifying body parts in the NIOSH studies. For nearly one half of the studies, including all of the ten upper-extremity studies, partial-body diagrams provided multiple views of designated regions of interest, as illustrated in Figure 4.1 (top). Each of these targeted regions was accompanied in the survey with a series of questions and rating scales (described below) for assessing multiple facets of discomfort at that location. In most of the remaining studies (which surveyed both upper- and lower-extremity discomfort), only a single attribute of discomfort (usually intensity) was rated. Thus it was possible to target all regions of interest in a single integrated diagram, with a space for recording ratings contiguous to each designated region, as illustrated in Figure 4.1 (bottom). Similar to the SNQ, rear-view perspectives of the body are presented in most of these

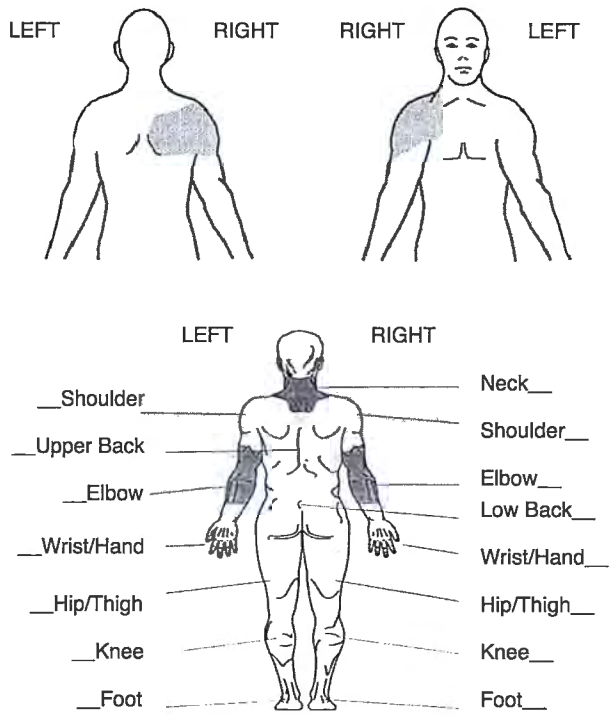

FIGURE 4.1 Example of partial- and whole-body diagrams used to target discomfort assessments in NIOSH studies.

whole-body diagrams. Two NIOSH studies (Galinsky et al. 1997, 2000) used only verbal descriptions of body sites to target discomfort assessments, similar to the UMUEQ.

4.2.2 Assessing the Nature of Discomfort

Most discomfort surveys, including the SNQ, use descriptors such as "pain," "bother," "problems," and "discomfort" without further definition of these conditions to screen for the presence of an untoward state within a specified time period (usually one year), and then rate these conditions using various severity indicators. The UMUEQ similarly asks about the presence and severity of a "problem" in a specific location, but also asks the respondent to qualify the problem in terms of the types of symptoms experienced (burning, stiffness, tingling, etc.). Discomfort surveys used in most of the NIOSH studies in Table 4.1 take a slightly different approach. Rather than beginning by asking about the presence of discomfort or a similar condition in general terms, the survey begins with a single question that screens for the presence of one or more of six symptoms (pain, aching, stiffness, burning, numbness, or tingling) in each body region. An affirmative response is then followed by a rating of this "problem" using as many as three severity measures (duration, frequency, and intensity).

As shown in Table 4.1, all but six of the NIOSH studies (Baron and Habes, 1992; NIOSH, 1989a, 1989b, 1990a, 1990b; Sauter et al., 1991) rated the intensity of discomfort, over one half of the studies used two or more severity measures, and nearly one third of the studies used all three measures. Table 4.2 describes the actual discomfort rating scales most commonly used in the NIOSH studies.

The discomfort duration scales used in NIOSH studies were adapted from work at the University of Michigan (Silverstein and Fine, 1984; Silverstein, 1985), and are similar to the discomfort duration scale in the UMUEQ. Eleven of the 12 NIOSH studies (all but study 1) that rated discomfort duration used the scale shown in Table 4.2 or a close variation of this scale. Nine of the 13 studies (all but 1, 2, 5, 18) that rated discomfort frequency used the Table 4.2 scale or a slightly altered version of this scale. Less consistency is seen in the rating of discomfort intensity among NIOSH studies. Only six studies (7, 11,

TABLE 4.2 Discomfort Rating Scales Commonly Used in NIOSH Studies

Discomfort Duration	Discomfort Frequency	Discomfort Intensity
Less than 1 hour	Almost never (every 6 months)	No pain
1 to 24 hours	Rarely (every 2 to 3 months)	Mild
25 hours to 1 week	Sometimes (once a month)	Moderate
More than 1 to 2 weeks	Frequently (once a week)	Severe
More than 2 weeks to 1 month	Almost always (daily)	Worst pain ever in life
More than 1 to 2 months		
More than 3 months		

12, 15, 18, 23) used the intensity scale shown in Table 4.2. Eight other studies employed verbal-numeric scales with four to six intensity levels ranging from "comfortable" or "no pain/discomfort" at one extreme to "very/extreme/severe discomfort" or "worst pain ever imaginable" at the other extreme. Similar to the UMUEQ, two studies (16, 20) used ten-point numeric scales for rating discomfort intensity. But with these two exceptions, neither the frequency nor intensity scales used by NIOSH have close parallels in either the SNQ or UMUEQ.

