Physical Exposures in Work Commonly Done by Women

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Abstract/Résumé

The North American work force is still highly sex-segregated, with most members of each sex in jobs composed primarily of workers of the same sex. This division is accentuated when jobs involve physical demands. Women have traditionally been assigned to tasks whose physical demands are considered to be light. Nevertheless, these tasks can have biological effects, sometimes serious. Phenomena related to physical demands of women's work can be considered in three categories: (a) musculoskeletal and cardiovascular demands of tasks often assigned to women in factories and service work; (b) sex- and gender-specific effects of toxic substances found in the workplace; and (c) interactions between work and the domestic responsibilities of many women. These phenomena are described, using examples recently gathered from workplaces. Effects of biological sex are distinguished, as far as possible, from effects of gender (social roles).

On constate une division sexuelle du travail dans la population active nord-américaine, où la plupart des travailleurs et travailleuses occupent un emploi majoritairement détenu par des personnes du même sexe. Cette séparation s'accentue dans les emplois présentant des exigences physiques. On affecte les femmes à des tâches dont les exigences physiques sont réputées être faibles. Cependant, ces tâches peuvent comporter des effets biologiques, parfois sérieux. Les phénomènes associées aux exigences physiques du travail des femmes peuvent

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se diviser en trois catégories: (a) les exigences musculo-squelettiques et cardiovasculaires des tâches souvent assignées aux femmes dans les manufactures et dans les emplois du secteur des services; (b) les effets des substances toxiques retrouvées en milieu de travail qui se distinguent selon le sexe et le genre; et (c) les interactions entre le travail et les responsabilités domestiques de beaucoup de femmes. Nous décrivons ces phénomènes à l'aide d'exemples puisés dans les milieux de travail. Nous distinguons, autant que possible, entre les effets du sexe biologique et ceux du genre (rôle social).

Introduction

Health differences between women and men have recently been reviewed (Goldman and Hatch, 2000; Spitzer et al., 2004). Occupational health effects also differ by gender. Men have more workplace accidents (Gluck et al., 1998; Wagener et al., 1997), but women report more illnesses such as sick building syndrome (Stenberg and Wall, 1995) and upper limb musculoskeletal disorders (Punnett and Herbert, 2000).

A number of literature reviews demonstrate that the distributions of most physical characteristics of women and men overlap, but that there are important mean differences in anthropometrics (Chamberland et al., 1998; Pheasant, 1996) and in the performance of certain tasks (Cook and Neumann, 1987; Laubach, 1976; Perrault, 1996). It is often tempting, therefore, to attribute workplace health differences to biological sex differences.

However, it is not always easy in practice to distinguish between sex and gender effects. For example, many clinicians attribute differences in profiles of sports injuries to male and female knee anatomy (Fulkerson and Arendt, 2000; Huston et al., 2000; Kirkendall and Garrett, 2000). Examining these studies reveals that differences in injury profile seem to have been ascribed to sex before considering possible differences in exposure. For example, cited studies often involve "athletes" but results are not broken down by sport. Since women and men do not practice the same sports in the same numbers, sex differences in injury rates do not only reflect biological differences between the sexes. In the absence of information on differential exposures of males and females, explanations for differences center on anatomic specificities.

The question of whether biological differences completely explain phenotype differences such as health disparities between women and men has a long history (Emslie et al., 1999; Fausto-Sterling, 2000; Spitzer et al., 2004). In the case of occupational health, the information needed to answer the question can be categorised as follows:

1. What are the extent and pattern of work related health differences between women and men workers?
2. To what extent are apparent differences due to artefacts of institutional recognition, e.g., differences in medical diagnoses (Alexanderson, 1998) or in workers' compensation decisions (Lippel, 1999, 2000)?
3. To what extent are these differences due to hormonal or other factors largely determined by the chromosomal complement (sex differences)?

4. To what extent are these differences due to education, training, and other social forces that induce males and females to adopt different roles in society, to be perceived differently by others, and to respond to stimuli in different ways (gender differences)?
5. To what extent are these differences due to differential exposure to factors in the physical or social environment at work?
6. To what extent are these differences due to interactions between the physical or social work environment and sex or gender differences?

This paper will concentrate on information gathered from ergonomic studies, which bears primarily on Questions 5 and 6. The employment context of women and men will be summarised as well as some ways in which their specific insertion in the job market translates into physical job demands.

