Routledge
Taylor & Francis Group

Archives of Environmental & Occupational Health

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/vaeh20

Association between physical limitations and working life exposure to carrying heavy loads assessed using a job-exposure matrix: CONSTANCES cohort

Laure Ngabirano, Marc Fadel, Annette Leclerc, Bradley A. Evanoff, Ann Marie Dale, Angelo d'Errico, Yves Roquelaure & Alexis Descatha

To cite this article: Laure Ngabirano, Marc Fadel, Annette Leclerc, Bradley A. Evanoff, Ann Marie Dale, Angelo d'Errico, Yves Roquelaure & Alexis Descatha (2021) Association between physical limitations and working life exposure to carrying heavy loads assessed using a job-exposure matrix: CONSTANCES cohort, Archives of Environmental & Occupational Health, 76:5, 243-247, DOI: 10.1080/19338244.2020.1819184

To link to this article: https://doi.org/10.1080/19338244.2020.1819184

Published online: 16 Sep 2020.

ARCHIVES OF ENVIRONMENTAL & OCCUPATIONAL HEALTH
2021, VOL. 76, NO. 5, 243–247
https://doi.org/10.1080/19338244.2020.1819184

BRIEF REPORT

Association between physical limitations and working life exposure to carrying heavy loads assessed using a job-exposure matrix: CONSTANCES cohort

Laure Ngabirano[a,b], Marc Fadel[b,c], Annette Leclerc[b], Bradley A. Evanoff[d], Ann Marie Dale[d], Angelo d'Errico[e], Yves Roquelaure[a], and Alexis Descatha[a,b,c]

[a]Univ Angers, CHU Angers, Univ Rennes, Inserm, EHESP, Irset (Institut de recherche en santé, environnement et travail) - UMR_S 1085, CAPTV CDC, Angers, France; [b]Versailles St-Quentin Univ, Paris Saclay Univ, Inserm, U1018, UMS011, Villejuif, France; [c]AP-HP, UVSQ, Unité Hospitalo-Universitaire de Santé professionnelle Hôpitaux Universitaires de Paris Ile-de-France Ouest, site Raymond Poincaré, Garches, France; [d]Division of General Medical Sciences, Washington University School of Medicine in St. Louis, St Louis, USA; [e]Local Health Unit TO3, Epidemiology Department - Piedmont Region, Italy

ABSTRACT
Introduction: Decline in physical performance with age varies among workers. We studied the association between lifetime exposure to carrying heavy loads and limitations in climbing stairs.
Methods: We used data from the French CONSTANCES study. A biomechanical Job-Exposure Matrix (JEM) was combined with lifetime job histories to build a cumulative exposure score, and compared with reported limitations in climbing stairs using robust Poisson models, stratified by sex and educational level.
Results: Of the 26,255 subjects, 618 men and 1,080 women reported difficulties in climbing stairs; this outcome was associated with cumulative exposure to carrying heavy loads: adjusted PR= 2.17 (1.75-2.73) for men, 1.50 (1.30-1.74) for women. The association was primarily seen among less educated subjects.
Conclusion: Cumulative work exposure to carrying heavy loads across the working life was associated with physical limitations in climbing stairs among the less educated in both genders.

ARTICLE HISTORY
Received 7 November 2019
Accepted 8 August 2020

KEYWORDS
epidemiology; job-exposure matrix; work disability; physical exposure; physical limitation

Introduction

Decline of physical performance at early old age is a major issue, as workers begin to delay retirement age. A literature search of the predictors of functional physical performance decline found socio-economic differences.[1–3] In an Italian cohort study, having a work history of only manual work was associated with low physical function among workers aged 80 or more, after adjustment for sociodemographic, personal, behavioral, and health factors, which suggests that working conditions might help explaining this social inequity.[4] In another study among electrical and gas workers, there were differences in self-reported physical limitations between men and women associated with perceived physical strain at work.[5]

Retrospective assessment of biomechanical exposure remains problematic,[6] and recall-based measures often lead to misclassification of the exposure. Exposure assessment may be especially problematic in studies of older individuals (>65years) or workers who already suffer from chronic comorbidities that decrease their physical function. The purpose of this study was to investigate the relationship between workers' lifetime occupational exposure to heavy physical loads and their current physical limitations represented by difficulty in climbing stairs. The study was conducted in a large, nationally representative population sample; cumulative physical exposures were assessed using a Job-Exposure Matrix (JEM).[7]

Methods

CONSTANCES is a population-based prospective cohort which includes more than 200,000 participants between 18 to 69 years of age who were randomly recruited from 2012 to 2019 among people covered by the French National Health Insurance.[8] Data of

CONTACT Laure Ngabirano laure.ngabirano@inserm.fr Inserm U1018, Equipe d'Epidémiologie Respiratoire Intégrative, CESP, 16 Avenue Paul Vaillant Couturier, 94807 Villejuif cedex, France.

