








# Influence of Weekly Working Hours on Musculoskeletal Disorder Risk Associated with Biomechanical Factors

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## OCCUPATIONAL APPLICATIONS

Assessing individual risk for musculoskeletal disorders (MSDs) associated with biomechanical factors requires a comprehensive evaluation of various occupational parameters, including weekly working time. Our results provide compelling evidence suggesting a positive linear correlation between weekly working hours and the risk of MSDs, a finding observed across various job categories and anatomical regions. This correlation suggests that reducing work hours, including implementing reduced work schedules or part-time employment, may offer potential benefits for MSDs prevention. However, to more comprehensively understand the complex relationship between weekly working hours and MSDs development, rigorous longitudinal studies are essential. These studies would provide valuable insight into the temporal dynamics of MSDs risk and allow for a more nuanced assessment of the long-term health effects of different work schedules. Such evidence will better equip occupational health professionals and policymakers to develop effective, evidence-based strategies for MSDs prevention and promote healthier work environments.

## TECHNICAL ABSTRACT

**Background:** Epidemiological studies suggest that high levels of exposure to biomechanical factors may increase the risk of MSDs, especially when combined. Several methods have been proposed for hazard exposure and risk assessment, yet a general gold standard does not exist. Prior studies on work-related MSDs were conducted primarily in standardized industrial environments in which workers were involved in repetitive tasks. However, with the rise of automation and new employment practices, there has been a shift toward more flexible working models.

**Purpose:** We wanted to investigate and analyze the biomechanical risk modifications introduced by variability in the content and duration of tasks.

**Methods:** To determine the potential impact of work duration, specifically how part-time jobs could impact the risk of MSDs because of biomechanical factors, we performed a preliminary literature search from already published data on biomechanical risk/pathologies/injuries when involving part-time activities, compared to the full-time ones.

**Results:** By pooling the few studies reporting part-time vs full-time biomechanical risk assessment/evaluation, we noticed an increasing trend of the risk of developing MSDs when working more hours, highlighting the lower risk of part-time jobs compared to full-time jobs.

**Conclusion:** Because existing data are limited and heterogeneous, further research is required to robustly assess and quantify potential benefits of part-time jobs.

**Acronyms:** MSDs: Musculoskeletal Disorders; CTS: Carpal Tunnel Syndrome; LBP: Low Back Pain; LBI: Low Back Injury; MSS: Musculoskeletal Symptoms

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## KEYWORDS

Biomechanical risk factors; ergonomics; occupational injuries; musculoskeletal disorders; part-time; full-time

## 1. Introduction

Musculoskeletal disorders (MSDs) are a relevant public health issue that have multifactorial causes (Bonfiglioli et al., 2022) and are frequently reported by workers in most industrialized, middle-income and low-income

countries and have often been related to biomechanical risk factors (*Musculoskeletal Health*, 2022; Publications Office of the European Union, 2017). Epidemiological studies suggest that jobs involving exposure to manual material handling, or manual work which requires fast,

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forceful and continuous exertions, especially if associated with non-neutral postures and vibrations, may increase the risk of MSDs, especially when combined (Bernard et al., 1997; Jan de Kok et al., 2019).

Many scientific studies on work-related MSDs have been performed in highly standardized industrial environments, in which workers usually have a full-time job, repeating the same tasks day after day, five to six days per week, usually with a weekly working time approximately 40 hours. Currently, in many occupational settings there is a higher task variability within a single workday, both in terms of job content and duration. New forms of employment have recently paved their way, replacing permanent jobs with temporary, casual, part-time, and contract jobs, especially in services jobs (Hurley & Litardi, 2024; Park et al., 2019).

