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Integrating Physical and Psychosocial Risk Assessment Across Age and Gender: Preliminary Findings From the European WAge Project

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ABSTRACT

The ageing of the workforce, together with the combined influence of ergonomic and psychosocial factors, poses a growing challenge for occupational health and sustainable work. This study, conducted within the European project WAge (wagehealth.eu), aims to develop an integrated analytical model that links physical and psychosocial risk assessment while explicitly considering age and gender. The ultimate goal is to inform evidence-based policies and interventions to improve working conditions and worker well-being. A cross-sectional field study was carried out between Q4 2024 and Q1 2025 in Spain, Portugal, and Poland, including a sample of >500 workers from industrial and service sectors. For each job position, data collection combined: (1) sociodemographic and job information; (2) objective physical workload assessment through video recording and observational ergonomic evaluation (REBA); and (3) self-reported measures covering perceived physical workload (based on ISO 12295), musculoskeletal health (Nordic Musculoskeletal Questionnaire), and psychosocial conditions (HEROCheck). Data are being analysed using descriptive statistics and multivariable regression models, adjusted for age, gender and job type, to explore associations between physical demands, psychosocial exposures, and health/work ability outcomes. Preliminary results of the Spanish sample (N = 113) indicate meaningful relationships between physical and psychosocial factors. A detailed characterization of these interactions will support the development of a practical, adaptable screening methodology for diverse job profiles.

Keywords: Musculoskeletal disorders, Ergonomic risk assessment, Perceived physical workload, Psychosocial job demands and resources, Integrated risk assessment

INTRODUCTION

The progressive ageing of the working population represents a major challenge for occupational health management in Europe (Eurostat, 2025). This demographic shift calls for renewed approaches to the assessment and

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prevention of occupational risks, taking into account not only the physical demands of work tasks but also psychosocial working conditions and individual characteristics such as age and gender.

A growing body of evidence has shown that psychosocial factors—such as time pressure, perceived control and autonomy—are associated with musculoskeletal disorders (MSDs) and can exacerbate the health impact of physical workload (Bezzina et al., 2023; Leka & Jain, 2010). However, physical and psychosocial risk factors are often assessed separately, limiting the understanding of how they interact in real working environments. Personal factors further modulate these relationships but are rarely integrated into standard occupational risk assessment models.

Current approaches to risk assessment also differ according to the type of exposure considered. Physical workload is typically evaluated using observational or semi-quantitative ergonomic methods (Yadav, 2023), whereas psychosocial risks are commonly assessed through self-reported questionnaires capturing workers' perceptions (Fernandes & Pereira, 2016). When these dimensions are analyzed jointly, questions remain regarding the convergence and complementarity of different sources of information and their relative contribution to musculoskeletal risk.

In this context, there is a clear need for integrated analytical frameworks that combine objective and subjective indicators of physical workload with psychosocial factors, adopting a perspective sensitive to age and gender. The present study is part of the European project **WAge: Healthy Working Environments for All Ages: An Evidence-Driven Framework** (https://wagehealth.eu/), which aims to develop such an integrated approach. This article presents the methodological framework, reports findings from the Spanish field study, and discusses their implications for occupational risk prevention and the development of integrated assessment methodologies.

OBJECTIVES

The aim of this study was to develop an integrated analytical framework for the assessment of working conditions, combining ergonomic, psychosocial and personal factors.

Specifically, the study aimed to: (i) examine the consistency and convergence between subjective and objective indicators of physical workload; (ii) analyse the associations between physical and psychosocial working conditions and musculoskeletal symptoms; and (iii) explore the amplifying and buffering role of psychosocial job demands and resources in musculoskeletal risk.

MATERIAL AND METHODS

Study Design and Participants

A cross-sectional study was conducted within a broader European research project involving a total sample of more than 500 workers from the industrial and service sectors across three European countries: Spain, Portugal and Poland.

The present article reports the results corresponding to the Spanish subsample, which was carried out in the SEAT manufacturing plants.

