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RELATING OLDER WORKERS' INJURIES TO THE MISMATCH BETWEEN PHYSICAL ABILITY AND JOB DEMANDS

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Abstract

Objective—We examined the association between job demand and occupational injury among older workers.

Methods—Participants were workers aged 50+ enrolled in the Health and Retirement Study, 2010–2014. Participants reported physical ability within three domains: physical effort, stooping/kneeling/crouching, and lifting. To measure subjective job demand, participants rated their job's demands within domains. We generated objective job demand measures through the Occupational Information Network (O*NET). Using Poisson regression, we modeled the association between physical ability, job demand, and self-reported occupational injury. A second model explored interaction between job demand and physical ability.

Results—The injury rate was 22 /1,000 worker-years. Higher job demand was associated with increased injury risk. Within high job demands, lower physical ability was associated with increased injury risk.

Conclusions—Older workers whose physical abilities do not meet job demands face increased injury risk.

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INTRODUCTION

The population of older workers is growing; more older adults are now in the workforce than at any time since the turn of the century.[1] As of May 2016, 19% of Americans age 65 and above were employed. In addition, employed adults age 65 and above are working longer hours, with 64% working full-time in 2016.[1] Older workers have lower injury rates relative to younger and middle-aged workers, but when injuries occur, they are more serious and more costly.[2–4] Following injury, older workers require more time off,[5] are less likely to be offered modified work or to be recommended rehabilitation post-injury,[6] and are less likely to ever return to work compared to younger workers.[7] In a 2015 study, 11% of older workers reported they intended to retire early as a consequence of prior injury.[8] Among individuals aged 51 to 61 years receiving Social Security Disability Insurance, 37% were disabled due to a workplace injury or illness.[9]

Aging-related health changes impact occupational injury risk.[10–17] Older adults have a higher incidence and prevalence of chronic diseases.[17] Declines in vision and hearing may limit the ability to perceive safety hazards and safety measures, or interfere with processing work-related instructions.[11,18] Age-related changes in cardiovascular and musculoskeletal systems[17,19–21] and bone density[11] may impact dexterity, reaction to stress, and strength.[10–15,22]

Beyond health status, occupational injury risk is influenced by job demand, defined as occupational expectations or the physical requirements involved in performing a job.[23] Using data from 1992 and 1994 panels of the Health and Retirement Study (HRS), researchers found that among respondents age 51 to 61 excluding farmers, respondent-based subjective assessment of the importance of hearing, vision and physical job demands showed a strong relationship with occupational injury rates.[24–26] Objective measures of job demand based upon occupational titles have been generated using the Canadian National Occupational Classification (NOC) system and the Occupational Information Network (O*NET).[5,27–29] Studies demonstrated an informative and statistically significant association between high physical job demand as measured by O*NET and the Canadian NOC and adverse occupational outcomes.[5,27–29]

Researchers have theorized that a mismatch or imbalance between the worker’s physical abilities/capabilities and job demands, specifically if the job has demands that the worker cannot physically meet, could adversely influence health outcomes, above and beyond job demand alone.[7,8,11,30–33] Matching worker abilities with occupation-specific needs[18] may reduce occupational injury risk, allowing older adults to work longer and more safely.

The aims of this study were to: (1) determine the degree to which subjective or objective job demands were associated with injury risk among older workers, (2) compare subjective and objective job demands in predicting risk of injury, and (3) explore via interaction the effects of a mismatch between an older worker's self-reported physical ability and job demands (measured subjectively or objectively) and the risk of occupational injury.

METHODS

Data Sources and Sample

This study was a retrospective secondary analysis of longitudinal survey data from the Health and Retirement Survey (HRS), a study of Americans aged 50 years and older. The HRS is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan.[34] The study's content and methods have been documented elsewhere.[35–37] Briefly, the study began in 1992, with additional participant cohorts added in subsequent panels.[38] Telephone or in-person interviews are conducted with study participants every two years.[77] The study has maintained a response rate over 75% in all groups except Hispanics.[39] The HRS survey gathers data on health, employment, and demographic variables.

Our study used HRS data from the 2010, 2012, and 2014 panels. HRS occupational injury data came from the subsequent panel (e.g. 2012 health data was analyzed with 2014 injury data) to ensure temporality. We restricted the analysis to individuals actively working full-time, working part-time, or working part-time but who stated an intention to retire shortly.

O*NET is an online database detailing 277 occupational attributes of 974 jobs,[40] and is sponsored by the United States Department of Labor/Employment and Training Administration.[41] O*NET provides day-to-day task descriptions, work environment details, and skill requirements for the typical worker.[42]

O*NET was sponsored by the United States Department of Labor/Employment and Training Administration and developed by the North Carolina Department of Commerce.[41] A literature review found O*NET's occupation characteristics to be a useful and underused source in analyzing relationships between occupational characteristics and health outcomes.[43]

O*NET categorizes occupations via the 2010 Standard Occupation Codes (SOC), while HRS uses Census occupation codes.[44] To link O*NET's descriptions of job demand with the HRS data, we used a United States Census Bureau crosswalk[45] between O*NET 2010 SOCs and the HRS 2010 Census occupation codes .[44] Of the 487 Census occupation codes present in the HRS, 72% exactly matched SOC codes in O*NET. We manually mapped an additional 20%. For example, the Census category 8350, "tailors, dressmakers, and sewers," was matched to "tailors, dressmakers, and custom sewers," SOC 51-6052. We excluded the remaining 8% of Census occupation codes that we were unable to cross-walk to an SOC, resulting in a loss of 3% (n=156) of HRS participants.