It might be assumed that reducing working hours would inherently lead to a proportional reduction in occupational risk exposures. Indeed, Alamgir et al. (2008) conducted a study on 8,640 registered nurses in acute care and 2,967 care aides in long-term care, finding that full-time workers were at higher risk of injury than part-time workers. Their investigation revealed that musculoskeletal injuries constituted most injuries, representing over 80% of the total. Among nurses, the overall injury rates were 7.4 per 100 person-years for full-time employees and 5.3 per 100 person-years for part-time employees. Care aides experienced overall injury rates of 25.8 per 100 person-years for full-time employees and 22.9 per 100 person-years for part-time employees. In multivariate models, even after adjustment for some confounding factors, such as age and gender, full-time nurses continued to show a significantly higher risk of injury than part-time workers (Alamgir et al., 2008).

The increasing phenomenon of involuntary part-time employment should also be considered, especially among female workers, and its possible effect on psychosocial factors and consequently to the burden of musculoskeletal pain (Iñigo Isusi et al., 2020). Recently, a systematic review showed that reducing weekly working hours (without reducing salary) could be effective in improving worker well-being, especially regarding stress and sleep, while there was only limited evidence on the potential benefit it may have on MSDs reduction (Vogolino et al., 2022). A working paper by the European Foundation for the Improvement of Living and Working Conditions reports a study showing that four-day workweeks with no pay reduction are an effective organizational intervention for enhancing workers' self-reported well-being outcomes (Schor et al., 2025).

Conversely, overtime is a recognized organizational risk, potentially causing various musculoskeletal

problems (Alencar et al., 2025; Hu et al., 2024). Observational methods to assess the exposure to biomechanical factors have been developed to identify risk conditions that deserve intervention (Takala et al., 2010). These methods were applied in industry where workers were repeating the same tasks for the entire daily working time. Validation studies are available for some of these methods for specific health outcomes: the Strain Index (Moore & Garg, 1995) and the TLV for Hand activity (TLVs and BEIs, 2000).

Furthermore, some methodologies have been revised to accommodate diverse operational models, such as multitasking, and to incorporate mathematical metrics for minimizing daily exposure durations (Garg et al., 2017; Occhipinti, 1998; TLVs and BEIs, 2018). However, there is a lack of studies assessing the proposed metrics regarding their predictivity in terms of risk reduction for MSDs. Other methodologies, such as Exposure Variation Analysis (EVA), were developed to quantify the variation of exposure variables and to distinguish recurring patterns over time. Practical application of the EVA approach was largely confined to recordings of posture and myoelectrical activity (EMG), subsequent to the determination of exposure thresholds correlated with elevated MSDs risk (Mathiassen & Winkel, 1991).

The objective of our investigation was to determine the preventative potential of decreased weekly working hours, specifically part-time work, regarding MSDs. We collected studies reporting part-time vs full-time biomechanical risk assessment to quantitatively evaluate the preliminary correlation between the risk of developing MSDs with the weekly working hours.

## 2. Methods

To summarize the existing research about musculoskeletal disorders (also described in the literature as diseases or injuries) in part-time workers, we conducted a PubMed search using different strings, combining the word “(part-time)” (AND) different health-related outcomes “low back pain”, “neck pain”, “carpal tunnel syndrome”, “shoulder tendinitis”, “shoulder supraspinatus tendinitis”, “shoulder rotator cuff”, and “elbow tendinitis”. No restrictions were applied regarding the publication date or the study design. We included articles (i) conducted in the occupational field, (ii) written in English, and in which (iii) a measure of prevalence or incidence of a musculoskeletal disorder was present comparing full-time and part-time workers.

A literature search on low back pain (LBP) returned 62 articles, each of which underwent independent

author review of the title and abstract. The references of each relevant article were searched, yielding two more papers fitting our three inclusion criteria. Subsequently, nine full-text articles were assessed for eligibility, with three subsequently excluded. After full-text review, six articles fit our inclusion criteria. Regarding carpal tunnel syndrome (CTS), we included two relevant articles out of seven. There were no relevant articles found about shoulder or elbow disorders, but we retrieved two articles about neck pain as an outcome with low back pain (included in the above selection). In the end, our study included and analyzed eight English-language scientific articles that quantitatively reported the prevalence or incidence of MSDs in full-time and part-time workers. Figure 1 provides a PRISMA diagram summarizing the article selection process.