The final sample consisted of **113 workers**. Of these, **74 were blue-collar workers** involved in production-related tasks (e.g., assembly, machining, painting and press operations), and **39 were white-collar workers** performing office-based and administrative activities.

Participants were actively employed at the time of the assessment and had sufficient job tenure to be familiar with their usual working conditions. All workers participated voluntarily and completed the assessment during working hours.

Sociodemographic information collected included age and sex. Work-related characteristics included job category (blue-collar or white-collar), working area, job seniority, work schedule and absenteeism due to health problems during the previous 12 months. Information on medically diagnosed or treated illnesses or injuries was also collected.

The study was conducted in accordance with ethical principles for research involving human participants. Data were collected anonymously and analysed in aggregated form to ensure confidentiality.

MEASURES

Observed physical workload was assessed using the **Rapid Entire Body Assessment (REBA)** method (Hignett & McAtamney, 2000). For each worker, up to six representative working postures were analysed during normal task performance. A weighted mean REBA score was calculated and normalised on a scale from 0 (no risk) to 1 (maximum risk), and used as the overall indicator of observed ergonomic risk.

Perceived physical workload was assessed using a **structured questionnaire** covering ten types of physical exposure (manual lifting and carrying, pushing and pulling, repetitive upper-limb movements, static or awkward postures of the head/neck, trunk, upper limbs, hands/wrists and lower limbs, prolonged standing and prolonged sitting). For each exposure, workers rated both frequency and perceived impact. Exposure-specific frequency × impact scores were normalised to a 0–1 scale, and an overall Index (*UnifiedLoad*) was calculated as the mean of all exposure scores.

Musculoskeletal symptoms were assessed using the **Nordic Musculoskeletal Questionnaire** (Kuorinka, et al, 1987). Workers reported the presence of pain or discomfort during the previous 12 months and the previous 7 days in nine body regions. A binary indicator of multisite musculoskeletal symptoms was created (*Multisite MSD*), defined as the presence of symptoms in two or more body regions during the previous 12 months.

Psychosocial working conditions were assessed using the **HERO (Healthy and Resilient Organizations) Check model** (Salanova, M., et. al, 2012). For the present analyses, the focus was placed on Job Demands and Job Resources. Job demands reflected quantitative and qualitative aspects of work intensity and were assessed on a scale ranging from 0 (never) to 6 (always). Job resources were operationalised as the mean score of six dimensions assessed within the HERO model: autonomy, feedback, social

climate of support, coordination, positive leadership, and generativity. Scores ranged from 0 (never) to 6 (always), with higher values indicating greater availability of psychosocial resources.

Statistical Analysis

Descriptive statistics were used to summarise participant characteristics and study variables. Associations between physical workload indicators, psychosocial factors and musculoskeletal outcomes were examined using correlation analyses and multivariable regression models.

Linear regression models were used for continuous outcomes, logistic regression models for binary outcomes, and ordinal logistic regression models for ordinal outcomes. All models were adjusted for age, sex and job category (blue vs white-collar). Interaction terms were included to examine the buffering role of job resources. Statistical significance was set at $p < 0.05$.

RESULTS

Sample Characteristics

The analytical sample consisted of **113 workers**, of whom **74 were blue-collar** (65.5%) and **39 white-collar** (34.5%). Participants covered a wide range of ages and job seniority.

Musculoskeletal symptoms were prevalent. Overall, 83.2% of workers reported pain in two or more body regions during the previous 12 months.

Blue-collar workers consistently showed higher observed ergonomic risk (REBA scores) and higher perceived physical load than white-collar workers.

H1. CONSISTENCY BETWEEN PHYSICAL WORKLOAD INDICATORS AND MUSCULOSKELETAL OUTCOMES

H1.1 Perceived Physical Load and Musculoskeletal Symptoms

The relationship between perceived physical load and musculoskeletal symptoms was examined using both correlation analysis and multivariable regression models.