Table 1. Association between lifetime exposure to carrying heavy loads and limitation in climbing stairs for men and women.

	Total	No limitation, n (%)	Limitation, n (%)	PR (CI 95%)-Crude	PR (CI 95%)-Exposure adjusted on age and BMI
Men	12,419	11,801 (95.0)	618 (5.0)		
Carrying heavy loads					
Not exposed	3950	3848 (97.4)	102 (2.6)	–	–
Moderately exposed	3499	3336 (95.3)	163 (4.7)	1.80 (1.41-2.32)	1.99 (1.56–2.57)
Strongly exposed	4970	4617 (92.9)	353 (7.1)	2.75 (2.22–3.44)	2.17 (1.75–2.73)
Age (years): mean (sd)	49 (12.9)	49 (13.0)	55 (10.8)	1.04 (1.03–1.05)	1.03 (1.02–1.04)
BMI (kg/m^2)					
Normal weight [18,5–25[	5681	5511 (97.0)	170 (3.0)	–	–
Overweight [25–30[	5127	4866 (94.9)	261 (5.1)	1.70 (1.40–2.07)	1.35 (1.11–1.65)
Obese (≥30)	1611	1424 (88.4)	187 (11.6)	3.88 (3.15–4.78)	2.83 (2.29–3.50)
Women	13,836	12,756 (92.2)	1080 (7.8)		
Carrying heavy loads					
Not exposed	6182	5814 (94.0)	368 (6.0)	–	–
Moderately exposed	4531	4184 (92.3)	347 (7.7)	1.29 (1.11–1.49)	1.44 (1.24–1.68)
Strongly exposed	3123	2758 (88.3)	365 (11.7)	1.96 (1.70–2.27)	1.50 (1.30–1.74)
Age (years): mean (sd)	48 (13.0)	48 (13.0)	54 (11.5)	1.04 (1.03–1.05)	1.03 (1.03–1.04)
BMI (kg/m^2)					
Normal weight [18,5–25[	8653	8281 (95.7)	372 (4.3)	–	–
Overweight [25–30[	3453	3124 (90.5)	329 (9.5)	2.22 (1.91–2.57)	1.90 (1.64–2.21)
Obese (≥30)	1730	1351 (78.1)	379 (21.9)	5.10 (4.42–5.88)	4.24 (3.66–4.90)

n: number, %: percent, PR: prevalence ratio, CI: confidence intervals, BMI: Body mass index, sd: Standard error.

interest were collected from the baseline self-administered questionnaires and health examinations conducted in 21 regional Health Screening Centers. Questionnaires included a variety of health outcomes and a history of all past jobs held.

At the time of analysis, lifetime job histories had been coded for 28,195 participants. We excluded 5% of the subjects due to missing data on parameters of interest and 2% of participants who were underweight (BMI $< 18.5\,kg/m^2$) because low BMI may be associated with severe chronic disease and death.[9] The final subsample included 26,255 participants.

Job exposure estimates were obtained from a job-exposure matrix. "JEM CONSTANCES" was developed from a different subsample of 35,526 currently employed participants from the CONSTANCES cohort.[7] The tool was created by pooling individual reports of 27 self-reported current workplace physical exposures at the level of 407 different job titles using the French 4-digit PCS2003 (Profession et Catégorie Sociale) codes. The bias-corrected mean metric gave a better within-job and between-job variances, and was used to estimate exposure for other workers. Carrying heavy loads (from 10 to 25 kg) was one of these exposures. It was based on answers to the questions: "During a typical working day, are you required to regularly handle, move or bear a load, part, or object weighing more than 1 kg?" and if yes, "how much time do you spend carrying weight between 10 and 25 kg?". Answers included: 1 = [Never or nearly never]; 2 = [Rarely (< 2 hours per day)]; 3 = [Often (2 to 4 hours per day)]; 4 = [Always or nearly always], and 0 was coded if the first question was not mentioned "yes". Then, using each participant's lifetime job history (1950-2019) and the JEM, we assigned an exposure rating to each job held and calculated a cumulative exposure score during their full working life. The score was computed by the sum of the exposure rating (0-4) times the number of years worked for each job title. The cumulative exposure score was categorized into 3 groups: "unexposed" (score = 0), "moderately exposed" (exposure below the median score among all those exposed, i.e. all scores > 0), and "strongly exposed" (score above the median score among the exposed). Categorizing into 3 groups is consistent with methods suggested in other studies,[10] and a threshold at the median allowed us to maximize statistical power.