The Gendered Division of Employment and Labour

In the United States, Canada, Sweden, and many other countries, men are found more often than women in forestry, fishing, manufacturing, and generally in the primary and secondary sectors of the economy, whereas women are largely in the service sector (Statistics Canada, 2001a; Wagener et al., 1997). Men are usually found at relatively higher positions in the hierarchy of the organisations in which they work. In Canada, men are 54% of the work force but 80% of senior managers (Statistics Canada, 2001b). In Canada the average woman's annual salary for full-time, full-year work is 69.9% of the average man's salary (Statistics Canada, 2001c). Besides this "vertical segregation" there is also "horizontal segregation." Women and men have different occupations (Tables 1 and 2, Statistics Canada, 2001b). Only one occupation, retail sales clerk, is found in the lists of the 10 most common jobs of both men and women.

Even within the same occupation, women and men are differentially distributed. For example, women in retail sales in Europe are more often found in cosmetics and shoes, whereas men more often sell automobiles and electronic equipment (McGauran, 2000). Similarly, in Canada, male and female gardeners (Messing et al., 1994) and cleaners (Messing et al., 1998) are not assigned to the same tasks. Thus, even within the same job title, men and women may be assigned to different tasks and be exposed to different working conditions (McDiarmid et al., 2000; Messing et al., 1994).

There are also gender differences in employment status and hours worked. The most obvious employment related difference is in schedules, with men working more total paid hours, more overtime, and more night shifts (Conseil du statut de la femme, 2000; Matte, 1998). In Canada, 10% of men and 27% of women are employed part time (Statistics Canada, 2001d). It may be thought that part-time work corresponds to a lower dose of workplace stressors, but this is not always true; in many organisations part-time workers are brought in at peak periods and may therefore be working at faster speeds.

The rest of the present review concerns the implications of sex-typed employment for musculoskeletal and cardiovascular function, work schedule demands, and toxic exposures.

Table 1 Ten Most Common Occupations of Women in Canada

Occupation	No. of men	No. of women	% Women
Retail sales clerk	215,345	339,025	61%
Secretary	5,435	311,835	98%
Cashiers	38,805	235,585	86%
Nurse	12,035	220,625	95%
Accounting clerk	45,015	219,895	83%
Elementary and kindergarten teacher	43,230	187,070	81%
Food server	42,780	176,310	80%
Office clerk	33,960	173,175	84%
Babysitter, nanny, parent helper	6,670	134,560	95%
Receptionist	5,885	118,985	95%
As a % of women in workforce			32%

Note: Calculated from Statistics Canada's Internet Site, http://www.statcan.ca/english/census96/mar17/occupa/table1/t1p00t.htm, December 7, 2001.

Occupations used are three-digit professions.

Table 2 Ten Most Common Occupations of Men in Canada

Occupation	No. of men	No. of women	% Men
Truck driver	222,795	4,515	98%
Retail sales clerk	215,345	339,025	39%
Janitor, concierge	185,035	85,400	68%
Retail trade manager	179,645	112,900	61%
Farmer	176,985	52,605	77%
Wholesale sales representative (nontechnical)	131,225	49,300	73%
Motor vehicle mechanic	127,185	1,195	99%
Materials handler	119,135	13,115	90%
Carpenter	112,965	1,360	99%
Construction helper	104,110	5,775	95%
As a % of men in workforce			20%

Note: Calculated from Statistics Canada's Internet Site, http://www.statcan.ca/english/census96/mar17/occupa/table1/t1p00t.htm, December 7, 2001.

Occupations used are three-digit professions.

Musculoskeletal and Cardiovascular Function

WORKSITE AND ANTHROPOMETRY

Average lengths of body segments of women and men differ, although there is some overlap (Chamberland et al., 1998). For example, the average Canadian woman is 0.12 M (7%) shorter than the average man. This rather small difference in averages translates into a substantial difference in distribution: the 50th percentile of women is below the 3rd percentile for men, and the 50th percentile for men is above the 97th percentile for women (Chamberland et al., 1998). Hand measurements differ even more: hand breadth of women averages 85% that of men, and the 50th percentile for women is below the first percentile for men, whereas the 50th percentile for men is higher than the 99th percentile for women.