### 3. Results

As summarized in Table 1, the results are heterogeneous in terms of population, study design, shift duration (hours/week), and main health-related outcome. Figure 2(a) presents a comparative analysis of musculoskeletal health risks for part-time workers, relative

to full-time workers as a reference group (normalized to 1), encompassing data from all the studies included in our analysis. It is noteworthy, as elaborated below, that although several investigations demonstrated a decreased risk for part-time employees, this finding was not universal across all studies.

The two studies conducted in supermarkets/hypermarkets (Bonfiglioli et al., 2007; Minghelli et al., 2019) showed different results. Bonfiglioli et al. (2007), in a quasi-experimental design study, showed a higher prevalence of CTS symptoms among full-time cashiers (31.0%) compared to part-time cashiers (19.3%) and controls (16.3%). Part-time cashiers and controls (office workers) showed a similar prevalence of CTS symptoms and cases, in line with the general female population. Univariate analysis revealed full-time cashiers had 2.3 times higher risk for current CTS symptoms than controls. Multivariate logistic regression confirmed increased risk for current CTS symptoms in full-time cashiers, even after adjusting for potential confounders. A similar, but not significant, trend occurred for CTS cases (OR 1.23; 95% CI 0.42–3.56;  $p = 0.702$ ). These findings suggest that longer working hours with inadequate recovery time may contribute to higher CTS risk, despite similar levels

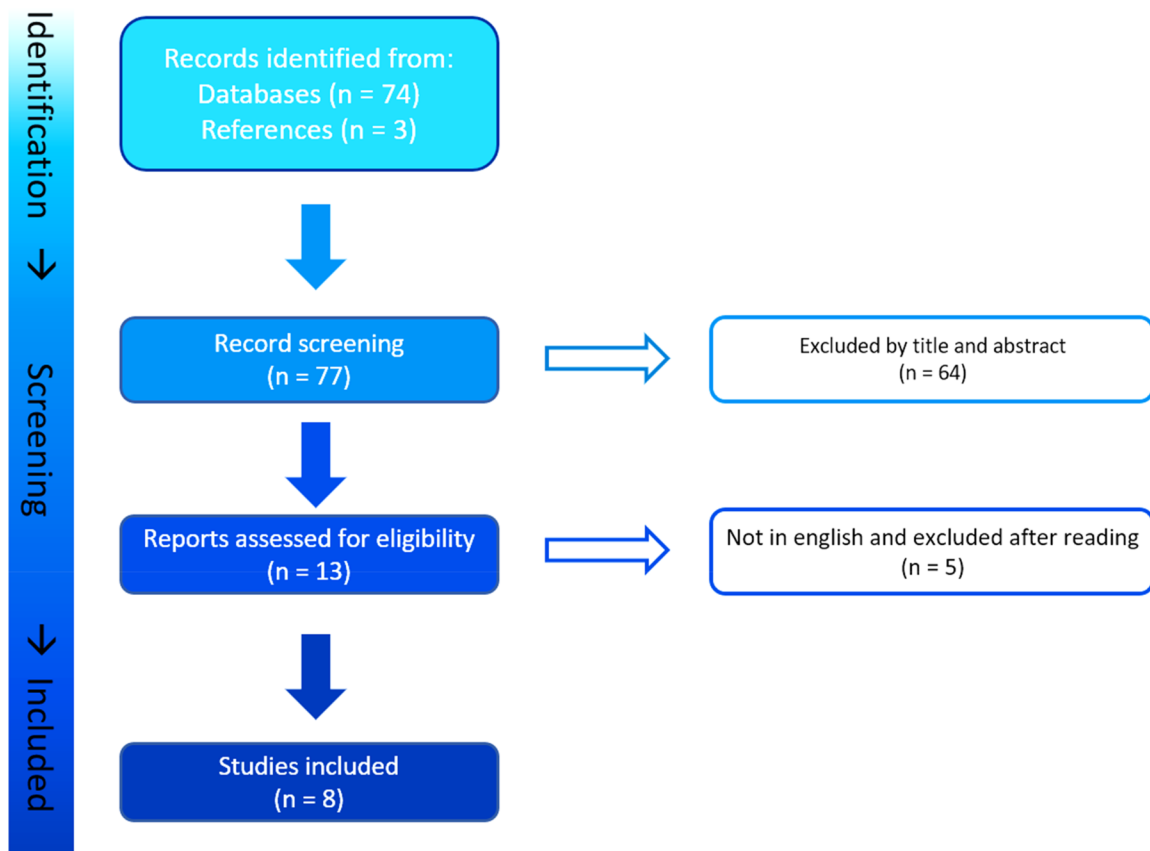
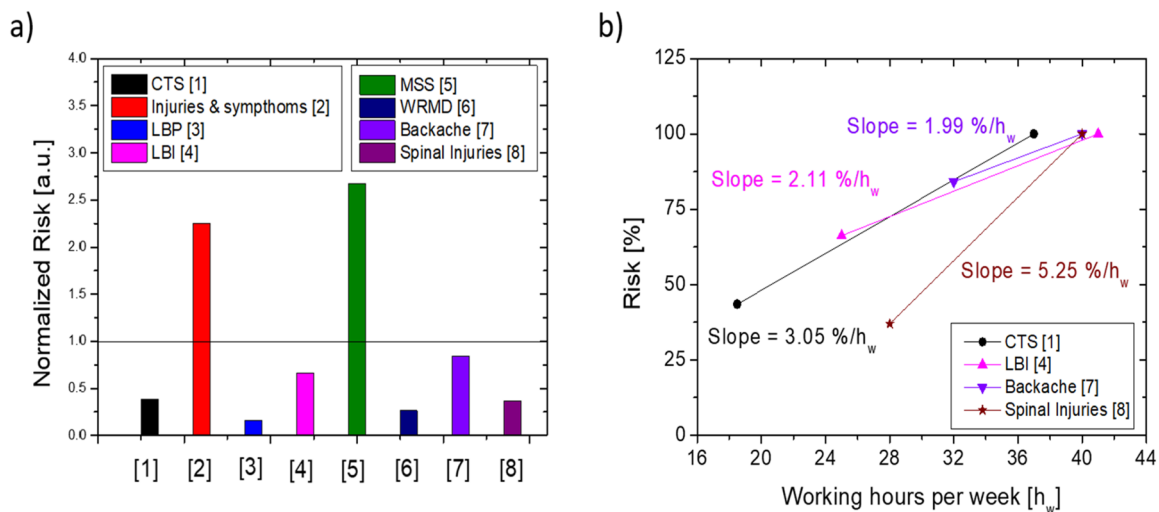


