



Association of occupational physical activity and disability pension in 756,159 Spanish workers: A prospective cohort study with 13 years follow-up

Rubén López-Bueno^{a,b,c}, Lars Louis Andersen^b, Joaquín Calatayud^{b,c,*}, José Casaña^c,
Begoña Martínez-Jarreta^d, José Francisco López-Gil^e, Borja del Pozo Cruz^f

^a Department of Physical Medicine and Nursing, University of Zaragoza, Zaragoza, Spain

^b National Research Centre for the Working Environment, Copenhagen, Denmark

^c Exercise Intervention for Health Research Group (EXINH-RG), Department of Physiotherapy, University of Valencia, Valencia, Spain

^d Faculty of Medicine, University of Zaragoza, Zaragoza, Spain

^e Health and Social Research Center, Universidad de Castilla-La Mancha, Cuenca, Spain

^f Centre for Active and Healthy Ageing, Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

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ABSTRACT

Recent research from Nordic countries identified occupational physical activity (OPA) as a risk factor for disability pension, but further research accounting for exhaustive analyses in novel populations is warranted. Our objective was to assess the association between OPA and disability pension using administrative data. This prospective registry-based cohort study used data from the Spanish Continuous Working Life Sample (CWLS). Participants were followed up from baseline (January 1, 2006) to first event of disability pension, mortality, or end of follow-up (September 1, 2019). The assessment of OPA was based on registers of economic activity and their correspondence with a validated OPA index. To examine the association between OPA and disability pension, adjusted proportional hazard, and Fine-Gray models using mortality as competing risk were conducted. We retrieved data from 756,159 workers (57.7% men) with an average age of 38.5 years (SD 11.9). During 13.6 years from baseline to the end of follow-up (9,463,041 person-years), 18,191 men (4.2%) and 9631 (3.0%) women received a disability pension. In the fully adjusted model, participants exposed to higher levels of OPA showed higher risk for disability pension in an exposure-response fashion. Men and women exposed to very high OPA showed the highest HR for disability pension (2.31 [95% CI, 2.17 to 2.46] and 1.68 [95% CI, 1.56 to 1.81], respectively). These results warrant preventative measures to address early involuntary exit from the labour market in workers exposed to high physical work demands.

1. Introduction

Disability pension is a social transfer payment received by an employee on temporary or permanent exclusion from working life before the normal age of retirement because of markedly reduced work ability due to severe health problems or work-related injuries (e.g., cardiovascular diseases, cancer, musculoskeletal disorders, or other injuries) (Falkstedt et al., 2021; Jääskeläinen et al., 2016). According to a recent report from the World Bank Group, the cost of disability pensions in countries from the European Union is on the rise due to the ageing of the population and the increase of chronic conditions, which represents a challenge for welfare systems (Wiener et al., 2017). In Spain alone, the

cost of disability pension has increased steadily over the last decade, and is currently estimated in 945 millions of euros per month (Ministerio de Empleo y Seguridad Social, 2021). Therefore, it is critical to identify factors that can increase the risk for premature exit from work and disability pension.

On the other hand, different levels of occupational physical activity (OPA, defined as physical activity during the working hours) have been observed in workers depending on their occupations (e.g., workers from agricultural occupations usually experience higher levels of OPA in comparison with those in administrative functions) (Proper and Hildebrandt, 2006). Importantly, OPA has been recently highlighted as a potential risk factor for major adverse cardiovascular events and early

* Corresponding author at: Department of Physiotherapy, University of Valencia, 46010 Valencia, Spain.

E-mail address: joaquin.calatayud@uv.es (J. Calatayud).

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mortality (Holtermann et al., 2021). However, according to an umbrella review on the topic by Cillekens and co-workers (Cillekens et al., 2020) OPA would still provide beneficial effects to a wide-range of examined health outcomes, including several types of cancer and ischaemic stroke, coronary heart disease, distal colon, and diabetes mellitus type 2; thus evidence regarding OPA and health outcomes remains mixed.