Design of work stations that rely on measurements for one sex may therefore be inadequate for the other, and a woman in a nontraditional workplace may find that some tools, equipment, and working heights are disadvantageous (Chatigny et al., 1995; Courville et al., 1991, 1992). This may even be true in jobs occupied primarily by women. For example, in Québec, bank counter heights and widths were too big for most tellers (Seifert et al., 1997). Among Norwegian women, shorter office and production workers had more neck and shoulder pain (Westgaard et al., 1993). The chambermaids in a Montréal hotel, many of Asian or South American origin, found the bar of their housekeeping cart too high (Seifert, 2001). Heights were measured at 107–117 cm, a design derived from manuals that recommend 102–117 cm, based on 70–80% of the acromial height of men (Kroemer, 1969).

The fact that proportions of body segments are different has implications for the design of personal protective equipment and clothing. For example, the average foot length of women is 90.5% that of men, but the average calf circumference is 97.2% that of men. Thus, boots should be designed with these different proportions in mind.

REPETITIVE MOVEMENTS

Repetitive movements can combine with other conditions to produce injuries due to friction, shearing, and intramuscular pressure leading to impaired circulation, and eventually pain (Johansson and Sojka, 1991; Kilbom, 1994; Kuorinka and Forcier, 1995). Repetitive movements at a joint are often combined, in factory and office jobs, with static, awkward, load-bearing postures that may amplify their effects. For example, in work at a computer terminal, the fingers move quickly while the elbows and wrists may be unsupported in a fixed position. The muscles around the latter articulations must contract to bear the weight of the arms, and this may affect circulation to the hand and arm as well as to the muscles directly involved. In some jobs the hand holds heavy tools that add to the load on the joints and require more sustained and forceful muscle contractions, further affecting circulation. Depending on the conformation of the keyboard or other work tools, the upper limbs may be in awkward postures that further restrict blood flow.

Women in the U.S. are absent from work due to repetitive motion injuries twice as often as men (U.S. Dept. of Health and Human Services, 1997: Table 23), even though they report less exposure to repetitive, strenuous work (U.S. Dept., 1997: Table 19), and even though job analysis suggests that “the proportion of physical work demands (in an analysis for 2838 males and 866 females) is very similar for both sexes” (Brauchler and Landau, 1994, p. 21). This paradox may be due to the difference in types of repetitive work assigned to women and to men.

A pioneering study of repetitive work done by Silverstein and colleagues (1986) examined production workers in six companies. Tasks were observed, forces were measured, and jobs were classed dichotomously according to the force (high = >4 kg) and repetition (high = >2 per minute or more than 50% of the time occupied by the same work cycle) required. Male workers were found preferentially in jobs classified as high-force/ low-repetition (HIF/LOR) and women in those classified as low-force/ high-repetition (LOF/HIR); both conditions were associated with increased hand-wrist cumulative trauma disorders. Repetitiveness and force were independently associated with disorders. This study is well known, and its methods have been widely adapted for studying repetition (Kilbom, 1994).

The cutoff point for repetition in this study (30-s cycles) is high, however, compared to the cycle times in many women’s factory jobs. Researchers have found that women are preferentially assigned to very fast, very repetitive work, with work cycles under 10 seconds (Courville et al., 1994; Dumais et al., 1993). Ergonomists observed men and women in a cake factory and found that women worked filling and wrapping cake packages in the middle of the production line, while men mixed ingredients and baking at the beginning and in packing boxes at the end (Dumais et al., 1993). The man at the most repetitive men’s task emptied 4-kg cake pans by tapping them on a counter at the rate of about 8 per minute, while the woman at the most repetitive women’s tasks aligned, wrapped, and packed cakes weighing 20–30 g at rates of about 60 per minute. Movement amplitude is smaller in the women’s jobs, translating into a higher static component. The woman’s trunk and arms are held relatively still while her fingers move quickly.

Although the men’s jobs in the cake factory were characterized by higher levels of force and lower levels of repetition compared to the women’s jobs, the men’s job would be classed as HIF/HIR and the women’s as LOF/HIR. Thus, by the usual standards, the difference in force would be made visible, but not the difference in repetition. A difference between men and women in the health outcome associated with the jobs classed as HIR, such as described in the Silverstein et al. study, would appear to be due to a sex difference and not an exposure difference. It is therefore possible that the apparent male/female difference in absence for repetitive motion injuries may be at least partly due to exposure differences (Messing, 2000).