This study was approved by University of Washington Human Subjects Division.

Measurement

For this study, we defined an occupational injury using HRS data as "an injury at work that required special medical attention or treatment or interfered with work activities."[46] The HRS contains no data on the severity or outcome of worker-reported injury. Occupational injury data were collected from the survey following collection of health, occupation title, and job demand data to ensure these metrics were not influenced by injury occurrence. For example, the 2012 physical ability and job demand responses were used to assess the risk of injury occurrence as reported in the 2014 interview.

Primary factors of interest fell into three domains: physical effort; lifting heavy objects; and stooping, kneeling, or crouching. Each domain was assessed by three metrics: (1) self-reported physical ability, (2) subjective HRS-based job demand, and (3) objective O*NET-based job demand (see Figure 1 and Appendix A).

HRS respondents rated their physical ability specific to each domain. We dichotomized responses such that individuals reporting no difficulty with the activity were categorized as having high physical ability, and individuals reporting difficulty or inability were categorized as having low physical ability (details for each metric can be found in Appendix A).

Subjective job demand was assessed by asking HRS respondents to rate how often their job required *"lots of physical effort," "lifting heavy loads,"* and *"stooping, kneeling, or crouching,"* ranging from "all or almost all the time" to "none of the time."[46] Responses were dichotomized so that *"all or almost all the time"* and *"most of the time"* were considered high job demands, and *"some of the time," "none or almost none of the time,"* and *"does not apply"* were low job demands.

We then mapped each physical ability metric to objective job demand from O*NET. In O*NET, objective job demand was measured by scales including level (how proficient one must be at an activity to perform the job), context (frequency of an activity during work in that job), and/or importance (how central an activity or ability is to a job).[47]

We selected O*NET demands (listed in Appendix A) from examination of the possible O*NET demand descriptions and the available literature. Multiple objective job demands matched to the subjective job demand within the physical effort and lifting heavy objects domains. Within each domain we assessed objective job demands for consistency using Cronbach's Alpha. The alphas were above 0.7[48] so we took a mean of the demands within a scale (i.e. within context, within importance, and within level).[49]

Objective job demand metrics were continuous rather than categorical so we dichotomized the context and importance scales (both range from 1 to 5) at 2.5 and the level scale (which ranges from 0 to 7) at 3. The cut-points were chosen intrinsically (based on the scale's interpretation) rather than extrinsically (based on the values present in the data, e.g. the median) to be consistent with the subjective job demand dichotomization (see Appendix A).[27,50]

Covariates included age, sex, and health measures. We converted age to a categorical variable in increments (50–55, 56–60, 61–65, 66+). Comorbidity was measured by the number of serious diseases (i.e., high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, and arthritis) diagnosed by a physician.[51] Regression models also included a composite measure of fine motor skills (e.g., picking up a dime, eating), and a composite measure of mobility (e.g., walking several blocks, climbing stairs).

The value of each composite measure represents the number of listed activities with which an individual reported difficulty. The comorbidity count and the mobility and fine motor skills composite measures were generated by RAND using HRS data.[52] Regressions were also adjusted for self-reported hearing and vision, dichotomized as "good" and above versus "fair" and below.[25] Lastly, we included work status (working full-time compared to part-time or semi-retired).

Statistical Analysis

Modified Poisson regression models for binary outcomes[53,54] were used to test the association between objective and subjective job demands and occupational injury in the subsequent time period. We used robust variance estimates[55] and clustered on the level of the individual to account for participants included in multiple study periods. Pearson's goodness-of-fit tests were not significant, suggesting reasonable model fit for Poisson models. Within each domain (physical effort; lifting heavy objects; and stooping, kneeling, crouching), we generated separate models (1) with physical ability alone, (2) with physical ability and subjective job demand, and (3) with physical ability and objective job demand. We compared the information content of each set of models using the Akaike Information Criterion (AIC). AIC provides a means for comparing the fit of models having the same dependent variable, but differing independent variables. A lower score indicates comparatively better fit.[56,57]

We used interaction terms to examine the association between a mismatch between self-reported physical ability and job demand (measured subjectively or objectively) and the risk of occupational injury. Relative risks were reported for each combination of physical ability and job demand: (1) high physical ability/low job demand (reference group), (2) high physical ability/high job demand, (3) low physical ability/low job demand, and (4) low physical ability/high job demand.

All regressions were adjusted for age, sex, number of comorbidities, mobility, fine muscle strength, hearing, eyesight, and working status. Analyses were performed using STATA Version 13.1 (StataCorp, College Station, TX).