The outcome was a reported limitation in climbing stairs, measured on a 4-point scale as follows: "Are you able to walk up or down a flight of stairs alone?" Responses were a) Yes, without difficulty; b) Yes, but with some difficulty; c) Yes, but with significant difficulty; d) No. In this study, no limitation for climbing stairs ("Yes, without difficulty") was compared to any reported limitation (all other responses grouped due to small numbers in categories c and d).

We included sociodemographic and clinical factors in the analysis (sex, age, body mass index (BMI) in kg/m^2, and educational level). We assessed age as a continuous value. BMI was defined in 3 categories: normal weight [18.5-25 kg/m^2], overweight [25-30 kg/m^2], and obese (≥ 30 kg/m^2). Educational level was defined in three levels: <bachelor's degree, bachelor's degree, and master's degree or higher.

We used robust Poisson regression models in order to estimate prevalence ratios[11] to assess associations between lifetime physical work exposures and limitation in stair climbing. Crude and adjusted models were

Table 2. Association between lifetime exposure to carrying heavy loads and limitation in climbing stairs for men and women, for different educational levels.

	< Bachelor's degree				≥ Bachelor's degree				≥ Master's degree			
	No limitation, *n* (%)	Limitation, *n* (%)	PR (CI 95%)—Crude	PR (CI 95%)—Exposure adjusted on age and BMI	No limitation, n (%)	Limitation, n (%)	PR (CI 95%)—Crude	PR (CI 95%)—Exposure adjusted on age and BMI	No limitation, n (%)	Limitation, n (%)	PR (CI 95%)—Crude	PR (CI 95%)—Exposure adjusted on age and BMI
Men, Carrying heavy loads	*n* = 4085				*n* = 4638				*n* = 3696			
Not exposed	245 (97.2)	7 (2.8)	–	–	1102 (96.9)	35 (3.1)	–	–	2501 (97.7)	60 (2.3)	–	–
Moderately exposed	692 (89.4)	82 (10.6)	3.81 (1.90–9.09)	4.55 (2.25–10.87)	1756 (97.1)	53 (2.9)	0.95 (0.62–1.47)	1.23 (0.80–1.93)	888 (96.9)	28 (3.1)	1.30 (0.82–2.02)	1.40 (0.88–2.18)
Strongly exposed	2792 (91.3)	267 (8.7)	3.14 (1.61–7.37)	3.27 (1.67–7.67)	1614 (95.4)	78 (4.6)	1.50 (1.01–2.26)	1.41 (0.95–2.13)	211 (96.3)	8 (3.7)	1.56 (0.69–3.07)	1.17 (0.51–2.31)
Women, Carrying heavy loads	*n* = 3603				*n* = 6537				*n* = 3696			
Not exposed	780 (89.1)	95 (10.9)	–	–	2570 (93.6)	177 (6.4)	–	–	2464 (96.2)	96 (3.8)	–	–
Moderately exposed	936 (84.9)	167 (15.1)	1.39 (1.09–1.80)	1.46 (1.13–1.89)	2328 (94.2)	143 (5.8)	0.90 (0.72–1.12)	1.21 (0.96–1.53)	920 (96.1)	37 (3.9)	1.03 (0.70–1.49)	1.16 (0.78–1.69)
Strongly exposed	1365 (84.0)	260 (16.0)	1.47 (1.17–1.87)	1.45 (1.15–1.85)	1218 (92.3)	101 (7.7)	1.19 (0.93–1.51)	1.11 (0.87–1.42)	175 (97.8)	4 (2.2)	0.60 (0.18–1.42)	0.42 (0.13–1.01)

n: number, %: percent, PR: prevalence ratio, CI: confidence intervals, BMI: Body mass index.

carried out separately for men and women. Additional models by sex were stratified by educational level, a determinant of social position related to occupational exposure.[12]

All analyses were performed using R version 4.0.1 software (stats package).

Results

Of the 26,255 participants (12,419 men, 13,836 women), 5.0% of men (n = 618) and 7.8% of women (n = 1,080) reported difficulties in climbing stairs. Men and women with limitations in climbing stairs were more likely to have a lower education level (57.6% vs 48.3% respectively).