STATIC EFFORT OF THE LOWER LIMBS

Prolonged standing with little movement of the lower limbs is associated with pain and fatigue in the back, legs, and feet (Arcand et al., 2000; Messing and Kilbom, 2001; Ryan, 1989). The discomfort is an important negative element in job perception. For example, Canadian bank tellers cited pain and discomfort associated with prolonged standing as their most important health and safety problem, over the fear of bank robberies or stress associated with a work reorganization (Seifert et al., 1997). Some evidence, gathered in male populations, associates prolonged standing with worsening of coronary artery disease (Krause et al., 2000), varicose veins (Tüchsen et al., 2000), and chronic venous insufficiency (Krijnen et al., 1997). Older studies by Buckle et al. (1986), Sejersted and Westgaard (1988), Edwards (1988), Hansen et al. (1998), Whistance et al. (1995), and McGill et al. (2000) suggest that the discomfort and health damage from prolonged constrained standing arise from four main sources: (a) interference with the circulation resulting in tissue hypoxia; (b) interference with the venous return to the heart, resulting in edema; (c) intervertebral disc stress; and (d) stretching of ligaments ("creep").

In North America this posture is found among production workers, grocery checkout clerks, bank tellers, sales clerks, and other service workers, most of whom are women (Messing et al., in press). Among men it is found primarily among production workers. The Québec Health Survey showed that a majority of workers (62% of men and 53% of women) work primarily in a standing position (Arcand et al., 2000). Those who report that they usually stand at work are much more likely to experience pain in the lower limbs and lower back than those who sit. Women who work standing report more pain in the lower limbs and back than do men (Table 3), posing the question of whether women are particularly sensitive to pain.

Table 3 Usual Posture at Work and Resulting Pain, Québec 1998–99.

	Pain in feet %	Pain in lower limbs %
Men		
usually stand	8	14
usually sit	1	3
Women		
usually stand	13	18
usually sit	1	3

Note: From Arcand et al. (2000)

However, pain reports are less common among those who are free to sit at will, and among those who can move around at work (Arcand et al., 2000), possibly because edema and hypoxia are rapidly relieved by a change in posture (Seo et al., 1996). Thus the degree of constraint may be a determinant of health symptoms among standing workers. In the Québec Health Survey population, standing is associated with more mobility among men than among women (Arcand et al., 2000).

Pain sensitivity in the foot and pain sites in the back and lower limbs were studied among 44 researchers, sales people, and food service workers in Québec and Sweden, of whom 33 were women. Pain sensitivity and number of pain sites increased after work compared to before work among sales people and food service workers, who worked standing 60 to 90% of the time, moving during less than half of that time. No such AM-PM difference was found among the researchers, who sat 95% of the time. Men had higher pain thresholds at the beginning of the day, in accordance with the literature (Brennum et al., 1989; Johansson et al., 1999; Riley et al., 1998). In a logistic regression, increase of pain sensitivity during the work day was related significantly to number of steps taken (Messing and Kilbom, 2001; Messing et al., 2002) for both sexes. The higher level of pain reported by women in the Québec Health Survey can be attributed in part to their lower pain threshold, but it may also be partly attributable to differences in working postures.

EFFORT

Swedish researchers have explored the relationship between perceived effort at work, registered on a Borg CR-100 scale (Borg and Borg, 2002), and metabolic measures of exertion. Some evidence shows that women register a higher level of perceived exertion than men, at the same level of MET values (Leijon, 1999). However, static effort is not well measured by MET, since MET levels are a measure of oxygen uptake. Brabant et al. (1989) examined cardiovascular stress from static effort in a hot environment. They found that, in a task rated as "light work" according to standards for dynamic work, recommended limits for cardiac frequencies were regularly exceeded.

Karlqvist et al. (2003) examined a population of 94 male and 94 female Swedish workers in 85 job classifications, and found that aerobic capacity of the men averaged 35 $ml \cdot kg^{-1} \cdot min^{-1}$ compared to 32 $ml \cdot kg^{-1} \cdot min^{-1}$ for the women. Among the women, 22% (compared to 27% of the men) experienced physical work demands (assessed by interview, expressed in MET) that exceeded 30% of their maximal aerobic capacity (assessed by $\dot{V}O_2$ max, converted to MET). These workers were considered to be exposed to excessive work demands.