RESULTS

Sample description

The linked sample contained data from 7,386 surveys collected from 5,586 individuals. Overall, 313 individuals reported one or more occupational injuries (6%), with a rate of reporting any occupational injury at 22 per 1,000 person-years.

The length of job tenure ranged from 0 to 78 years, with a median of 15 years. Almost all individuals were under age 65 when they entered the study (Table 1). Individuals who sustained at least one occupational injury during the study generally resembled those who did not sustain an injury, with two exceptions— those in younger age categories and who worked full-time were more likely to report an occupational injury (Table 1).

In regression analysis (unadjusted for job demand, occupation, or industry), there were statistically significant associations between occupational injury and age, number of comorbidities, hearing, and working part-time (Appendix B). Workers age 61–65 and 66 and above were at 40% lower risk of occupational injury compared to workers age 50–55.

Job demand and physical ability

As Table 1 displays, results for self-reported physical abilities showed statistically significant differences in percentage injured for large muscle strength, lifting heavy objects, and stooping, kneeling or crouching. Occupational injuries were more common among those who reported low physical ability compared to those who reported high physical ability.

As shown in Figure 2, the mean and quartiles of subjectively-assessed job demands were generally higher than objective assessments from O*NET. Table 2 presents the proportion of individuals with an occupational injury according to job demand metrics within each domain. The proportion of respondents reporting occupational injuries was higher in each case for those with high job demands compared to those with low job demands. There were low, positive correlations (0.03 to 0.37) between subjectively-assessed and objectively-assessed job demands within domains.

Table 3 shows results from models of the association among physical ability, subjective job demand, objective job demand, and occupational injury, adjusted for the health factors in Appendix B, With the exception of physical ability relating to lifting, all job demand and physical ability metrics were significantly associated with occupational injury. For example, within Table 3 model 11, respondents stating that their job required frequent stooping, kneeling or crouching had almost double the risk of occupational injury compared to those stating their job rarely or never required stooping, kneeling or crouching, adjusted for physical ability (and factors listed in Appendix B). Respondents stating they had no difficulty stooping, kneeling or crouching had 36% lower risk of occupational injury, adjusted for subjective job demand (and factors listed in Appendix B). The AIC was lowest in models that included objective job demand for all 3 domains. The coefficient for physical ability was consistent across models that included and that excluded terms for job demand, suggesting that job demand did not have an influence on the importance of physical ability.

Job demand and physical ability interaction

The models presented in Figure 3 shows for each domain a strong, statistically significantly interaction between physical ability and job demand such that, compared to the safest situation (low job demand/high physical ability), individuals with high job demand/low physical ability were at 2.21 to 3.91 times as great a risk of occupational injury. The heavy lifting domain within the subjective job demand metric was an exception- results were in the same direction as for the other domains but not statistically significant.

To assess if low physical ability was associated with higher injury risk compared to high physical ability when job demand was high (comparing a mismatch to a match within job demands), we changed the reference category to those with high job demand/high physical ability. The resultant model showed that compared to those with job demand and physical ability in agreement and both high, those with high job demand but low physical ability had a higher increased risk of occupational injury within the physical effort and stooping, kneeling, or crouching domains, subjective demand and objective demand- level scale metrics (figure 4).

DISCUSSION

In this large cohort of older workers, respondents who reported higher levels of physical ability had lower risk of occupational injury than those who reported lower levels of physical ability. Conversely, people with higher levels of subjective and objective job demands had a higher risk of occupational injury than those with lower levels of subjective and objective job demands. These findings agreed with previous studies using O*NET and other job demand-evaluation systems, which found higher objectively-measured physical job demands to be associated with adverse outcomes, including more costly workers compensation claims,[50] delayed return-to-work,[5] and occupational injury.[27–29] Additionally, results showed a large, statistically significant elevated risk of occupational injury among those with high job demands/low physical ability compared to both high job demand/high ability and low job demand/high physical ability.

Although the importance of matching job demand with physical ability has been hypothesized,[7,8,11,30,33] few studies have examined how occupational injury risk may be associated with a mismatch between physical ability and job demand. Our findings emphasize that in situations of high job demand for physical effort, low physical ability is associated with increased risk of occupational injury, more so than in situations when job demand and physical ability are both high. Efforts to improve the match between occupational demand and physical ability may be particularly important for older adults because of the greater adverse outcomes associated with an occupational injury in that population, though initiatives to ameliorate the effects of a mismatch between job requirements and worker physical ability may benefit workers of all ages.

Within the domain of heavy lifting, the risk of injury was not significantly different in those with high job demand/low ability mismatch compared to those with high job demand and high physical ability, although the same direction of effect was present. It is possible that workers were able to customize their jobs to their own physical abilities within this domain. For example, lifting patients presents a challenge to nurses, a group which compared to other hospital workers, is at higher risk of occupational injury.[58,59] Nurses may avoid manually lifting patients, instead using patient handling equipment or lift teams.[58] Consequently, although lifting is a central requirement of their job, nurses may customize the job demand to their physical abilities.