Contemporary research has also suggested that high levels of OPA are associated with an increased risk of disability pension (Ropponen et al., 2014; Fimland et al., 2018). A recent study conducted in Norway found that increasing levels of OPA were associated with all-cause disability pension. (Fimland et al., 2018) The same study reported stronger associations for disability pension due to musculoskeletal diseases whereas there was no clear association between OPA and risk of disability pension due to mental disorders (Fimland et al., 2018). Similarly, Falkstedt et al. observed that heavier physical workload was associated with higher risk of disability pension due to musculoskeletal, cardiorespiratory and respiratory diagnoses among a large cohort of Swedish workers (Falkstedt et al., 2021). Despite these studies suggesting an association between high OPA and risk of disability pension, the validity and generalizability of their findings remain constrained by their data and methods. First, all the studies to date were conducted in

Nordic countries. The distinctively different socio-occupational and economic hierarchies and work environment, regulations and cultural norms in other countries may influence the associations between OPA and risk of disability pension. Also, recent relevant research has used single-item questions to estimate OPA and to confirm working status with no follow-up of working trajectories derived from administrative data (Dalene et al., 2021), which may be subjected to both critical measurement and selection bias (Ainsworth et al., 1999). Notably, the use of administrative data remains a reliable strategy to assess the risk of disability pension (Bethge et al., 2020). Thus, registry-based studies with broader samples of workers are needed to get more generalizable estimations for the association between OPA and disability pension. Further methodological shortcomings of previous studies include non-representative, small sample sizes; studies with short follow-up periods; and lack of control for competing risks (i.e., mortality) (Lahelma et al., 2012; Fimland et al., 2015).

The present study aimed to investigate the exposure-response association between OPA and risk of all-cause disability pension in a novel, representative, registry-based sample of Spanish workers. Based on prior literature, we hypothesized that higher levels of OPA will lead to higher risk of disability pension.

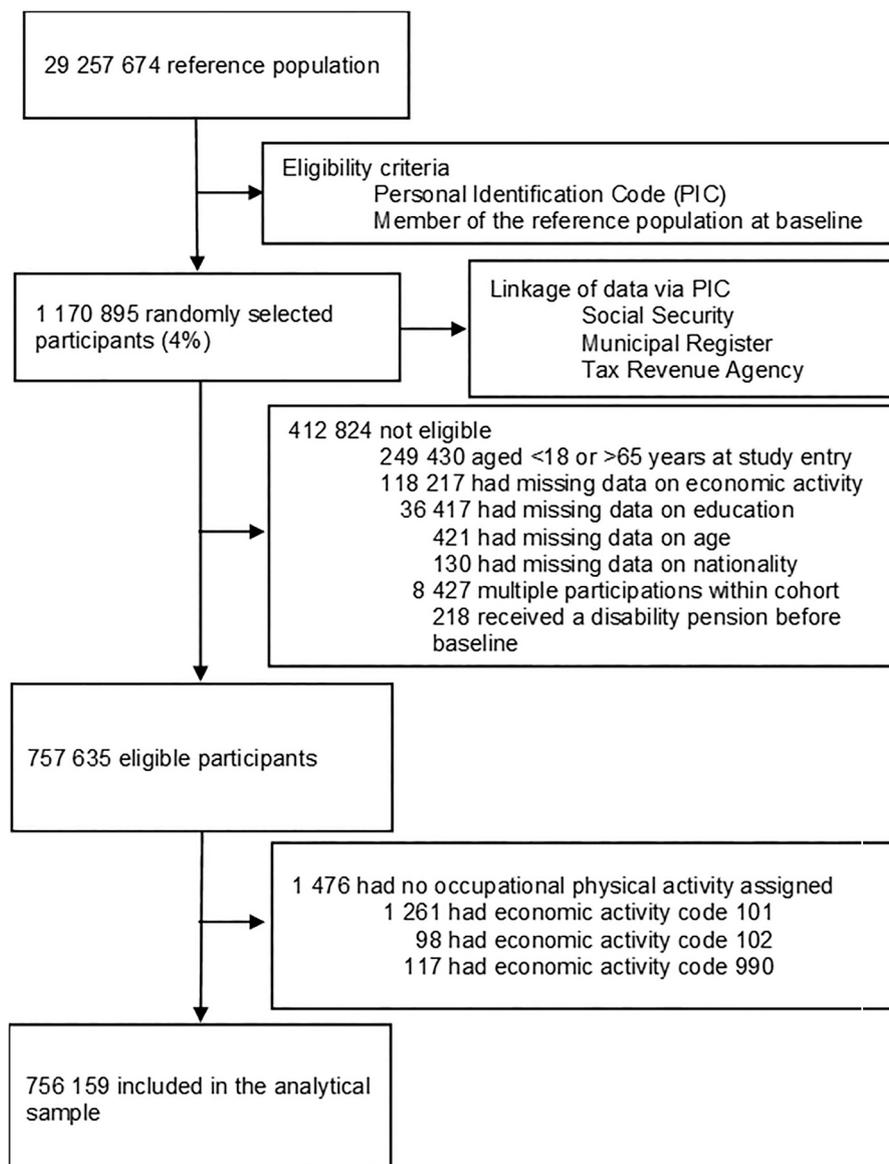


Fig. 1. Cohort profile.

