ORIGINAL ARTICLE

Occupational physical demands and same-level falls resulting in fracture in female workers: an analysis of workers' compensation claims

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Objectives: To examine the association between occupational physical demands and risk of same-level falls resulting in fracture in female workers' compensation claimants.

Methods: From workers' compensation claims for same-level falls, 7286 female workers from three age groups (18–49, 50–59 and 60–79 years) were randomly selected. Levels of occupational physical activity, standing and sitting were assigned using occupational codes. Fracture occurrence was determined using the International Classification of Diseases codes. Risks of same-level falls resulting in fracture were compared by quartiles of physical activity, standing and sitting.

Results: In the 18–49-year age group, physical activity, standing and sitting at work were not significantly associated with risk of same-level falls resulting in fracture (p value trend: 0.07, 0.18 and 0.10, respectively). In the 50–59 and 60–79-year age groups, increasing duration of standing and decreasing duration of sitting were associated with decreasing risk of same-level falls resulting in fracture (p value trend: standing <0.001, 0.01; sitting <0.001, 0.02). In the 50–59-year age group, the relative risks of same-level falls resulting in fracture were 0.53, 0.41 and 0.82 for the second, third and highest quartiles of physical activity, respectively, as compared with workers in the lowest quartile (95% confidence interval 0.35 to 0.80, 0.23 to 0.72, 0.56 to 1.21, respectively). In the 60–79-year age group, there was a similar, but not significant, U-shaped association between occupational physical activity and risk of same-level falls resulting in fracture.

Conclusion: Moderate occupational physical demands may be associated with a decreased risk of same-level fall resulting in fracture in female workers' compensation claimants ⩾50 years of age.

Several studies have reported that women ⩾45 years of age are at increased risk of fracture due to same-level falls.[1–4] Davies *et al*[2] suggested that osteoporosis, decreased muscle strength and increased reaction time could be among the potential factors responsible for this increased fracture risk. However, it is not clear whether older working women fall at a higher rate or whether risk of fracture after falls increases with age. In a recent study, Cherry *et al*[5] found that older working women were at increased risk of fracture after a fall.

There is considerable literature on risk factors for falls and fracture—particularly hip fracture—in elderly women. However, few studies have examined the risk factors for falls and fracture in working-age women. Falls on the same level are an important cause of workplace injury and subsequent disability.[6] According to the US Bureau of Labor Statistics data, same-level falls account for about 12% of all workplace injuries resulting in lost workdays.[7] In all, 14% of the workers who missed ⩾1 days from work due to a same-level fall sustained a fracture. Fractures are one of the most disabling workplace injuries that result from same-level falls.[7]

Physical activity may improve bone and muscle strength, and epidemiological studies suggest that leisure time physical activity is associated with reduced risk of hip and other fractures in older women.[8–10] Keegan *et al*[11] found that leisure time physical activity was associated with reduced risk of fracture among those who fell. However, the relationship between occupational physical activity and risk of fracture is less certain. Jaglal *et al*[12] found that women who worked for ⩾20 years in occupations requiring moderate-to-heavy activity were strongly protected against hip fracture compared with those working in sedentary-to-light occupations. A review by Joakimsen *et al*[13] reported that only three of seven studies focusing on physical activity at work found a significant association with hip fractures. Coupland *et al*[14] did not find a consistent association between lifetime occupational activity and bone mineral density in postmenopausal women. Suen[15] reported a U-shaped relationship between occupational physical activity and risk of hip fracture in female workers.

With the value of occupational physical activity still unresolved, we examined its association with the risk of fracture in female workers' compensation claimants who reported a same-level fall. We also examined whether age was associated with the risk of same-level falls resulting in fracture. We hypothesized that age is associated with increased risk of same-level falls resulting in fracture, that physical activity at work is associated with a decreased risk of fracture once a fall had occurred, and that this association would be stronger in older female workers' compensation claimants.