At the bivariate level, perceived physical load (UnifiedLoad) showed a **moderate and statistically significant positive correlation** with musculoskeletal symptom burden: higher perceived physical load was associated with a greater number of symptomatic body regions during the previous 12 months.

This association was confirmed in a binary logistic regression model predicting the presence of multisite musculoskeletal symptoms (≥2 regions), adjusted for age, sex and job category. Higher perceived physical load was associated with a higher probability of multisite musculoskeletal symptoms.

H1.2 Perceived Physical Load and Observed Ergonomic Risk

The consistency between perceived physical load and observed ergonomic risk was first examined using correlation analysis. A **moderate positive correlation was observed between UnifiedLoad and REBA scores**. However,

this association did not persist in multivariable linear regression analyses. After adjustment for age, sex and job category, **perceived physical load was not significantly associated with REBA scores**. In contrast, **job category showed a strong and statistically significant association with observed ergonomic risk,** with blue-collar workers exhibiting substantially higher REBA scores than white-collar workers.

Table 1: Correlations between physical workload indicators and musculoskeletal outcomes (H1).

Variables	Pearson's r	p-value
UnifiedLoad ↔ Nordic_multisite_12	**0.48**	**<0.001**
UnifiedLoad ↔ REBA	**0.41**	**<0.001**

Table 2: Associations between perceived physical load, observed ergonomic risk and musculoskeletal symptoms (H1).

Hypoth.	Outcome	Predictor	Model	Effect Estimate	95% CI	p-value	Model Fit
H1.1	Multisite MSD	UnifiedLoad	Logistic regression	OR = 148.46	2.82 – 7818.85	0.013	AUC = 0.76
H1.2	REBA	UnifiedLoad	Linear regression	β = –0.031	–0.081 to 0.019	0.230	R^2 = 0.60
H1.2	REBA	Job category (BC vs WC)	Linear regression	β = 0.132	0.108 to 0.155	<0.001	—

H2 PSYCHOSOCIAL JOB DEMANDS AND MUSCULOSKELETAL RISK

H2.1 Association Between Job Demands and Perceived Physical Load

The relationship between psychosocial job demands and perceived physical load was examined using multivariable linear regression models. **Higher job demands were significantly associated with higher perceived physical load,** after adjustment for age, sex and job category.

H2.2 Association Between Job Demands and Musculoskeletal Symptoms

The association between job demands and musculoskeletal symptoms was examined using binary logistic regression models predicting multisite musculoskeletal symptoms.

Higher job demands were significantly associated with an increased probability of reporting multisite musculoskeletal symptoms.

Job category also showed a strong independent association with multisite symptoms, with blue-collar workers presenting a higher probability of reporting multisite pain. Age and sex were not significantly associated with the outcome.

H2.3 Association Between Job Demands, Absenteeism and Injuries

The relationship between job demands and absenteeism due to health problems during the previous 12 months was examined using ordinal logistic regression. Higher job demands were significantly associated with greater absenteeism severity, with increasing job demands linked to a higher probability of belonging to more severe absenteeism categories.

In contrast, no statistically significant association was observed between job demands and the presence of medically diagnosed or treated illness or injury once covariates were taken into account.

H2.4 Association Between Job Demands and Observed Ergonomic Risk

The relationship between job demands and observed ergonomic risk was examined using linear regression models with REBA scores as the outcome. **Job demands were not significantly associated with observed ergonomic risk** after adjustment for age, sex and job category.

Observed ergonomic risk was largely explained by job category, with blue-collar work strongly associated with higher REBA scores.

Table 3: Associations between psychosocial job demands and perceived physical load, musculoskeletal symptoms and absenteeism (H2).