2. Methods

2.1. Study design and participants

This prospective, registry-based cohort study used data from the continuous Working Life Sample (CWLS), a random sample comprising 4% of the social security affiliated in Spain each year, which includes 95% of workers in formal employment (Gómez et al., 2016). More details of the CWLS have been previously described elsewhere (Gómez et al., 2016). Participants with missing values in the examined variables were removed from the study. Fig. 1 provides more details on the study cohort profile. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm et al., 2007) and received the approval from the Ethics Committee of Research in Humans of the University of Valencia (register code 1510464).

2.2. Occupational physical activity category (exposure)

To assess OPA levels, we selected the economic activity of longest duration registered for each worker within the period comprising the years 1981–2006. For individuals with two or more registers with the same length, the most recent registration was selected. Economic activity codes from the 2006 round of CWLS are based on the first version of the standard Statistical Classification of Economic Activities in the European Community (NACE), which describes the company or administration main activity. The physical work demand index created by Andersen et al. (Andersen et al., 2021) was used as proxy for OPA, and each CWLS participant was assigned their corresponding index score accordingly to their economic activity and education level (Supplementary Table S1). The index scores were categorised as low (0–10), moderate (>10–20), high (>20–30) and very high OPA (>30).

2.3. Disability pension (outcome)

Participants were prospectively followed up from baseline (Jan 1, 2006) until the date they received a disability pension, death date, or end of follow-up on Sept 1, 2019, whichever came first. Data concerning disability pension were obtained during follow-up from the social security registers included in CWLS. In the present study, disability pension was defined as the first (onset) time of receiving any type of registered disability benefit, requiring either permanent, full, or partial workability loss.

2.4. Covariates

We explored the potential causal and confounding pathways between OPA and first occurrence of disability pension using a directed acyclic graph (Supplementary Fig. S1). Data on potential confounders including age, sex, education, and nationality were retrieved from the CWLS sample.

2.5. Statistical analyses

We conducted all statistical analyses in Stata version 16.1 (Stata-Corp, Texas, USA). We used Fine-Gray sub-distribution method using mortality as competing risk to estimate subdistribution hazard ratios (SHRs) of first episode of disability pension during follow-up; this takes competing risks into account, providing a more accurate estimation for the risk of the examined outcome. Time-on-study in months was used as the timescale. OPA was used as the exposure variable, and the lowest category of OPA served as reference. We examined the proportional hazards assumption by testing interactions with log (time) using `stphplot` command and found no evidence of violation. We detected a significant interaction between OPA and sex (chunk test). Consequently, we conducted all our analyses stratified by sex. Collinearity between

OPA and education was assessed through the variance inflation factor, which suggested no evidence of collinearity. Two models were tested; a model with age as confounder (model A) and a fully adjusted model (model B) that included age, education, and nationality as confounders. The results were visualized as forest plots. Unmeasured confounding was assessed through *E*-Values, which is defined as the minimum strength of association that an unmeasured confounder would need to have with both the exposure and the outcome to fully explain away the association between the exposure and the outcome, conditional on the measured covariates. Results are reported as SHRs with 95% CIs and levels of significance were set at $p < 0.05$.

2.6. Additional analyses

To minimize the potential influence of reverse causality, we excluded participants who received a disability pension within the first 5 years of follow-up. We assessed the exposure-response associations of OPA (modelled as a continuous exposure) and all-cause disability pension using a restricted cubic spline model to allow for potential non-linearity. For the purpose of this analysis, we trimmed observations <5% and >95% of the distribution. We pre-specified knots placed at the 10th, 50th (reference), and 90th percentiles of the exposure distribution. We assumed linearity for values below the 10th percentile and for values above the 90th percentile. Departure from linearity was assessed by a Wald test examining the null hypothesis that the coefficient of the second spline was equal to zero. Lastly, prospective associations between OPA and specific types of disability were also examined.