To ameliorate occupational injury risk when there is a mismatch between the demands of the job and the abilities of the older worker, workplaces can adjust job demand and improve physical health (or slow the rate of health decline). Adjusting job demands can occur through increased mechanization, ergonomic adjustment, or other functional modifications.[7,60] Although this benefits workers of all ages, it may be challenging in some environments and costly (although cost-benefit analyses support such programs[61]). Improvements in physical health can occur through workplace fitness programs and other worker health initiatives.[33] Profession and industry-specific studies across age groups have found a reduction in occupational injury rates after implementation of workplace health promotion programs that focus on exercise, stress reduction, quality of life, and health conditions.[62–64] Although studies theorize these benefits persist among older workers and that physical function can be amply maintained,[22,65–67] systematic reviews on health promotion programs specific to this population found limited evidence and large gaps in the literature.[15,68] As improvements in health among older workers are unlikely to comprehensively erase the change in physical work capacity,[69] approximately a 20% decline from age 40 to 60,[70] occupational safety may benefit from both these types of initiatives.

An additional option was illustrated by a study in which isometric strength tests were used for new manufacturing employees whose jobs required heavy lifting. The subsequent injury rate among new employees of all ages qualified by this method was one third that of employees qualifying by traditional medical exam.[71] Tailoring or creating job qualification exams specifically to frequent or important physical demands could ensure the new worker's ability meets said demands. However, instituting these exams may be ethically and logistically impossible for current workers, a group which represents a sizable contingent within the older worker population. For example, HRS respondents within this study had a mean of 17 years working at their current job. Conversely, workplace health promotion programs and functional modifications may benefit all workers.

Because our study used survey data, older adults were not randomly assigned to retire or work. Known as the healthy worker effect,[7,72] many workers with poor health may have retired while many older workers may have self-selected into jobs they could physically perform.[5] This could be considered self-matching physical ability and job demand.[71] Managerial oversight and responsiveness and environmental modifications have been shown to contribute to making workplaces older-worker friendly.[11,15,22] These same factors may make self-matching possible.

Regarding the comparison of job demand metrics in predicting risk of injury, models with physical ability and objective job demand appeared to fit the data better as indicated by lower AICs compared to models based on physical ability and subjective job demand metrics or physical ability alone. This better fit could reflect the different aspects of job demand measured by subjective and objective job demands. Subjective job demand measures self-rated frequency with which a worker performs a physical action.[52] Within objective job demand, the level scale relates to the required rigor or expertise needed the importance scale to how critical an action is to a job, and the context scale to the regularity of doing an action. It is possible that the self-rated frequency (from subjective demand) is less related to occupational injury risk compared to or how intensively they do it (from the objective demand, level scale) or how central the action is to the job (from objective demand, importance scale). Within the importance scale, greater task-specific importance may make it difficult for the worker to off-load or modify the task if it becomes too physically job demanding to perform safely. Within the level scale, in terms of intensiveness of an action, older adults on average have reduced oxygen uptake[11] which, in association with other changes in health, may impact stamina and physical strength.[10–15,22] High intensity activities may be particularly hazardous for older workers. In terms of injury prevention, the results of the AIC comparison emphasize the need to look beyond frequency of task to intensiveness or importance of a task when considering risk.

Additionally, while models including objective metrics appeared to be more informative than subjective metrics, all models with job demand metrics were more informative than models with physical ability alone. This reinforces the importance of incorporating some objective or subjective measure of job demands, in addition to physical ability, in future research on occupational injuries. Using AIC to compare job demands showed that O*NET can provide demand measures through occupation codes. This study demonstrates that O*NET can be a valuable resource for studies using databases that do not contain measures of job demand. Furthermore, O*NET's wealth of job descriptions provides details on occupational characteristics that may not be otherwise available to researchers.

Strengths and limitations

This study’s strength rests with the links between physical ability and job demand, with the latter measured from the personal (subjective) within HRS and the expert (objective) perspective measured in O*NET. These data sources also limit the study. HRS gathers no data on severity or mechanism of occupational injuries. This limits the ability to make a more detailed assessment of occupational injury risk. Reported injuries were nonfatal but were severe enough to be recalled at the next HRS study visit up to two years later. There is no other measure available to us to classify minor versus major injuries. Due to the potential for recall bias, the exposure data likely capture a higher proportion of severe injuries than minor injuries. While HRS does include data on the number of occupational injuries, we did not use this count as repeated injuries may relate to injury severity (e.g. a person with a minor injury may proceed to have other minor injuries while a person with a very severe injury may not be able to return to work and sustain another injury.

Health measures, including eyesight, hearing, and physical ability were self-reported. While including information about these factors in our models can be considered a study strength, self-reported health measures, notably among older adults, can be inaccurate.[73] Furthermore, some individuals may have changed jobs between the collection of ability, job demand, and occupation title data, and then sustaining an occupational injury in an unrelated job.