The cumulative exposure score was from 0 to 200. 38.6% of participants had a score equal to 0 and the median score among exposed subjects (score >0) was 18.5. This median score was used to separate "moderately" and "strongly" exposed.

Among men moderately exposed and men strongly exposed, 4.7% and 7.1% reported limitations in climbing stairs, respectively. Likewise, among women moderately exposed and strongly exposed, 7.7% and 11.7% reported limitations (Table 1). In all models, cumulative exposure to carrying heavy loads at work was associated with a limitation in climbing stairs.

When stratifying by educational level (Table 2), these associations were only found among less educated subjects.

Discussion

Overall, this study showed a positive association between cumulative occupational exposure to carrying heavy loads and limitations in climbing stairs mainly among less educated subjects. The modifying effect of education suggests that workplace contextual factors, such as higher job control or greater number of pauses, may moderate the effect of carrying heavy loads among workers with higher education.

The study had several strengths. The large sample from the CONSTANCES cohort is representative of all workers in France. The assessment of cumulative workplace physical exposures using a JEM avoids potential bias from recall of past jobs, and bias from only assessing current physical exposures, which may be markedly different from exposures in past jobs. There are several limitations. The outcome is self-reported and not an objective measure of limitations in climbing stairs. However, a previous study in the CONSTANCES cohort of persons over 45 years showed good agreement between self-reported limitations, such as climbing stairs and physical capacity, with objectively measured gait speed and hand grip.[13] We only used one occupational exposure to represent heavy physical work, and results might be different for other exposures. Our analyses controlled for some personal factors but did not account for alcohol and tobacco consumption, cardiovascular risk factors, and other disorders that have been associated with physical limitations in other studies. Given that we assessed the health outcome at only one time point, we cannot assess the potential impacts of a healthy survivor effect or reverse causality in our results. As prospective follow-up data from the CONSTANCES cohort become available, additional analyses examining these effects, additional potential confounders, additional data points, and assessing the potential pathways through which cumulative physical exposures may influence reduced physical ability should be pursued.

Though this study is the first to examine cumulative exposure to heavy work across the entire work life, some previous studies have shown association between biomechanical exposures at work and physical limitations. Among 364 subjects enrolled in a prospective cohort study performed in Italy, manual workers had significantly worse physical function after adjustment for potential confounders.[4] In France, 9,326 participants without physical limitations in 1989 were followed until 2012, and limitations in daily activities after retirement were associated with physically arduous working conditions preretirement.[5] Similarly to what we found, two nationally representative samples of subjects born in 1948 and 1953 in Sweden (22,889 participants in total) were linked to information from social insurance records on cause and date of disability pension. The authors found that high physical strain at work contributed to associations between low educational levels and disability pensions in multivariable models.[14]

A unique aspect of this study was the use of a JEM to provide an unbiased consistent assessment of biomechanical exposures across lifetime working histories; this approach has the potential for many interesting future applications to assess cumulative exposures based on job titles.[15] One limitation is that JEM exposures do not account for individual variation of exposures within the same job and so may underestimate the true relationship between exposure and symptomatic disorders.[16] However, by providing an estimate of past exposure unbiased by disease status, JEM exposures may avoid overestimation of exposure associated with recall bias when considering individual self-reported exposures, and thus provide a better estimate of true associations.[17]

In summary, this study found that cumulative occupational exposure to carrying heavy loads across the working life was associated with physical limitations in climbing stairs for less educated men and women. Future studies examining the long-term relationships, potential mechanisms of heavy physical work, premature disability, or other potential confounders like non-occupational physical activities, are important given the aging workforce and delayed retirement of workers in industrialized countries, and may help guide targeted health programs.

Disclosure statement

None declared. Authors are paid by their institutions. Alexis Descatha is also paid as Editor-in-chief by Elsevier Masson and is associate editor of Archives of Environmental and Occupational Health (did not take part in the review process).

Ethics

All participants signed informed consent. The protocol of the CONSTANCES study (http://www.constances.fr/) was approved by the Comité consultatif pour le traitement des informations relatives à la santé (CCTIRS) and the Commission Nationale de l'Informatique et Liberté (CNIL).

Funding

This study was supported by IReSP, CapaciT project (Institute for research in public health, in French- http://www.iresp.net/). The CONSTANCES Cohort Study was supported and funded by the Caisse nationale d'assurance maladie (CNAM). The CONSTANCES Cohort Study is an "Infrastructure nationale en Biologie et Santé" and benefits from a grant from ANR (ANR-11-INBS-0002) and from the Ministry of Research. CONSTANCES is also partly funded by MSD, AstraZeneca and Lundbeck by Inserm-Transfert.