3. Results

3.1. Demographics

The final sample included 436,525 (57.7%) men and 319,634 (42.3%) women, with a mean age of 39.3 (SD 12.2) and 37.4 (SD 11.4) years at baseline respectively (Table 1). During a period of 13.6 years of follow-up and 9,463,041 person-year, 18,191 (4.2%) men and 9631 (3.0%) women received a disability pension.

3.2. Outcomes and adjusted analyses

Model adjusted for age only (model A) showed that higher levels of OPA significantly increased the risk of disability pension for men in an exposure-response fashion, with the maximum risk observed for men performing very high OPA (SHR 2.74; 95% CI 2.59 to 2.89) when compared with the lowest OPA category. For women, significant associations were also observed with the highest risk estimated for those exposed to very high OPA (SHR 1.99; 95% CI: 1.86 to 2.12) (Fig. 2).

In the fully adjusted model (model B), the association remained consistently significant in a linear exposure-response manner in men; and the highest risk estimates were observed for the very high OPA category (SHR 2.31; 95% CI: 2.17 to 2.46). Similarly, women performing higher OPA showed significant higher risk of disability pension, although those exposed to very high OPA were the group who showcased the highest risk (SHR 1.68; CI: 1.56 to 1.81) (Fig. 3). This fully adjusted model additionally adjusting for age, educational length, and nationality slightly attenuated the association between OPA and disability in all the examined subgroups.

The estimated *E*-values showed a broad margin for residual confounding bias in the significant associations observed in model B, although these values were remarkably low for women in all the examined OPA categories (Table 2).

Additional analyses after removing participants receiving a disability pension within the first 5 years of follow-up were similar results to our main analyses, confirming the robustness of the found associations (Supplementary Table S2). The model using OPA as a continuous exposure (i.e., spline modelling) also yielded consistent results for both

Table 1
Baseline characteristics of study participants stratified by sex.

	Men = 436,525 (57.7%)		Women = 319,634 (42.3%)	
	N = 756,159	n (%)	n (%)	Mean (SD)
Age (y)		39.3 (12.2)		37.4 (11.5)
Education length ^a				
None	7533 (1.7)		4587 (1.4)	
1–9 years	118,743 (27.2)		68,142 (21.3)	
10–16 years	162,457 (37.2)		110,288 (34.4)	
>16 years	147,792 (33.9)		136,617 (42.7)	
Nationality				
Spanish	400,818 (91.8)		301,084 (94.2)	
Not Spanish	35,707 (8.2)		18,550 (5.8)	
OPA ^b				
Low (0–10)	71,936 (16.5)		63,037 (19.7)	
Moderate (11–20)	132,929 (30.4)		101,573 (31.8)	
High (21–30)	83,674 (19.2)		57,721 (18.1)	
Very high (>30)	147,986 (33.9)		97,303 (30.4)	
Disability pension during follow-up				
Yes	18,191 (4.2)		9631 (3.0)	
No	418,334 (95.8)		310,003 (97.0)	

Abbreviation: OPA, occupational physical activity.

^a Highest level attained at baseline Jan 1, 2006.

^b Based on physical activity index ranging from 5.2 to 37.6.

men and women and confirmed the linear exposure-response association between OPA and disability (Supplementary Figs. S2-S5). The results were consistent for total disability in both men and women, but there was a less clear association for absolute and severe disability pension (Supplementary Fig. S6). Finally, the correlation between the individual participant values of physical work demands and the mean index values

based on economic activity and education was good (Pearson's $r = 0.54$).

4. Discussion

4.1. Main findings

The results of our study suggest the existence of a robust exposure-response association between incremental levels of OPA and risk of disability pension for both men and women. Such association was stronger among men as compared to women and could only be confirmed for total disability pension. Our study provides novel data and sheds light to the scarce existing literature examining the associations between OPA and disability pension, a phenomenon only previously explored in Nordic countries. Individuals working in economic activities with high physical demands such as manufacture of wood, furniture, food or plastics may be at higher risk for disability pension than those working in lighter physical activities such as computer programming, consultancy and related activities.