Due to the aforementioned healthy worker effect, individuals may self-match their abilities to their job.[71] A reciprocal relationship may also be present, wherein job demand impacts physical health, e.g. a physically demanding job may lead to higher health ratings indicating better health.[7] Additionally, individuals with poor health may be overall less likely select into the workforce, may have shorter tenure in the workforce, and more likely to select out of the workforce.[30,74] Because of these biases, results from this study of working people cannot be generalized to the entire nation's working and non-working population age 50 and above.[72,74,75]

Lastly, HRS and O*NET metrics could have shortcomings with content and structural validity. Although some areas of the objective job demand metrics have been used and validated by other studies (see Appendix A), other objective metrics and the subjective HRS metrics have not. Although most metrics were clearly and narrowly defined, it is possible that the items, individually and when combined by scale, may not fully represent the construct of interest. In addition, O*NET provides exposure ratings for the average worker, based on average assessments. These assessments could misclassify exposure for an individual worker, even if it accurately represents exposure within the job category overall.[76,77]

CONCLUSION

This study suggests that older workers' physical ability and job demand are associated with risk of injury. In particular, mismatch between physical ability and job demand was associated with higher risk of occupational injury. Because older workers are more vulnerable to labor market issues and severe, costly injury,[78] studying these issues within an age-specific context may be important. An examination of the job characteristics associated with injury and the most common physical activities among older workers may also be useful.

Preventing occupational injuries may help to keep workers healthier and active in the workforce, decrease job stress and turnover intent, and increase job satisfaction.[79] Understanding determinants of injury among older adults, and orienting workplace health initiatives accordingly, increases our ability to retain and protect these workers in the workforce.

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Citations

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Appendix A

A list of each grouped physical ability/job demand interplay, subjective job demands from HRS, and objective job demands from O*NET domains response recoding

Domain	HRS physical ability*	HRS Respondent-based subjectively-assessed job demand*	O*NET based objectively-assessed job demand#μ
PHYSICAL EFFORT	"A composite measure of large muscle strength created by RAND. It is the number of activities a respondent has difficulty doing: sitting for 2 hrs., getting up from a chair, stooping, kneeling or crouching, and pushing or pulling large objects. For each activity, 0 meant the respondent had no difficulty with the activity and 1 meant difficulty"∞	*"Individuals respond to the following prompt:* Thinking of your job, please tell me how often this statement is true: My job requires lots of physical effort. 1. all or almost all the time 1. most of the time 0. some of the time 0. none or almost none of the time 0. does not apply Missing (excluded): Don't Know, Not Ascertained, Refused, Inapplicable); Partial Interview"Ω	*"Performing General Physical Activities* — Performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling of materials."[28,72,73] (level and importance scales) *"Dynamic Strength* — The ability to exert muscle force repeatedly or continuously over time. This involves muscular endurance and resistance to muscle fatigue." (level and importance scales) *"Explosive Strength* — The ability to use short bursts of muscle force to propel oneself (as in jumping or sprinting), or to throw an object." (level and importance scales) *"Stamina* — The ability to exert yourself physically over long periods of time without getting winded or out of breath." (level and importance scales) *"Trunk Strength* — The ability to use your abdominal and lower back muscles to support part of the body repeatedly or continuously over time without 'giving out' or fatiguing." (level and importance scales)
LIFTING HEAVY OBJECTS	*"Individuals respond to the following prompt:* Because of a health problem do you have any difficulty with lifting or carrying weights over 10 pounds, like a heavy bag of groceries? 1. no 0. yes 0. can't do 0. don't do Missing (excluded):don't know, refuse, inapplicable"Ω	*"Individuals respond to the following prompt:* Thinking of your job, please tell me how often this statement is true: My job requires lifting heavy loads. 1. all or almost all the time 1. most of the time 0. some of the time 0. none or almost none of the time 0. does not apply Missing (excluded): Don't Know, Not Ascertained, Refused, Inapplicable), Partial Interview"Ω	*"Handling and Moving Objects* — Using hands and arms in handling, installing, positioning, and moving materials, and manipulating things" (importance and level scales) *"Static Strength* — The ability to exert maximum muscle force to lift, push, pull, or carry objects."[28,68,72]. (importance and level scales)

Domain	HRS physical ability*	HRS Respondent-based subjectively-assessed job demand*	O*NET based objectively-assessed job demand#μ
STOOPING, KNEELING, OR CROUCHING	*"Individuals respond to the following prompt:* Because of a health problem do you have any difficulty with stooping, kneeling, or crouching? 1. no 0. yes 0. can't do 0. don't do Missing (excluded): don't know refuse, inapplicable"Ω	*"Individuals respond to the following prompt:* Thinking of your job, please tell me how often this statement is true: My job requires stooping, kneeling, or crouching. 1. all or almost all the time 1. most of the time 0. some of the time 0. none or almost none of the time 0. does not apply Missing (excluded): Don't Know, Not Ascertained, Refused, Inapplicable), Partial Interview"Ω	*"Spend Time Kneeling, Crouching, Stooping, or Crawling* — How much does this job require kneeling, crouching, stooping or crawling?"[28,74,75] (context scale)

*HRS descriptions of job demands for all three subjective job demand descriptions and physical ability for two domains (except for physical effort) came from the HRS codebook.[47] The description of the physical ability for physical effort is quoted from RAND[53]

#O*NET's description of workplace attributes came from the O*NET website[43,76]

μThe context and importance scales from O*NET's objective measures are continuous and dichotomized at 2.5, so that 1.0 to 2.49 can be considered "low frequency/importance" and 2.5 to 5.0 can be considered "high importance" The level scales from O*NET's objective measures is also continuous and dichotomized at 3, so that 0 to 3.0 can be considered "low demand" and 4.01 to 7 can be considered "high demand"

ΩHRS responses represented here were made binary. The coding represented here was assigned by this study and not by the HRS.