ORCID

Marc Fadel http://orcid.org/0000-0002-1554-0021
Alexis Descatha http://orcid.org/0000-0001-6028-3186

References

1. Guillemin F, Carruthers E, Li LC. Determinants of MSK health and disability-social determinants of inequities in MSK health. *Best Pract Res Clin Rheumatol.* 2014;28(3):411–433. doi:10.1016/j.berh.2014.08.001.

2. Li CY, Wu SC, Wen SW. Longest held occupation in a lifetime and risk of disability in activities of daily living. *Occup Environ Med*. 2000;57(8):550–554. doi:10.1136/oem.57.8.550.
3. Plouvier S, Carton M, Cyr D, et al. Socioeconomic disparities in gait speed and associated characteristics in early old age. *BMC Musculoskelet Disord*. 2016;17:178doi:10.1186/s12891-016-1033-8.
4. Russo A, Onder G, Cesari M, et al. Lifetime occupation and physical function: a prospective cohort study on persons aged 80 years and older living in a community. *Occup Environ Med*. 2006;63(7):438–442. doi:10.1136/oem.2005.023549.
5. Descatha A, Herquelot E, Carton M, et al. Is physically arduous work associated with limitations after retirement? Findings from the GAZEL cohort. *Occup Environ Med*. 2016;73(3):183–186. doi:10.1136/oemed-2015-103130.
6. Leclerc A. Exposure assessment in ergonomic epidemiology: is there something specific to the assessment of biomechanical exposures?. *Occup Environ Med*. 2005;62(3):143–144. doi:10.1136/oem.2004.017889.
7. Evanoff BA, Yung M, Buckner-Petty S, et al. The CONSTANCES job exposure matrix based on self-reported exposure to physical risk factors: development and evaluation. *Occup Environ Med*. 2019;76(6):398–406. doi:10.1136/oemed-2018-105287.
8. Goldberg M, Carton M, Descatha A, CONSTANCES team, et al. CONSTANCES: a general prospective population-based cohort for occupational and environmental epidemiology: cohort profile. *Occup Environ Med*. 2017;74(1):66–71. doi:10.1136/oemed-2016-103678.
9. Bhaskaran K, Dos-Santos-Silva I, Leon DA, Douglas IJ, Smeeth L. Association of BMI with overall and cause-specific mortality: a population-based cohort study of 3·6 million adults in the UK. *Lancet Diabetes Endocrinol*. 2018;6(12):944–953. doi:10.1016/S2213-8587(18)30288-2.
10. Palmer KT. Carpal tunnel syndrome: The role of occupational factors. *Best Pract Res Clin Rheumatol*. 2011;25(1):15–29. doi:10.1016/j.berh.2011.01.014.
11. Deddens JA, Petersen MR. Approaches for estimating prevalence ratios. *Occup Environ Med*. 2008;65(7):501–506. doi:10.1136/oem.2007.034777.
12. Leclerc A, Gourmelen J, Chastang J-F, Plouvier S, Niedhammer I, Lanoë J-L. Level of education and back pain in France: the role of demographic, lifestyle and physical work factors. *Int Arch Occup Environ Health*. 2009;82(5):643–652. doi:10.1007/s00420-008-0375-4.
13. Amiard V, Libert J-P, Descatha A. Is there an accurate relationship between simple self-reported functional limitations and the assessment of physical capacity in early old age?. *PLoS ONE*. 2019;14(3):e0211853doi:10.1371/journal.pone.0211853.
14. Falkstedt D, Backhans M, Lundin A, Allebeck P, Hemmingsson T. Do working conditions explain the increased risks of disability pension among men and women with low education? A follow-up of Swedish cohorts. *Scand J Work Environ Health*. 2014;40(5):483–492. doi:10.5271/sjweh.3441.
15. Sirén M, Viikari-Juntura E, Arokoski J, Solovieva S. Physical and psychosocial work exposures as risk factors for disability retirement due to a shoulder lesion. *Occup Environ Med*. 2019;76(11):793–800. doi:10.1136/oemed-2019-105974.
16. Bouyer J, Hémon D. [Job-exposure matrices. *Rev Epidemiol Sante Publique*. 1994;42(3):235–245.].
17. Viikari-Juntura E, Rauas S, Martikainen R, et al. Validity of self-reported physical work load in epidemiologic studies on musculoskeletal disorders. *Scand J Work Environ Health*. 1996;22(4):251–259. doi:10.5271/sjweh.139.