MATERIALS AND METHODS

Study population

Administrative claims data from a large workers' compensation insurer representing approximately 10% of the private US workers' compensation market were used in this study. In the US, compensation for injuries and illnesses sustained on the job is organized and regulated at the state level. Generally, for non-fatal injuries each state's system provides reimbursement for medical treatment and partial reimbursement for wages lost as a result of the injury (for an overview of the US system of workers' compensation, see Mont *et al*).[16] The study included

Abbreviations: HRT, hormone replacement therapy; ICD-9 CM, International Classification of Diseases, Ninth Revision, Clinical Modification; O*NET, Occupational Information Network.

Table 1 Age, tenure and common fractures resulting from same-level falls by age group in a sample of female workers from a workers' compensation database

	Age groups (years)		
	18–49 (n = 2356)	50–59 (n = 2418)	60–79 (n = 2512)
Age in years, mean (SD)	36.2 (8.85)	54.1 (2.78)	65.1 (4.84)
Job tenure in years, mean (SD)	6.0 (6.31)	10.5 (9.45)	11.2 (9.89)
Falls resulting in fracture (%)	71 (3.0)	143 (5.9)	212 (8.4)
Radius and ulna—813*	18 (25.35)	50 (34.97)	65 (30.66)
Ankle—824*	17 (23.94)	21 (14.69)	29 (13.68)
Tarsal and metatarsal bones—825*	14 (19.72)	16 (11.19)	8 (3.77)
Humerus—812*	3 (4.23)	14 (9.79)	40 (18.87)
Patella—822*	5 (7.04)	8 (5.59)	17 (8.02)
Neck of femur—820*	0 (0.00)	6 (4.20)	14 (6.60)
Others	14 (19.72)	28 (19.58)	39 (18.40)

*Three-digit International Classification of Diseases, Ninth Revision, Clinical Modification code.

workers' compensation claims from each state of the US and the District of Columbia, except North Dakota. The technical aspects of the data source used for this study have been extensively documented by Murphy *et al*.[17]

Information was collected regarding the injured employee, injury and medical services provided for the injury. Claims information (date of injury, age at injury, sex, date of report, accident description, injury description, injury cause, occupation, job description, tenure, name of employer and industry) and medical service information (Current Procedural Terminology code—developed by the American Medical Association, International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9 CM) code and amount paid for service) were provided by the insurance company.

Female workers who filed a workers' compensation claim for same-level falls with this insurer from 1 January 2000 to 31 December 2002 and who had been working with the same employer for at least 1 year at the time of injury were eligible for inclusion in the study (n = 61 644). Women with job tenure <1 year were excluded to ensure at least 1 year of occupational physical activity at the level before injury. Of these 61 644 female workers, 38 527 (62.5%) were 18–49 years of age, 16 397 (26.6%) were 50–59 years of age and 6411 (10.4%) were 60–79 years of age. We randomly selected 3000 women from each of these three age groups for analysis. These age divisions were selected to reflect typical onset periods for menopause-related changes and age-related bone and muscle strength loss in later life.[18]

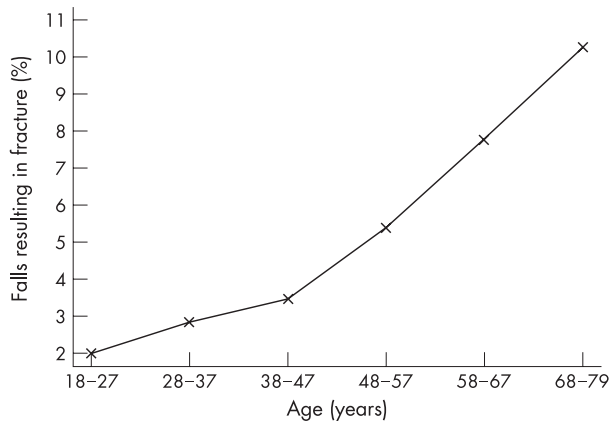


Figure 1 Percentage of same-level falls resulting in fracture by age in a sample of female workers from a workers' compensation database.