∞Responses made binary by dichotomizing at 2 so that *0* to *1* was coded as *1* and *2* through 4 were coded as 0. We chose to dichotomize based on the codebook's listed possible responses rather than individuals' responses (e.g. using the mean or median) to generate a metric extrinsic to the data, consistent with other metric.

Appendix B

Multivariate base model of covariates and their association with occupational injury in subsequent injury.

	relative risk	95% CI		p-value
Comorbidities (count)	1.18	1.08	1.30	<0.01
Female (vs. male)	0.89	0.72	1.11	0.32
Difficulty with mobility	0.93	0.58	1.51	0.78
Difficulty with fine motor skills	0.83	0.28	2.48	0.74
Hearing*	0.67	0.51	0.88	<0.01
Eyesight^	1.07	0.80	1.43	0.64
Work part-time ((reference: full-time)	0.68	0.51	0.90	<0.01
Age (yrs.)				<0.01
50–55	reference			
56–60	0.87	0.68	1.12	
61–65	0.40	0.26	0.62	

	relative risk	**95% CI**		**p-value**
66+	0.40	0.27	0.61	

This table does not include primary variables of interest (e.g. physical ability and job demand)

*excellent-very good-good vs. fair poor-legally deaf (reference)

^excellent-very good-good vs. fair poor-legally blind (reference)

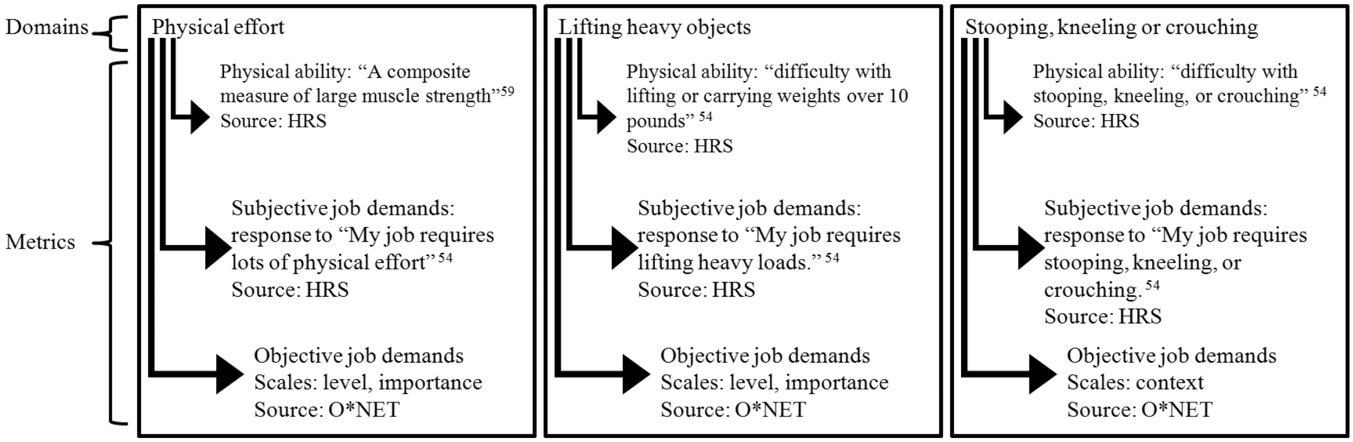

Figure 1.