Gender, Sex, and Toxic Exposures

Toxicology studies have usually been done in working populations primarily composed of men. For a long time, women were largely excluded from studies of occupational cancer: of 1,233 studies published between 1971 and 1990, women were absent from 86% (Zahm et al., 1994). Although Zahm's study sparked an interest in women's occupational cancers (reviewed by Blair et al., 1999), toxicological investigations still concentrate on male-dominated professions. The 1999 annual report of the respected Québec Institute for Research in Occupational Health and Safety (IRSST) described 22 studies of toxic agents with reference to the studied occupations. Twenty of these (91%) were traditionally male workplaces where the average percent of women in these occupations and workplaces is expected to be 15.8%, according to Statistics Canada data on the occupations concerned (Messing, 2002).

There is increasing awareness, however, that traditional female jobs such as hairdresser, cleaner, and laboratory technician involve a risk of toxic exposures, resulting in illnesses such as cancer, dermatitis, and neurological impairment. In addition, attention is being paid to female patterns of toxic exposure in mixed workplaces and employment sectors (Zahm et al., 2000). London et al. (2002) found that women in agriculture were exposed to pesticides in different contexts from those of men. Men may apply the pesticides to the plants, but women often weed the pesticide-drenched areas. Bailie and London (1998) showed that 61% of cases of pesticide poisoning in an area of South Africa involved women, and exposures were primarily related to paid work. Under-reporting of pesticide poisoning (on the order of 80%) was concentrated among women. Similarly, exposure to non-ionizing (electromagnetic) radiation among women in North America has concentrated on such men's jobs as hydroelectric and telephone workers, but it has recently been found that women can be exposed to high doses of extremely low electromagnetic radiation as industrial sewing machine operators and in other factory jobs (Deadman and Infante-Rivard, 2002).

Women may be identified less often as part of an exposed population because data are lacking. A Canadian study of the effects of agricultural exposures was forced to eliminate women since only the husband of a farm family was identified as a farmer in most provincial records (Semenciew et al., 1993). Also, many death certificates have not contained information on women's professions, in part because once a woman has retired she may be considered a housewife. McDuffie (1994) showed that the patterns of exposure and effects of pesticides among Canadian women may differ from those of men, for physiological and occupational reasons.

Genetically-determined metabolic differences may affect toxicity (Setlow et al., 1998). For example, the same level of exposure to a chemical may be more detrimental to one sex than the other, due to sex differences in skin thickness, percentage of fat tissue, airway dimensions, breathing patterns, respiratory volume, etc. (Ernstgard et al., 2003; Silbergeld, 2000). Men's higher rate of lung cancer from asbestos may reflect higher exposure, higher smoking rates, or differences in susceptibility (Blair et al., 1999), whereas women may be more likely to get lung cancer from tobacco smoking (Perera, 1997). However, it is also possible that the apparent sex difference in fact represents a failure to correct for body size (Ernstgard et al., 2002).

When biological data on reactions to the workplace are being analyzed, correction factors by sex may be used. For example, in analyzing data on the effects of mercury exposure, researchers used slightly different factors to calculate creatinine clearance for women and men (Frumkin et al., 2001). However, it might be better to measure differences in skinfold thickness directly rather than using sex as a surrogate for estimating percent body fat. In analyzing data on heart rate elevation during work, researchers (ourselves among them) have been tempted to correct for different resting level heart rates for women and men (Leijon et al., 2002). Using this kind of correction based on sex-typing can be unwise, since the correction factors may incorporate some of the phenomena being studied. For example, a male/female difference in resting heart rate may possibly reflect different levels of activation in response to different life conditions. In such a case, individual resting heart rates would not be well represented by an aggregate value attributed according to sex.

Gender, Sex, and Family Responsibilities

WORK SCHEDULES

Work schedules may affect circadian rhythms, with consequent effects on physiology and eventually on health. The effects of work schedules vary according to both gender and sex. Night work, found more commonly among men, is associated with heart disease and other illnesses (reviewed by Boggild and Knutsson, 1999). Irregular, unpredictable, or extended work schedules are more often found among men, with men working more total paid hours, more overtime, and more night shifts, whereas women more often work part time. The effects of these types of schedules also vary according to gender, since primary responsibility for child care and elder care usually falls to women (reviewed by Walters et al., 2002). Schedule variability and shift work impact those responsible for such care in different ways from those without such responsibilities (Prévost and Messing, 2001). Effects of work schedules may also vary by sex, for biological reasons. Schedule variability is associated with perimenstrual pain and with menstrual cycle irregularities (Messing et al., 1992, 1993).