Exposure assessment

On the basis of reported occupations in the workers' compensation claims, levels of general physical activity and standing and sitting duration were estimated for each worker using the Occupational Information Network (O*NET) database V.6.0. Reported occupations were assigned O*NET codes (http://online.onetcenter.org) by a person blinded to injury outcomes. Occupational data in O*NET are collected under the auspices of the US Department of Labor. O*NET was developed to replace the Dictionary of Occupational Titles.[19] V.6.0 of the O*NET data collection program contained 908 occupations and provided several hundred job attributes, based on a survey of sampled workers (current V.9.0). Appendix A includes specific questions in the O*NET questionnaires to assess general physical activity level, and standing and sitting durations of an occupation. Occupational attributes from O*NET, which are relatively new, have been used in a few studies as measures of occupational exposure.[20 21]

Of the 9000 participants, sufficient occupational information to assign an O*NET code was not available for 1714 (19%). The proportion of cases that could not be assigned an O*NET code was similar in those who did and those who did not sustain a fracture after a same-level fall (20% and 19%, respectively, p = 0.65). However, the proportion of cases that could not be assigned an O*NET code was lower in women workers aged 60–79 years (16%) than in those aged 18–49 years (21%) and in those aged 50–59 years (19%; p<0.001).

Outcome assessment

All women in this cohort filed workers' compensation claims for same-level falls and a subset of them had fracture. A fracture was defined to have occurred when all three of the following criteria were met: (1) the nature of injury in the administrative databases was coded as ''FRACTURE''; (2) three or more medical services were provided with ICD-9 CM codes associated with fracture (codes 800–829); and (3) the total amount paid for medical services with ICD-9 CM codes associated with fracture was ⩾US$ 100.

Statistical analysis

Female workers were categorized into quartiles on the basis of levels of occupational physical activity and standing and sitting durations. Log-binomial regression was used to examine the association between age group and fracture and that between physical activity level and fracture stratified by age group.[22] All p values were based on two-sided tests. SAS V.9.1 was used for the data analysis.

RESULTS

Out of the 7286 female workers' compensation claimants who were assigned O*NET codes, 426 (6%) had a fracture after

same-level falls. Table 1 presents the selected characteristics of female workers in the study and common fractures that resulted from same-level falls. Other common injuries resulting from falls were contusion (34%), strain (23%), sprain (9%), inflammation (6%) and laceration (5%).

Age was significantly associated with an increased risk of same-level falls resulting in fracture. Compared with the 18–49-year age group, the relative risk (RR) of same-level falls resulting in fracture was 2.0 in the 50–59-year age group (95% confidence interval (CI) 1.5 to 2.6) and 2.8 in the 60–79-year age group (95% CI 2.2 to 3.6). When age was treated as a continuous exposure, risk of fracture after a same-level fall increased by 19% for every 5-year increase in age (95% CI 1.14 to 1.24; fig 1).

In female claimants aged 50–59 years, occupational physical activity showed a U-shaped association with risk of same-level falls resulting in fracture. Compared with women working in sedentary occupations (first quartile), the RR of fracture was 0.53 for the second quartile (95% CI 0.35 to 0.80), 0.41 for the third quartile (95% CI 0.23 to 0.72) and 0.82 for the highest quartile of physical activity occupations (95% CI 0.56 to 1.21; table 2).

In women aged 60–79 years, occupational physical activity suggested a similar U-shaped association with risk of fracture (the quadratic term was significant at 95% confidence level when quartiles were used as ordinal variable, data not shown), although none of the estimates of the RR was significant at a 95% confidence level. In the 18–49-year age group, physical activity level had a marginal negative association with risk of same-level falls resulting in fracture.

Among those ⩾50 years (50–59 and 60–79-year age groups), the risk of same-level falls resulting in fracture increased with both increasing levels of sitting and decreasing levels of standing at work (table 2). These associations were not significant in the 18–49-year age group at a 95% significance level.