Our findings are in agreement with previous studies (Falkstedt et al., 2021; Ervasti et al., 2019a), and highlight the existence of a exposure-response association between increasing OPA and risk of disability pension even when using restrictive cubic spline modelling. Particularly, high physically demanding working conditions have been identified as a major risk factor for early disability retirement due to both all causes and musculoskeletal diseases (Lahelma et al., 2012; Ervasti et al., 2019b). The regular use of medication to relieve musculoskeletal pain may increase the risk of long-term sickness absence and, consequently, the risk of disability pension in a concerning vicious circle (Sundstrup et al., 2017a; Salonen et al., 2018). Thus, a continuous process from the onset of a long-term sickness absence due to a specific musculoskeletal disorder eventually leading to disability pension seems a rather plausible pathway for understanding the strong association between OPA and disability pension observed in our study. Nonetheless, the detrimental influence of potential risk factors for disability pension such as musculoskeletal disorders on mental health disorders (e.g., depression), which can also increase the risk of disability pension, should not be discarded (Hannerz et al., 2020; Amiri and Behnezhad, 2019).

Interestingly, higher levels of OPA may elicit a worsening of health-related behaviours such as lower levels of leisure-time physical activity

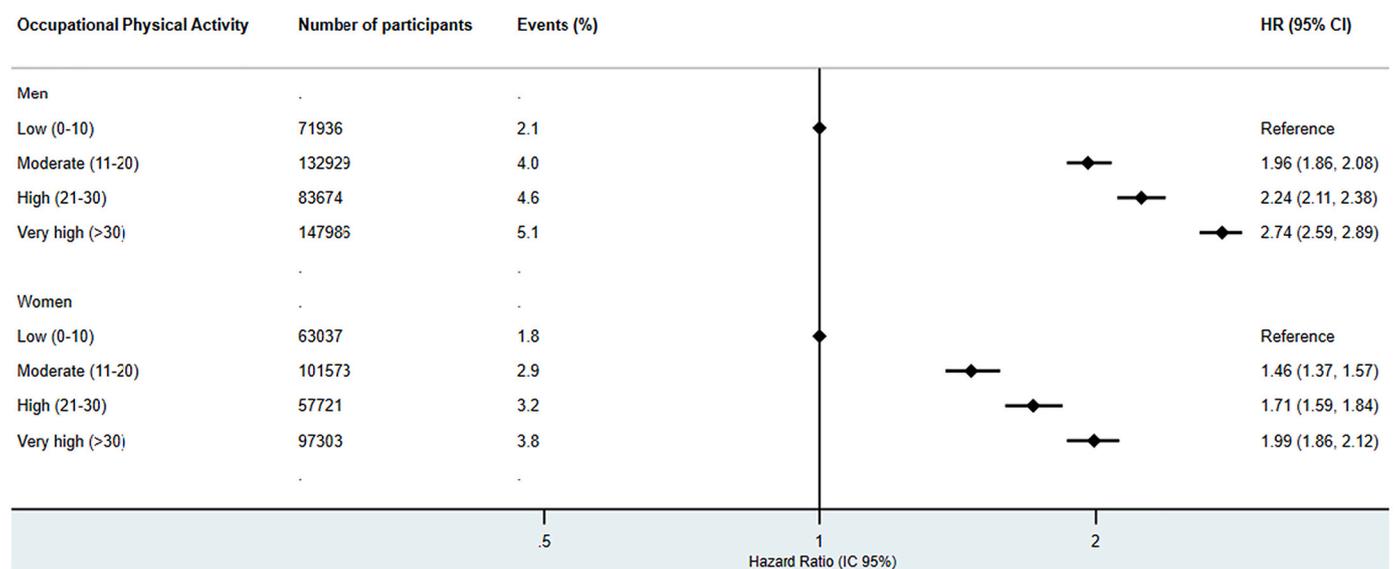


Fig. 2. Prospective associations between occupational physical activity and all-cause disability pension among Spanish workers by sex (Model A Crude) Adjusted for age. Occupational physical activity is presented in 4 categories based on a physical activity index: Low (0–10), Moderate (11–20), High (21–30), and Very high (>30).

Note: Events are disability pension onsets.