Several NIOSH surveys also incorporated questions asking about medical follow-up of discomfort and effects of discomfort on performance, and a series of questions to ascertain the work-relatedness of discomfort (e.g., onset in relation to current employment; prior traumatic injury and underlying medical conditions). Similar items appear in the UMUEQ, whereas the SNQ asks only about medical follow-up and activity restrictions.

Nearly one half of the NIOSH studies (1–4, 6, 7, 11, 12, 15, 18) used discomfort ratings together with information from questions on the work-relatedness of discomfort to define cases of work-related musculoskeletal "disorders" and to examine the prevalence of disorders and their relationships to various job factors. The case definition most commonly employed by NIOSH required satisfaction of all of the following criteria:

- Discomfort within the past year
- Discomfort began after employment in the current job
- No prior accident or sudden injury (affecting focal area of discomfort)
- Discomfort episodes occur monthly or the duration exceeds a week

Seven studies (3, 6, 7, 11, 12, 15, 18) used this definition or a close variant. As an additional step, in seven of the NIOSH studies (1, 2, 4, 7, 9, 11, 23), physical examinations were conducted. Positive findings were used together with symptom information to derive cases for calculation of incidence rates of musculoskeletal disorders and for statistical analysis of these disorders in relation to the work situation.

4.3 Quality of NIOSH Discomfort Survey Methods

Whether for epidemiologic research or surveillance purposes, discomfort surveys need to be practical to use (i.e., quick and easy to administer in a variety of populations and workplaces, readily analyzed, etc.). They also need to demonstrate acceptable psychometric properties (reliability and validity). However, with just a few exceptions (e.g., recent evaluations of the reliability and validity of the UMUEQ), these aspects of discomfort surveys have received surprisingly little study.

In a recent examination of musculoskeletal symptom surveys, NIOSH researchers (Baron et al., 1996) cite the widespread use of the SNQ and NIOSH surveys as evidence of their practical quality. A cursory literature search reveals over three dozen studies in many countries since 1990 that relied on the SNQ or a variation of this instrument. Additionally, Baron et al. (1996) note that the typical NIOSH survey requires an average of just 30 minutes to administer and has been used among thousands of workers in occupations with widely varying literacy requirements.

4.3.1 Reliability

Test-retest reliability data on NIOSH discomfort surveys have not been previously reported. However, recent analysis of data from repeat administration (within 48 hours) of the survey employed by Lowe et al. (2001) produced encouraging findings in a sample of 89 office workers. Identical responses across survey administrations were examined for items denoting discomfort (yes/no) during the last seven days in eight upper-extremity regions. Agreement rates across survey administrations for these items ranged from 91 to 99% (mode = 93%). Kappa values ranged from 0.75 to 0.89 for seven items (0.95 for the eighth item). Strong inflation of these agreement rates and kappa values relating to memory effects might be suspected owing to the short test-retest interval. However, these agreement rates and kappa values compare very favorably with findings reported in two reliability studies of the UMUEQ (Franzblau et al., 1997; Salerno et al., 2001) where the test-retest interval was three weeks for items asking about the presence of upper-extremity discomfort within the past year. For example, agreement rates for the left- and right-hand discomfort questions were 92% and 96% (kappa = 0.82 and 0.87), respectively, in the retest of the NIOSH survey, and the agreement rates in the retest of the hand discomfort item (both hands together) in the UMUEQ studies were 93% in each study (kappa = 0.84 and 0.86 in the two studies).

In addition to studies of the UMUEQ, test-retest reliability studies of the SNQ are described by Kourinka et al. (1987) and Dickinson et al. (1992). One-week, 15-day, and 3-week retests in these studies resulted in identical response rates across questions ranging from 70 to 100%. Additionally, van der Grinten (1991) reports good retest reliability of a body-part discomfort survey over a fortnight. However, the absence of statistical analysis in these studies limits interpretation.

4.3.2 Validity

Like "fatigue" or "effort," discomfort is a psychological construct. As such, the validity of a discomfort measure can be assessed by judging the appropriateness of the items comprising the measure (content validation) and by examining its association with other measures that should in theory be related to discomfort (construct validation).