DISCUSSION

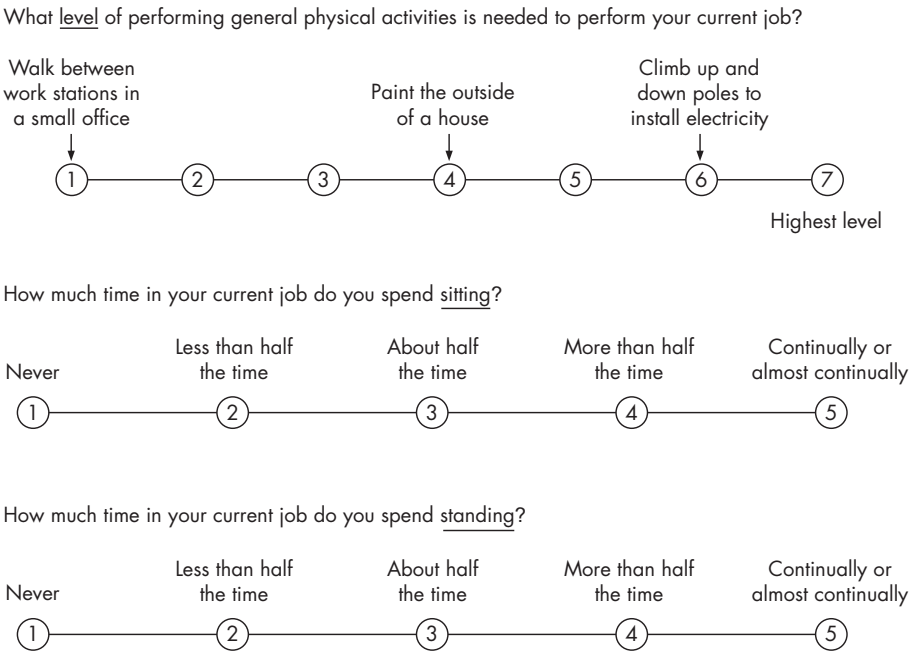
This study found that among female workers' compensation claimants, the risk of same-level falls at work resulting in fracture increased with age. We also found that those ⩾50 years of age who were working in occupations with high durations of standing or low durations of sitting were at lower risk of fracture after same-level falls. However, general physical activity level had a U-shaped association with risk of fracture in female claimants ⩾50 years of age, with the lowest risk of fracture observed in occupations with moderate physical activity levels (second and third quartiles).

Studies have reported that the risk of fracture increases with age in women.[1–4] However, it is not clear whether this increased risk is due to an increased risk of falls or greater proportion of falls resulting in fracture. Our study looked only at women who fell on the same level and filed a workers' compensation claim for it, and found that the RR of fracture after a fall increased with age. The RR of fracture in female workers aged 50–59 years (RR = 2.0, 95% CI 1.5 to 2.6) was comparable to that found by McNamee *et al*[1] (OR = 2.07 in Sweden and 1.7 in England). In a recent study of working women in England, Cherry *et al* also found that the risk of fracture after falls at work increased steadily with age.[5]

Weight-bearing activity has been shown to improve skeletal health and may reduce fracture risk. Keegan *et al*[11] found leisure time physical activity to be negatively associated with risk of fracture after a fall in women ⩾45 years of age. We found that for female workers' compensation claimants ⩾50 years of age, occupations with a higher duration of standing were associated with a reduced risk of same-level falls resulting in fracture, whereas occupations with a higher duration of sitting were associated with an increased risk of fracture after a same-level fall.

However, the association between physical activity at work and risk of same-level falls resulting in fracture was not linear in female claimants ⩾50 years of age. Among these women, occupations with moderate levels of physical activity (second and third quartiles) were associated with a lower risk of fracture than were occupations with low and high levels of physical activity.