Hypoth.	Outcome	Predictor	Model	Effect Estimate	95% CI	p-value	Model Fit
H2.1	Unified Load	Job Demands	Linear regression	$\beta = +0.041$	0.012 – 0.070	0.006	$R^2 = 0.31$
H2.2	Multisite MSD	Job Demands	Logistic regression	OR = 2.30	1.07 – 4.95	0.034	AUC = 0.71
H2.3	Absenteeism	Job Demands	Ordinal logistic regression	OR = 1.42	1.05 – 1.92	0.022	—
H2.4	REBA	Job Demands	Linear regression	$\beta = 0.008$	–0.021 – 0.037	0.588	$R^2 = 0.60$

H3 PSYCHOSOCIAL JOB RESOURCES AS PROTECTIVE AND BUFFERING FACTORS

H3.1 Association Between Job Resources and Perceived Physical Load

The association between psychosocial job resources and perceived physical load was examined using multivariable linear regression models. **Higher job resources were significantly associated with lower perceived physical load,** after adjustment for age, sex and job category.

Age showed a small but significant positive association with perceived physical load, whereas sex was not significantly associated with the outcome.

H3.2 Association Between Job Resources and Musculoskeletal Symptoms

The relationship between job resources and musculoskeletal symptoms was examined using binary logistic regression models predicting multisite musculoskeletal symptoms during the previous 12 months.

Higher job resources were significantly associated with a lower probability of reporting multisite musculoskeletal symptoms. Job category showed a tendency toward higher musculoskeletal risk among blue-collar workers, although this association did not reach statistical significance once job resources were included in the model. Age and sex were not significantly associated with multisite symptoms.

H3.3 Association Between Job Resources and Absenteeism

The association between job resources and absenteeism due to health problems during the previous 12 months was examined using ordinal logistic regression models. **Higher job resources were significantly associated with lower absenteeism severity.** None of the covariates showed significant associations with absenteeism once job resources were taken into account.

H3.4 Buffering Effect of Job Resources on the Relationship Between Physical Exposure and Musculoskeletal Symptoms

The buffering role of job resources was examined by introducing interaction terms into logistic regression models predicting multisite musculoskeletal symptoms.

A statistically significant interaction was observed between **job resources and observed ergonomic risk (REBA)**. Higher job resources attenuated the association between ergonomic risk and multisite musculoskeletal symptoms. At lower levels of job resources, increases in REBA were associated with a marked increase in musculoskeletal risk, whereas this relationship was substantially weaker at higher levels of job resources. The interaction between job resources and perceived physical load showed a similar but weaker pattern ($p = 0.075$).

Table 4: Associations and buffering effects of psychosocial job resources on musculoskeletal outcomes (H3).

Hypoth.	Outcome	Predictor	Model	Effect Estimate	95% CI	p-value	Model Fit
H3.1	Unified Load	Job Resources	Linear regression	β = –0.043	–0.078 – –0.008	0.016	$R^2 = 0.31$
H3.2	Multisite MSD	Job Resources	Logistic regression	OR = 0.40	0.19 – 0.87	0.020	AUC = 0.76
H3.3	Absenteeism	Job Resources	Ordinal logistic regression	OR = 0.61	0.42 – 0.90	0.011	—
H3.4	Multisite MSD	REBA × Job Resources	Logistic regression	OR = 0.37	0.15 – 0.91	0.031	AUC = 0.76
H3.4	Multisite MSD	UnifiedLoad × Job Resources	Logistic regression	OR = 0.22	0.04 – 1.17	0.075	AUC = 0.80

DISCUSSION

This study aimed to develop an integrated analytical framework to examine the joint contribution of ergonomic, psychosocial and personal factors to musculoskeletal risk (da Costa &Vieira, 2010). The findings provide convergent evidence supporting the relevance of combining subjective and objective measures of physical workload (Punnett & Wegman, 2004) within a Job Demands–Resources perspective (Bakker & Demerouti, 2017).

Consistency Between Perceived Physical Load, Ergonomic Exposure and Musculoskeletal Symptoms

The analyses showed a differentiated pattern of consistency between measures. Perceived physical load was strongly and consistently associated with musculoskeletal symptoms, both in bivariate correlations and in multivariable regression models. Higher perceived physical load was associated with a markedly increased probability of reporting multisite musculoskeletal symptoms, independent of age, sex and job category. This finding supports the internal consistency of subjective workload indicators and their close alignment with workers' experience of musculoskeletal discomfort.