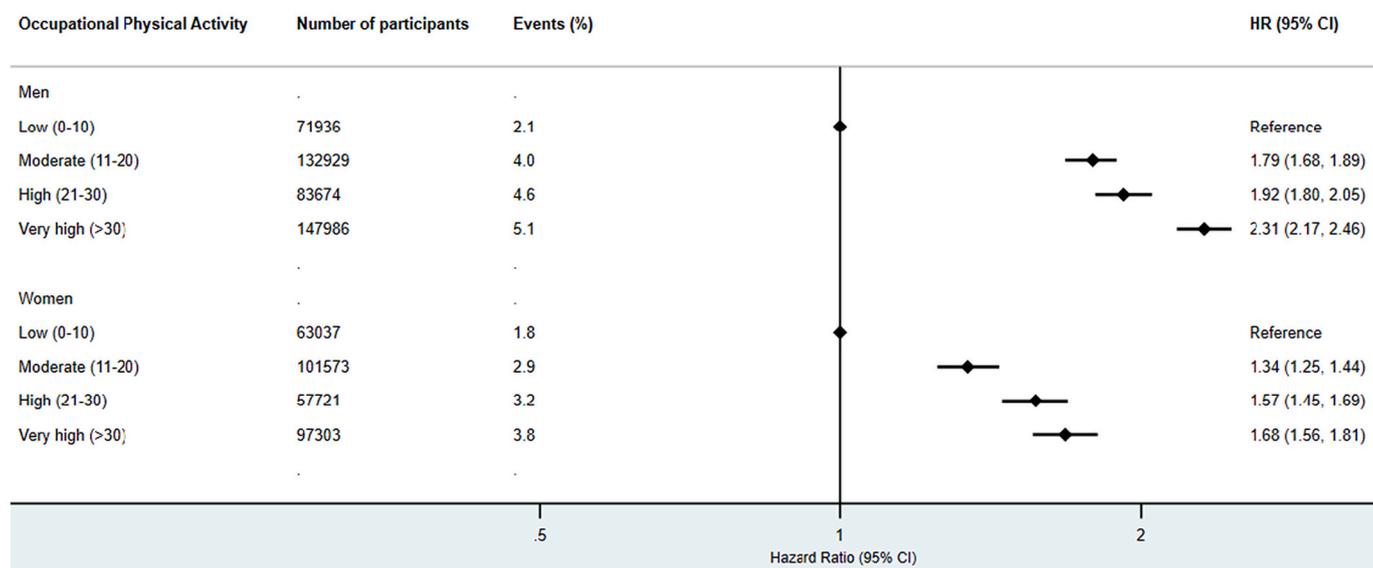


Fig. 3. Prospective associations between occupational physical activity and all-cause disability pension among Spanish workers by sex (Model B fully adjusted) Adjusted for age, education length, and nationality. Occupational physical activity is presented in 4 categories based on a physical activity index:Low (0–10), Moderate (11–20), High (21–30), and Very high (>30). Note: Events are disability pension onsets.

Table 2

E-Values for the association of Occupational physical activity with disability pension. Occupational physical activity is presented in 4 categories based on a physical activity index:Low (0–10), Moderate (11–20), High (21–30), and Very high (>30).

Subgroup	Occupational physical activity*	E-value (95% IC lower limit)
Men	Moderate (11–20)	3.79 (2.99)
	High (21–30)	5.04 (3.87)
	Very high (>30)	11.47 (7.62)
Women	Moderate (11–20)	1.55 (1.35)
	High (21–30)	2.37 (1.88)
	Very high (>30)	2.99 (2.32)

*model B (fully adjusted model; adjusted for age, education, and nationality) The E-value is the minimum strength of association on the hazard ratio scale that an unmeasured confounder would need to have with both the treatment and the outcome to explain away an exposure-outcome association.

(Nooijen et al., 2018), which may further contribute to the detrimental effects of OPA on the risk of disability pension (Fimland et al., 2018; Fimland et al., 2015; Kirk and Rhodes, 2011). The causal pathways that might explain the detrimental effects of OPA on the health of individuals (and thus the connection with disability pension) may include factors such as an excessive exposure to lifting heavy weights, repetitive rotation of the back combined with prolonged awkward postures, or specific injuries associated with physically heavy work (Ervasti et al., 2019b; Sirén et al., 2019; Sundstrup et al., 2017b). Thus, high biomechanical loading negatively affecting the musculoskeletal system may decrease physical capacity in the long term (Ropponen et al., 2014). In addition, job strain as consequence of an effort-reward imbalance observed in white-collar workers from the public sector (i.e., an imbalance between job demands and control or efforts and rewards at work) can represent another relevant pathway leading to disability pension since this has been associated with coronary heart disease (Juvani et al., 2014; Sara et al., 2018), possibly attenuating the observed associations between OPA and disability pension.