In our study, stock clerk, registered nurse and housekeeping staff were the three most common occupations in the highest quartile of physical activity. McNamee *et al*[1] also reported that the RR for fracture after a same-level fall was highest among registered nurses and shop assistants in Sweden. Suen[15] reported an increased risk of hip fracture in both sedentary and weight-bearing occupations compared with intermediate



Appendix A: Questions used in O*NET questionnaires to obtain information about physical activity and duration of sitting and standing at work.

Table 2 Percentage of same-level falls resulting in fracture, RR of fracture after a same-level fall, 95% confidence interval by quartiles of physical activity and standing and sitting durations, and p value associated with Cochran–Armitage trend test in each age group of sampled female workers from a workers' compensation database (n = 7286)

	Physical activity						Standing						Sitting					
	18–49 years		50–59 years		60–79 years		18–49 years		50–59 years		60–79 years		18–49 years		50–59 years		60–79 years	
Quartile	% frac	RR (95% CI)	% frac	RR (95% CI)	% frac	RR (95% CI)	% frac	RR (95% CI)	% frac	RR (95% CI)	% frac	RR (95% CI)	% frac	RR (95% CI)	% frac	RR (95% CI)	% frac	RR (95% CI)
First	4.21	Ref	8.36	Ref	9.45	Ref	3.29	Ref	8.22	Ref	9.92	Ref	2.35	Ref	2.25	Ref	6.42	Ref
Second	3.07	0.73 (0.39 to 1.36)	4.42	0.53 (0.35 to 0.80)	7.41	0.78 (0.56 to 1.09)	4.20	1.28 (0.72 to 2.28)	6.22	0.76 (0.51 to 1.11)	9.72	0.98 (0.69 to 1.39)	2.07	0.88 (0.40 to 1.95)	5.50	2.45 (1.19 to 5.03)	7.21	1.12 (0.73 to 1.74)
Third	2.41	0.57 (0.30 to 1.09)	3.40	0.41 (0.23 to 0.72)	7.02	0.74 (0.47 to 1.18)	1.84	0.56 (0.27 to 1.17)	5.19	0.63 (0.41 to 0.98)	8.91	0.96 (0.62 to 1.30)	3.99	1.70 (0.90 to 3.19)	5.92	2.63 (1.30 to 5.34)	10.73	1.67 (1.08 to 2.59)
Fourth	2.49	0.59 (0.32 to 1.09)	6.85	0.82 (0.56 to 1.21)	10.12	1.07 (0.75 to 1.52)	2.67	0.81 (0.42 to 1.58)	3.26	0.40 (0.23 to 0.67)	6.38	0.67 (0.45 to 0.91)	3.45	1.47 (0.76 to 2.82)	8.61	3.83 (1.91 to 7.65)	9.53	1.48 (0.95 to 2.33)
p Value*	0.07		0.26		0.58		0.18		<0.001		0.01		0.10		<0.001	0.02		

*p Value Cochran–Armitage trend test.

activity occupations in female workers ⩾50 years old in Australia. Occupations with heavier physical demands may possibly be associated with higher-impact falls (eg, falling during manual handling of material, falling on hard surfaces *v* more compliant surfaces, etc), which, combined with decreased bone and muscle strength in women ⩾50 years of age, contributes to this increase in the risk of falls resulting in fracture. More research is needed to understand the unique risk factors for fractures in heavy-physical-activity occupations.

Although the population base for this study is workers' compensation claimants in the US, the results are consistent with studies conducted in England, Sweden, Australia, Canada and in different populations in the US.[1–3 5 15] Our finding that sedentary occupations are associated with increased risk of fracture in women ⩾50 years of age is consistent with studies examining the effect of leisure time physical activity and with some of the studies examining the effect of occupational physical activity on risk of fracture.[8 11 12] The increased risk of fracture in women working in occupations involving heavy-physical-activity is more likely to be due to workplace-associated risk factors. Though other studies have also found this increased risk, more studies are needed to assess the generalizability of the study findings.[1 15]