Figure 1. PRISMA diagram schematically summarizing the article selection process.

**Table 1.** A comparative analysis of musculoskeletal disorder health risks among full-time and part-time employees.

Reference	Population ( <i>study design</i> )	Shift duration (hours/week, $h_w$ )	Main health-related outcome	Main results
(Bonfiglioli et al., 2007)	324 participants (71 full-time and 155 part-time cashiers; 98 office workers, as control group) 100% females ( <i>cross-sectional</i> )	Full-time cashiers (37 $h_w$ ); part-time cashiers (18.5 $h_w$ ) 6 and 3 days/week work schedule respectively	Carpal Tunnel Syndrome (CTS) symptoms (current nocturnal and/or diurnal numbness, tingling, burning or pain in at least one of the first three fingers) and CTS cases (CTS symptoms + slowing of sensory conduction velocity from wrist to palm)	Full-time cashiers presented an increased risk for CTS symptoms compared to office workers (control group) (OR 2.3; 95% CI 1.10–4.80, $p=0.026$ ) (univariate analysis). No significant increase of CTS symptoms and cases was observed for part-time cashiers when compared to controls.
(Minghelli et al., 2019)	176 Hypermarket cashiers (86 full-timers and 90 part-timers) 95% females ( <i>cross-sectional</i> )	Cashiers could work between 5 to 40 $h_w$ (average: 31.89 ± 8.83)	Incidence of musculoskeletal injuries over the last 6 months (pathologies of the upper limbs, including CTS; herniated disk injury and self-reported painful symptoms such as LBP and neck pain)	Part-timers presented a 2.25 times higher injury probability (95% CI 1.17–4.32; $p=0.015$ ) compared to full-timers. The most common injuries were in the shoulder, the cervical and lumbar spine.
(Manninen et al., 1995)	363 middle-aged farmers (104 full-time farmers, 82 part-timers and 177 retired) 46.8% females (12-year follow-up study)	Not specified	Unspecified Low Back Pain (LBP) and sciatic pain	Risk of sciatic pain (OR = 0.16; 95% CI 0.03–0.72) and unspecified LBP (OR = 0.16; 95% CI 0.19–1.84) in part-time farmers compared to full-time ones.
(Krause et al., 2004)	1233 transit driver operators (990 full-time drivers, 107 part-timers and 136 overtime workers) 14.4% females ( <i>prospective</i> )	Regular part-time: 20–30 $h_w$ ; Regular full-time: 31–50 $h_w$	Low back non-traumatic injury (LBI) relating to the lumbar or sacral region of the spine	Compared to part-time driving, full-time driving was associated with an increase in the hazard rate of LBI by 51% (HR = 1.51; 95% CI 0.96–2.36; $p=0.071$ )
(Alelyani et al., 2023)	814 participants (clinical radiologists, specialists, residents and consultants) (592 full-timers and 222 part-timers) 49.6% females ( <i>cross-sectional</i> )	Not specified	Self-reported musculoskeletal symptoms (MSS) in different body regions (neck, wrist/hand, shoulder, upper back, lower back, elbow, hip/thigh/buttock, ankle, and knee)	Part-time radiologists showed a 2.673-fold increase in the probability of developing MSS compared to full-time (95% CI 1.43–4.98)
(Muaidi & Shamb, 2016)	690 physical therapists (545 full-time and 145 part-time) 40.9% females ( <i>cross-sectional</i> )	Not specified	Work-related musculoskeletal disorders (WRMDs)	Full-timers showed a higher prevalence of WRMDs than part-timers (79.0% of WRMDs prevalence for full-timers vs. 21.0% for part-timers; $t=2.28$ ; $p=0.023$ )
(Benavides et al., 2000)	15146 European workers (11180 full-timers, 3043 part-timers, 923 small employers) Male/female percentage was not specified ( <i>cross-sectional</i> )	Part-time ( $\leq 35 h_w$ )	Self-reported health outcomes: fatigue, backache, muscular pain in arms or legs	Permanent part-time and fixed-term part-time showed OR $\leq 1$ for all outcomes (risk of backache in part-timers: OR = 0.83) (full time permanent employment was used as the reference category)
(Krause et al., 1998)	1854 transit vehicle operators (full-timers and part-timers not specified) Male/female percentage was not specified ( <i>prospective</i> )	Part-time: 30 $h_w$ ; Full-time: 40 $h_w$	Spinal injuries (events resulting in a workers' compensation claim do to strain, sprain, contusion or pain of the spine)	Regular part-time driving was associated with a 2.7-fold reduced risk for spinal injury compared with full-timers (OR: 0.37; 95% CI 0.15–0.93)



**Figure 2.** (a) Comparative Analysis of Musculoskeletal Health Risks in Part-Time Versus Full-Time Workers (Full-Time Normalized to 1 represented by the black solid line). The reported studies comply with the order in Table 1 and are labeled as follows: [1] Bonfiglioli et al., 2007; [2] Minghelli et al., 2019; [3] Manninen et al., 1995; [4] Krause et al., 2004; [5] Alelyani et al., 2023; [6] Muaidi and Shanb, 2016; [7] Benavides et al., 2000; [8] Krause et al., 1998. (b) Percentage of the risk for part-time workers normalized on the full-timers (reference 100%) for the studies reporting the weekly working hours for part- and full-timers. For studies reporting a weekly hour range, the middle value of the range was used. Graphs and data analysis were performed using OriginPro 8.5.