Similar to previous research (Falkstedt et al., 2021), we observed associations of stronger magnitude for men compared with women. Several factors may account for this observation including the nature of

the employer (i.e., women working in the public sector experienced higher risk for disability pension compared with women in private sectors), low job security, and low social support in the case of women (Albertsen et al., 2007). The nature of the physical exposure at work may also account for the observed differences. For example, working with hands above shoulder level has been shown to significantly increase the risk for disability pension in men compared to women, whereas other physical work load factors such as lifting has been reported to increase the risk of disability pension for both sexes (Sirén et al., 2019; Sundstrup et al., 2017b).

4.2. Strengths and limitations

Key strengths of the present study include the use of a novel, large, and representative sample of Spanish workers. We used mortality as a competing risk in our modelling strategy, which directly overcomes one of the major limitations of previous studies exploring the association between OPA and risk of disability pension. Unlike previous literature on the topic, our OPA measure allowed us to model the continuous exposure-response association between OPA and risk of disability. Moreover, we used a job exposure matrix framework by combining highly reliable data on economic activity and education from administrative registers, which may reduce the chance of misclassification bias (Descatha et al., 2022). Finally, we took measures to minimize the possibility of reverse causation (i.e. healthier participants employed in active occupations) and undiagnosed/occult disease by removing all disability pension events occurring the first 5 years of follow up.

We acknowledge that our work has some limitations. First, OPA is based on average index values retrieved from prior research conducted in Denmark (Andersen et al., 2021), which along with the mean index values used, may lead to a certain degree of specific misclassification bias for men and women. Owing to possible differences related to legislation, work organization or technological development for each economic activity sector between Denmark and Spain, the likelihood of misclassification bias may be increased. However, such bias is thought to be partially lessened by the education stratification of the index (i.e., because educational level is usually associated with physical demands at work, this stratification served to better discriminate OPA exposure among workers within a specific economic activity). Furthermore, the

NACE classification is developed according to European standards and is designed to compare economic activities across European countries, which could reduce the likelihood for the aforementioned bias. Moreover, working trajectories subjected to stable physical and psychosocial working conditions have been previously observed in the European context (Corin et al., 2021), thus drastic changes leading to critical OPA differences in a substantial number of workers during their working life are unlikely. Second, analyses examining the association of OPA and disability pension stratified by sex and type of disability displayed that such association is stronger for the most common type of disability pension (i.e., total disability pension) and lower and no significant for less common but more severe types of disability in women, and absolute disability in men, which could be attributed to a different job role composition depending on sex as well as a late entry of Spanish women in the workforce (Albertsen et al., 2007; Guner et al., 2014). This would have possibly reduced the amount of OPA exposure in women, leading to a less severe disability pension than men. Also, there is still a chance for measurement bias since the proxy for exposure might have not appropriately reflected the working trajectory of the participants (i.e., participants that have experienced long periods of unemployment or an early exit of the working life). Finally, the possibility of a residual confounding bias exists, although examined *E*-values discard that this can importantly vary the findings of the present study. Further investigation delving into the mechanisms that elicit disability pension due to high levels of OPA is warranted.

In a large administrative sample of Spanish men and women, we found that higher levels of OPA were associated with an increased risk of total disability pension in a exposure-response fashion. Our results emphasize the need for more research investment on understanding the potential detrimental effects of OPA and warrant updated labour legislations, particularly concerning physical activity at work.

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Credit author statement

Rubén López-Bueno: Conceptualization, Methodology, Formal analysis, Writing- original draft. **Lars Louis Andersen:** Conceptualization, Methodology, Writing- review & editing. **Joaquín Calatayud:** Conceptualization, Methodology, Writing- review & editing. **José Casaña:** Methodology, Writing- review & editing. **Begoña Martínez-Jarreta:** Methodology, Writing- review & editing. **José Francisco López-Gil:** Methodology, Writing- review & editing. **Borja del Pozo Cruz:** Conceptualization, Methodology, Formal analysis, Writing- review & editing.

Declaration of Competing Interest

None declared.

Data availability

Data is available upon formal request to the institution.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ympmed.2022.107380>.

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