In contrast, the relationship between perceived physical load and observed ergonomic risk was more limited. Although a moderate positive correlation was observed at the global level, this association disappeared after adjustment for job category, and stratified analyses showed weak or non-significant relationships within job groups. These results indicate that perceived physical load and observational ergonomic risk converge at a structural level—reflecting differences between types of work—but are not interchangeable at the individual level.

Taken together, these findings suggest that perceived physical load captures the experiential and functional impact of work, whereas observational ergonomic methods primarily reflect task-level biomechanical exposure. Both approaches therefore provide complementary information and address different dimensions of musculoskeletal risk.

Psychosocial Job Demands as Amplifying Factors of Musculoskeletal Risk

Results show that psychosocial job demands play a significant role in musculoskeletal risk. Higher job demands were associated with higher perceived physical load, increased probability of multisite musculoskeletal symptoms, and greater absenteeism severity. Importantly, job demands were not associated with observed ergonomic risk, indicating that psychosocial demands do not reflect differences in biomechanical exposure but rather influence how physical work is experienced and tolerated.

These findings support the view that psychosocial demands amplify musculoskeletal risk through perceptual and experiential pathways, increasing symptom burden and functional consequences even when biomechanical exposure remains unchanged.

Protective and Buffering Role of Job Resources

Psychosocial job resources showed consistent protective effects across outcomes. Higher job resources were associated with lower perceived physical load, reduced probability of multisite musculoskeletal symptoms, and lower absenteeism severity. These associations remained significant after adjustment for demographic and job-related factors.

Beyond their direct effects, job resources also demonstrated a buffering role. The significant interaction between job resources and observed ergonomic risk indicates that psychosocial resources attenuate the impact of biomechanical exposure on musculoskeletal symptoms. Workers exposed to high ergonomic risk showed substantially lower symptom risk when job resources were high. A similar, though weaker, buffering pattern was observed for perceived physical load.

These findings align closely with the Job Demands–Resources model and highlight the importance of organisational and social factors in modulating the health impact of physical work.

Implications for Integrated Assessment

Together, these findings reinforce the need for integrated assessment approaches combining observational ergonomic methods, worker-reported physical load and psychosocial indicators. Previous research has highlighted the limitations of relying on single-method assessments for MSD prevention (Punnett & Wegman, 2004). The present study extends this work by empirically demonstrating how psychosocial factors amplify or buffer the relationship between physical exposure and musculoskeletal outcomes.

CONCLUSION

This study demonstrates the value of an integrated approach to musculoskeletal risk assessment that simultaneously considers ergonomic exposure, psychosocial working conditions and workers' perceptions. Perceived physical load showed a strong and consistent association with musculoskeletal symptoms, highlighting its relevance as an indicator of the experiential impact of physical work. In contrast, observational ergonomic risk primarily reflected structural differences in biomechanical exposure between job types, underscoring the complementary nature of subjective and objective measures.

Psychosocial factors played a central role in shaping musculoskeletal risk. Job demands were associated with higher perceived physical load, greater symptom burden and increased absenteeism, whereas job resources showed consistent protective effects across outcomes. Importantly, job resources also buffered the relationship between observed ergonomic risk and musculoskeletal symptoms, supporting a moderating role consistent with the Job Demands–Resources framework.

Future research will extend the present analyses to the full study sample collected in Spain, Portugal and Poland, allowing for cross-country comparisons and a more robust examination of the observed relationships.

Additional analyses will also explore further aspects of the interaction between physical workload and psychosocial factors, including other dimensions of job demands, resources and organisational practices assessed within the HERO framework.

Finally, the findings of this study will support the development of a combined objective–subjective screening model for the assessment of the ergonomic and psychosocial working conditions. Integrating observational ergonomic methods with worker-reported physical load and psychosocial indicators provides a more comprehensive understanding of risk mechanisms and may improve the targeting of preventive interventions that address both physical and organisational determinants of health.

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