Limitations

This study included only same-level falls for which a workers' compensation claim was filed. Falls that do not result in injury are unlikely to be filed for a claim. Therefore, falls that resulted in fracture were compared with falls that resulted in other injuries. In other words, we have matched the comparison groups on outcomes of falls (ie, injury). Such matching is likely to make the two groups similar and bias our result towards the null. However, by restricting our cohort to workers' compensation claimants, we have excluded falls that did not result in an injury. If women in one stratum of occupational physical demands are more likely to have falls that result in injury other than fracture, then we will artificially observe a decreased risk of fracture in that strata. Such a phenomenon will lead to similar results in all the three age groups, unless we further assume that the risk of fall resulting in an injury other than fracture is differential with respect to the occupational physical demands in one age group but not in others. Finally, such a phenomenon is unlikely to explain the U-shaped association of occupational physical demands with risk of fracture in female workers' compensation claimants ⩾50 years of age.

In this study, physical work demands were coded on the basis of occupational titles, thus minimizing the recall bias. However, exposure misclassification can be noteworthy when using generalizations based on occupational titles. Workers in the same occupation may experience widely varying levels of physical demands at work. Additionally, O*NET may not have adequately captured the physical activity level of women workers in different occupations. Although only women who were working with their current employer for ⩾1 year were included in the study, some workers would have changed jobs with the same employer within a year. Such misclassifications are likely to be non-differential with respect to fracture outcome and thus are more likely to bias the result towards the null.

Lack of information on confounding factors such as body mass index, use of hormone replacement therapy (HRT) and leisure time physical activity is a major limitation of this study. Mummery *et al*[23] did not find a remarkable association between sitting time at work and body mass index in female workers in Australia. However, HRT may be associated with socioeconomic status, and a few studies have reported that women on HRT are more likely to be in sedentary occupations.[24 25] Leisure time

Key points

- Although the literature suggests that leisure time physical activity may decrease the risk of fracture in postmenopausal women, it is unclear whether occupational physical activity is associated with risk of fracture after a same-level fall.
- Female workers' compensation claimants ⩾50 years of age were found to be at increased risk of same-level falls resulting in fracture.
- Increasing duration of standing at work and decreasing duration of sitting at work were associated with decreasing risk of same-level falls resulting in fracture in female workers' compensation claimants ⩾50 years of age.
- In female workers' compensation claimants ⩾50 years of age, occupations associated with moderate physical activity had lower risk of same-level falls resulting in fracture compared with sedentary occupations and those with heavy physical activity.

physical activity may be negatively associated with occupational physical activity.[26 27] Increased use of HRT and increased leisure time physical activity among women in sedentary occupations may bias our study results towards null. Future studies should obtain more detailed information to better control for these confounders and achieve a better estimate of the association between physical activity at work and risk of fracture after a same-level fall in female workers.

Implications for prevention

Falls on the same level are a leading cause of workplace injury and subsequent disability. Several studies, including ours, have found that women ⩾45–50 years of age are at an increased risk of fracture due to same-level falls. Given the increasing number of older adults in the labor force, falls on the same level and resulting fractures are not only an important health issue but also an important economic issue. Moreover, the health of these older adults is being increasingly affected by workplace exposures. Employers may consider implementing fall prevention programs at work and providing educational programs designed to increase leisure time physical activity and reduce falls and fracture risks in older working women, particularly those working in sedentary occupations.

Our finding that women working in occupations of heavy physical activity are at higher risk of fracture than those working in occupations of moderate physical activity, along with similar findings from other studies, suggests that some work-related exposures may increase the risk of same-level falls resulting in fractures. Although this study does not identify these individual risk factors for fracture, it highlights the need for more research to identify those work-related exposures that influence the risk of fracture in female workers in both sedentary occupations and those with heavy physical activity.

Conclusion

We found that older female workers' compensation claimants are more likely to have fractures after same-level falls at work. In female claimants ⩾50 years of age, high duration of standing, low duration of sitting and moderate physical activity levels at work were associated with reduced risk of same-level falls resulting in fracture. More research is needed to understand the unique risk factors for fracture in female workers working in sedentary occupations and those with heavy physical activity.

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