Aside from the effects of specific work schedules, work and family responsibilities can combine to produce stress and fatigue, affecting ambulatory blood pressure (Brisson et al., 1999). Chronic fatigue has been associated with combined professional and domestic workload (Souza et al., 2002; Tierney et al., 1990).

GENDER AND THE “HEALTHY WORKER EFFECT”

Any consideration of health effects of work must take into account the healthy worker effect. The population of workers is usually healthier than the general population, because those who become ill (including those made ill by their work) tend to leave the workplace. Paradoxically, the more physically demanding the workplace, the greater the positive health difference between workers and the general population. The healthy worker effect (HWE) often makes it difficult to identify effects of workplace exposures.

Male/female comparisons of health in the workplace must deal with how the HWE works in each sex, conditioned by differential family responsibilities. Joffe (1985) hypothesized that difficulties with reproduction might bring *less healthy* and therefore less fertile women preferentially into the workforce, counteracting the HWE in women, but not men. This hypothesis, not yet tested, is supported by the fact that women with many children are less likely to be found in the workplace. Baillargeon et al. (1998) found healthy worker effects on mortality that were roughly similar for men and women, although the rates attenuated differently with age for the sexes (possibly also due to family responsibilities). Lea et al. (1999) found that the healthy worker effect was manifested differently for semi-skilled women and men in the synthetic fiber industry. They found that healthy men were hired more often than unhealthy men but that there was no such effect for women. On the other hand, if those who had left employment were followed, women had a higher mortality rate than men, although both male and female ex-employees had a higher mortality rate than those who stayed on the job. It was not clear whether women’s higher mortality rate was an effect of job exposures, selection, or unemployment.

VALIDATING INSTRUMENTS

Care must be taken so that the research tools used are appropriate for both sexes. This involves various precautions, such as validating instruments for both male and female populations. For example, the widely used Job Content Questionnaire (University of Massachusetts, 1994) was derived in all-male populations, and only later validated with female populations (Ibrahim et al., 2001; Kawakami and Fujigaki, 1996; Pieper et al., 1989; Schnall et al., 1990).

A widely employed preemployment strength test was invalidated for women even though some women had been tested during development of the procedure. Data on the few women's performance had been swamped when merged with that of men, and the resulting published results obscured the fact that women's performance on the test related less well than men's to other tests of performance (Stevenson, 1995; Stevenson et al., 1996). Use of such tests to screen job applicants was later prohibited by a Canadian Supreme Court decision, citing Stevenson's research (British Columbia Public Service Employee Relations Commission v. British Columbia Government and Service Employees' Union [1999] 3 S.C.R.3).

Even validating an instrument on both sexes can involve pitfalls, however. Orhede and Kreiner (2000) have analyzed an instrument they were developing to test exposures in the psychosocial work environment. They found that, even though total scores on the instrument did not differ by sex, for almost all items used there was significant evidence of item bias, implying that the instrument did not work in the same way for men and women.

In some cases, validation of a test or even of individual items may not be enough. We can ask whether using an instrument derived with one sex and then validated with the other will include all variables most important to the other sex. Might an increase in explained variance be achieved by adding items more closely related to the experience of the other sex? For example, the Job Content Questionnaire (JCQ) is used by more than 100 research groups to measure psychosocial and organizational factors associated with heart disease and psychological distress (University of Massachusetts, 1994). The principal associated factor, "job strain," is a combination of heavy demand and little control over how the job is done. Although job strain is found more often among women (Hall, 1989), the JCQ was developed and tested with male subjects only and neglects many factors relevant for women (Pickering et al., 1991). For example, the questions on physical aspects of work cover dynamic work, repetition, awkward postures, and chemical exposures, but not the static work typical of women's factory and office jobs. The degree of repetition is not distinguished carefully enough to measure the effects of extremely fast manipulations found in women's jobs on assembly lines (Erdelyi et al., 1988; Sommerich et al., 1993).

Conclusions

Both women and men are exposed at work to constraints on their physiology and locomotor function. Because of the differences in their jobs, these constraints may vary by sex. Appropriate concepts and instruments must be developed so that all types of constraints can be recognized and their effects measured. In addition, men's and women's workplace experience may translate differently into physiological effects, because of gender-specific extraprofessional exposures. Research is particularly needed on women's exposures and their physiological effects.

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