Diagram of the relationships between data and key phraseology used

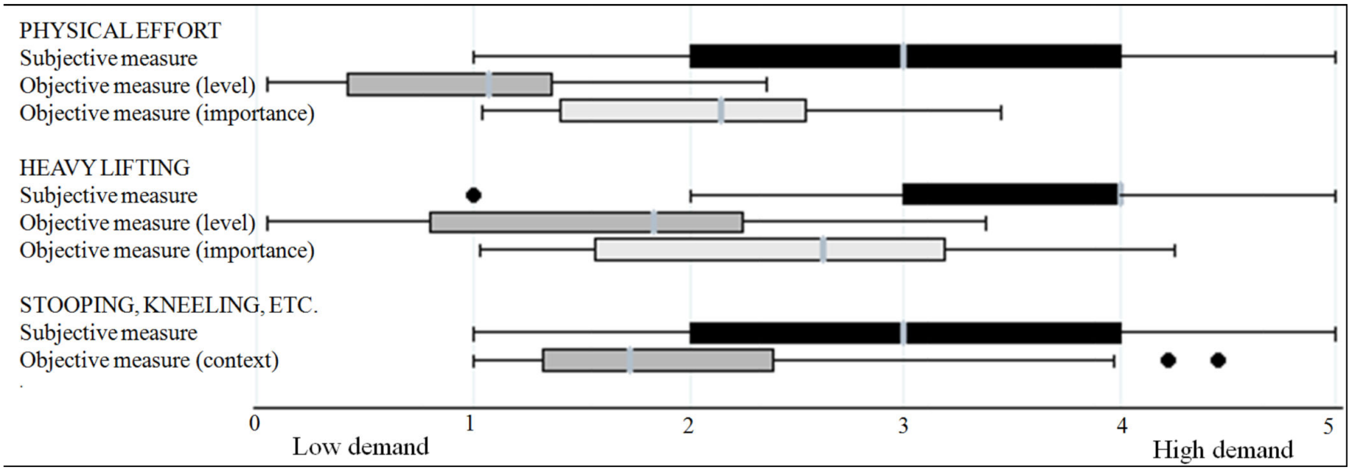

Figure 2.

Box plot of the distribution of job demand metrics, subjective and objective

The level scale ranges from 0 to 7 on O*NET. In order for it to align with the other metrics here, which use a 1 to 5 range, it has been recalibrated.

These metrics were dichotomized within the analysis. They were presented here to show the range and differences in responses.

	subjective job demand		objective job demand (level scale)		objective job demand (importance scale)		objective job demand (context scale)	
	high job demand	low job demand	high job demand	low job demand	high job demand	low job demand	high job demand	low job demand
PHYSICAL EFFORT								
High physical ability	2.25*	reference	1.80*	reference	1.96*	reference	n/a	n/a
Low physical ability	3.60*	1.69*	3.91*	1.78*	2.72*	2.11*	n/a	n/a
LIFTING HEAVY OBJECTS								
High physical ability	1.46	reference	2.23*	reference	2.32*	reference	n/a	n/a
Low physical ability	1.90	1.80*	2.21*	2.12*	2.40*	2.32*	n/a	n/a
STOOPING, KNEELING, OR CROUCHING								
High physical ability	2.00*	reference	n/a	n/a	n/a	n/a	2.07*	reference
Low physical ability	2.94*	1.65*	n/a	n/a	n/a	n/a	2.26*	1.96*

Figure 3.

Table of relative risk of occupational injury associated with the interaction between job demand and concomitant physical ability compared to high physical ability/low job demand (a mismatch between physical ability and job demand), adjusted for health factors

All models were adjusted for the variables in Appendix B

*statistically significant (p-value <0.05) relative risk compared to "high physical ability/low job demand"

	subjective job demand		objective job demand (level scale)		objective job demand (importance scale)		objective job demand (context scale)	
	high job demand	low job demand	high job demand	low job demand	high job demand	low job demand	high job demand	low job demand
PHYSICAL EFFORT								
High physical ability	reference	**0.45***	reference	**0.56***	reference	**0.51***	n/a	n/a
Low physical ability	**1.61***	0.74	**2.17***	0.99	**1.39**	1.08	n/a	n/a
LIFTING HEAVY OBJECTS								
High physical ability	reference	**0.56***	reference	**0.45***	reference	**0.43***	n/a	n/a
Low physical ability	**1.06***	0.81	**0.99***	0.95	**1.03***	1.00	n/a	n/a
STOOPING, KNEELING, OR CROUCHING								
High physical ability	reference	**0.50***	n/a	n/a	n/a	n/a	reference	**0.48***
Low physical ability	**1.47***	0.82	n/a	n/a	n/a	n/a	**1.09**	0.95

Figure 4.

Table of relative risk of occupational injury associated with the interaction between job demand and concomitant physical ability compared to high physical ability/high job demand (a match between physical ability and job demand), adjusted for health factors

All models were adjusted for the variables in Appendix B

*statistically significant (p-value <0.05) relative risk compared to "high physical ability/high job demand"

Table 1

Survey respondent characteristics at study entry, comparing those who sustained an occupational injury at some time during the study years to those who never sustained an occupational injury

Health, demographic, and work characteristics				
	Sample size (N=5,586)	No injury (N=5,273)	Injured (N=313)	p-value^
Age at first year of study inclusion				p<0.01
50–55	2,156	92.95%	7.05%	
56–60	1,622	93.65%	6.35%	
61–65	782	97.19%	2.81%	
66+	1,026	96.49%	3.51%	
Sex				0.22
Male	2,776	94.02%	5.98%	
Female	2,810	94.77%	5.23%	
Hearing				0.16
Excellent-very good- good	4,836	93.32%	6.68%	
Fair poor-legally deaf	750	94.58%	5.42%	
Eyesight				0.29
Excellent-very good-good	4,569	93.73%	6.27%	
Fair poor-legally blind	1,017	94.54%	5.46%	
Count of medical conditions *				0.11
0	1,655	94.68%	5.32%	
1	1,787	95.24%	4.76%	
2+	2,144	93.47%	6.53%	
Difficulty with mobility $^{\Omega}$				0.21
Difficulty with 0 to 2 activities	5,312	94.48%	5.52%	
Difficulty with 3 to 5 activities	274	92.70%	7.30%	
Difficulty with fine motor skills $^{\mu}$				0.91
Difficulty with 0 to1 activities	5,553	99.41%	99.36%	
Difficulty with 2 to 3 activities	33	93.94%	0.64%	
Working status				<0.01
Full-time	3,683	93.65%	6.35%	
Part-time	1,903	95.85%	4.15%	
Physical ability $^{\infty}$				
Difficulty with large muscle strength #				<0.01
Difficulty with 0 to 1 activities	4,312	95.11%	4.89%	
Difficulty with 2 to 4 activities	1,274	91.99%	8.01%	
Difficulty lifting heavy objects				0.01
No difficulty	5,047	94.65%	5.35%	
Yes difficulty	539	92.01%	7.99%	