Many of the discomfort surveys employed in NIOSH studies sample a wide domain of discomfort attributes, including multiple qualities of discomfort and multiple indicators of severity, thereby suggesting strong content validity of these surveys. Baron et al. (1996) reported significant correlations (0.27 to 0.38) among duration, frequency, and intensity measures of hand discomfort in NIOSH surveys, indicating a common underlying construct. Analyses of data subsequently collected in the context of two other NIOSH studies (Lowe et al., 2001; Sauter et al., 1997) show even stronger correlations among these variables for hand discomfort (0.39 to 0.64 and 0.31 to 0.59, respectively, for these two studies).

With regard to construct validity of NIOSH surveys, two types of evidence are relevant. Perhaps most compelling is that discomfort measures proved sensitive to ergonomic factors investigated in an overwhelming majority of NIOSH studies in the last decade. These factors varied widely, from heavy lifting in grocery warehouses to brief rest pauses in data processing.

Additionally, associations between NIOSH discomfort survey measures and other health-relevant outcomes are found in Baron et al. (1996) and in analyses of data from the Lowe et al. (2001) sample. Baron et al. (1996) reported significantly increased odds of seeking medical care among workers with elevated duration, frequency, and intensity of hand discomfort (odds ratio [OR] = 2.1). Similar results were found for analyses of discomfort severity measures and medical-care seeking in a sample of nearly 200 office workers in the Lowe et al. (2001) study (OR = 2.7 for hands and 1.6 to 4.0 for other regions). Using a survey similar to NIOSH surveys, Marley and Kumar (1994) were able to predict medical-care seeking with 82% sensitivity from an algorithm based on musculoskeletal discomfort frequency and duration (although specificity was just 56%).

Baron et al. (1996) also reported reasonable sensitivity (71%) and specificity (72%) of elevated hand discomfort in detecting cases of hand disorders as defined by physical exam. Additionally, Lowe et al. (2001) found that NIOSH measures of upper-limb discomfort were significant predictors (more so than

electromyography [EMG] measures of upper-limb loading) of upper-limb disorders defined by physical exam.

Related studies have also been conducted by Scandinavian and University of Michigan researchers. Using the SNQ, Ohlsson et al. (1994) found similar levels of sensitivity and specificity as Baron et al. (1996) for detecting upper-extremity diagnoses, although the sensitivity for hand disorders was lower (67%). Michigan researchers (Homan et al., 1999) found poor agreement between carpal tunnel cases as defined by the UMUEQ, physical examinations, and electrodiagnostic criteria. However, based on analyses of these data, the investigators concluded that discomfort surveys were the only procedures that could be used alone for surveillance of carpal tunnel syndrome in the workplace.

4.4 Summary and Implications

Surveys of musculoskeletal discomfort vary widely along many dimensions: the time frame for assessment (e.g., last year, last 30 days, last 7 days, current discomfort); assessment of qualitative aspects (pain or problem vs. specific symptoms); assessment of quantitative aspects (intensity and temporal characteristics) and scaling methods employed (from binary yes/no choices to Borg scales); and the derivation of summary indices of discomfort (ranging from region-specific cases of musculoskeletal disorders to continuous measures of whole-body discomfort). Many of these variations can be seen when comparing versions of the NIOSH survey, the UMUEQ, and variations of the SNQ.

It is of interest that, irrespective of these design differences, musculoskeletal discomfort surveys have proved remarkably effective in ergonomics applications. Research has shown the NIOSH surveys, UMUEQ, and SNQ to be sensitive to a wide range of physical stressors across many occupations, and to have prognostic value for more objective measures of musculoskeletal disorders. Psychosocial factors believed to influence musculoskeletal disorders are also associated with discomfort in NIOSH studies (Bernard et al., 1994; Hales et al., 1994). These findings provide strong convergent evidence of the validity and robustness of discomfort surveys.

The diversity of discomfort surveys, however, raises the question about the best survey measures of discomfort. This question cannot be answered without specifying the criterion measure (i.e., the standard for musculoskeletal disorders against which the measure will be judged). While no gold standard exists, physical signs, electrodiagnostic findings, and disability represent common outcomes of interest. Surprisingly few studies, however, have examined the relationship between the design of discomfort surveys and their predictive power for these different outcomes. In one such study, Homan et al. (1999) evaluated combinations of hand discomfort measures obtained with the Michigan questionnaire (recurrent symptoms of the hand-wrist-fingers, current symptoms, nocturnal symptoms, symptom intensity, and hand diagrams scores) for their relationship to electrodiagnostic evidence of carpal tunnel syndrome in a working population. Of interest, recurrent symptoms alone proved the best predictor of electrical abnormalities. Further investigations of this nature may lead to improvements in the design of musculoskeletal discomfort surveys by enabling researchers to optimize survey content and economy in relation to predictive capacity (sensitivity, specificity, positive and negative predictive value) for different outcomes.

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