Health, demographic, and work characteristics				
	Sample size (N=5,586)	**No injury (N=5,273)**	**Injured (N=313)**	**p-value^**
Difficulty stooping, kneeling, or crouching				<0.01
No difficulty	3,892	95.25%	4.75%	
Yes difficulty	1,694	92.55%	7.45%	

^ p-value represents the results of a chi-squared test of homogeneity

* This is a composite measure of how many diseases the respondent has ever been diagnosed with by a doctor. Diseases include high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, and arthritis

Ω This is a composite measure of mobility. It is the number of activities a respondent has difficulty doing: walking a block, walking several blocks, walking across a room, climbing a flight of stairs, and climbing several flights of stairs.

μ This is a composite measure of fine muscle strength. It is the number of activities a respondent has difficulty doing: picking up a dime, eating, and dressing activities.

∞ High physical ability includes “no difficulty” and “difficulty with 0 to 1 items.” Low physical ability includes “yes difficulty” and “difficulty with 2 to 4 items.”

This is a composite measure of large muscle strength. It is the number of activities a respondent has difficulty doing: sitting for 2 hrs., getting up from a chair, stooping, kneeling or crouching, and pushing or pulling large objects.

Table 2

Percent of respondents with an occupational injury by job demand

	Physical domain					
	Physical effort		**Lifting heavy objects**		**Stooping, kneeling, or crouching**	
Demand metrics	**low job demand**	**high job demand**	**low job demand**	**high job demand**	**low job demand**	**high job demand**
HRS Respondent-based subjectively-assessed job demand	4%	9%	5%	9%	5%	9%
O*NET-based objectively-assessed job demand						
level scale	5%	12%	4%	8%	N/A	N/A
importance scale	5%	8%	4%	7%	N/A	N/A
context scale	N/A	N/A	N/A	N/A	5%	8%

Table 3

Comparison of models, adjusted for covariates in Appendix B (i.e. comorbidities, sex, difficulty with mobility, difficulty with fine motor skills, hearing, eyesight, age, and working status)

Physical ability and job demand by domain*			RR	95% CI			P-value	AIC
BASE MODEL	Model 1: Job demand or physical abilities metrics not included		NA	NA		NA	NA	2624
PHYSICAL EFFORT	Model 2:	High physical ability*	0.57	0.44	,	0.74	<0.01	2609
	Model 3:	High physical ability*	0.62	0.48	,	0.80	<0.01	2490
		High subjective job demand$^{\Omega}$	2.22	1.76	,	2.80	<0.01	
	Model 4:	High physical ability*	0.55	0.42	,	0.71	<0.01	2484
		Objective job demand (level scale)$^{\Omega}$	1.91	1.29	,	2.84	<0.01	
	Model 5:	High physical ability*	0.56	0.43	,	0.73	<0.01	2473
		Objective job demand (importance scale)$^{\Omega}$	1.70	1.35	,	2.15	<0.01	
LIFTING HEAVY OBJECTS	Model 6:	High physical ability*	0.73	0.51	,	1.04	0.08	2623
	Model 7:	High physical ability*	0.74	0.52	,	1.07	0.11	2535
		High Subjective job demand$^{\Omega}$	1.72	1.35	,	2.17	<0.01	
	Model 8:	High physical ability*	0.71	0.50	,	1.03	0.07	2474
		High Objective job demand (level scale)$^{\Omega}$	2.00	1.58	,	2.53	<0.01	
	Model 9:	High physical ability*	0.72	0.50	,	1.04	0.08	2472
		Objective job demand (importance scale)$^{\Omega}$	2.07	1.61	,	2.65	<0.01	
STOOPING, KNEELING, OR CROUCHING	Model 10:	High physical ability*	0.64	0.50	,	0.81	<0.01	2602
	Model 11:	High physical ability*	0.64	0.50	,	0.81	<0.01	2501
		High Subjective job demand$^{\Omega}$	1.91	1.52	,	2.40	<0.01	
	Model 12:	High physical ability*	0.62	0.48	,	0.79	<0.01	2465
		High Objective job demand (context scale)$^{\Omega}$	1.65	1.29	,	2.11	<0.01	

All models were adjusted for the variables in Appendix B

*reference group: low physical ability

[a] reference group: low job demand