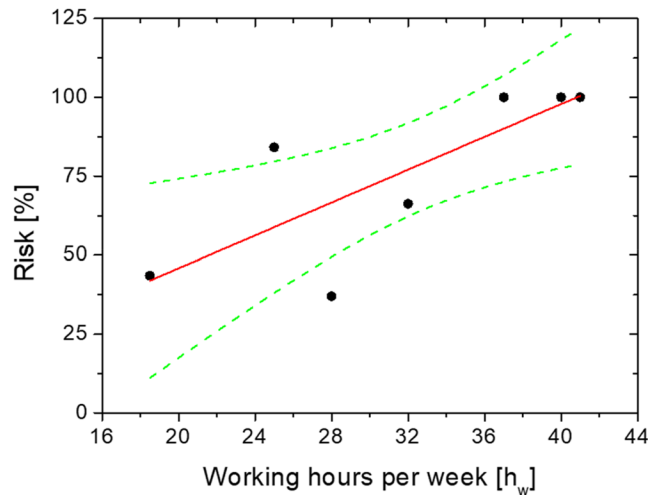
of force and repetitiveness between full-time and part-time cashiers. The importance of considering work duration and recovery time is highlighted in occupational risk assessments for upper limb musculoskeletal disorders.

Minghelli et al. (1995), in contrast, observed a higher risk of musculoskeletal injury among part-time workers in a study of 176 hypermarket checkout employees. Analyzing self-reported injuries, including carpal tunnel syndrome (CTS), these authors found that part-time cashiers experienced a 2.25 times greater risk of injury compared to their full-time counterparts (95% CI: 1.17-4.32;  $p=0.015$ ). The primary anatomical regions affected were the shoulder, cervical and lumbar spine, and wrist. However, the authors acknowledged the potential influence of non-work activities (e.g., hobbies, sports) on these results, highlighting the importance of considering such factors when investigating the relationship between occupational workload and health outcomes (Voglino et al., 2022). It is important to note that the cross-sectional study design limited the establishment of causal inferences.

The other studies retrieved showed part-time workers having a lower risk of developing musculoskeletal disorders or injuries than full-time workers, except for the study of Alelyani et al. (2023), in which the likelihood of developing self-reported musculoskeletal symptoms in radiologists who worked part-time was

higher than in full-timers. Indeed, part-timers may work in night shifts, and this has been shown to have a significant effect on the musculoskeletal system (Yizengaw et al., 2021). This finding is also consistent with a study by Lee et al. (2018), who reported that employment status significantly affected musculoskeletal symptoms. Among the studies included, only the longitudinal study of Krause et al. (2004) found a statistically significant dose-response relationship between weekly driving hours, including overtime driving, and the hazard of LBI: the risk increased 1.2% for every hour of weekly driving (HR= 1.12; 95% CI = 1.00-1.25;  $p=0.047$ ).

Figure 2(b) shows the trend in health-related outcome risk for the four studies (Benavides et al., 2000; Bonfiglioli et al., 2007; Krause et al., 1998; 2004) that precisely reported the weekly shift length of part-timers and full-timers. Fitting the trend allowed us to compute slopes (i.e. the risk scaling factors from part-time to full-time), which assesses the increase/decrease in the risk percentage upon additional working hours. For example, the Bonfiglioli et al. (2007) study highlights a 3.05% increase in the risk of developing CTS for each additional hour of weekly activity. While Figure 2(b) illustrates a range of risk levels across the various studies, it's important to acknowledge that all studies consistently show a decreased risk of adverse health outcomes for part-time workers, even though the specific health issues varied (for example, some



**Figure 3.** Best fit (red line) and confidence interval (green dotted lines) of the risk percentage of part-time workers normalized on the full-timers (reference 100%) for the 4 studies included in Figure 2(b). Data analysis and graphical representations were performed with OriginPro 8.5 software.

studies focused on lower back injuries, while others examined carpal tunnel syndrome symptoms affecting the hands and wrists).

The overall risk trend of MSDs regarding working hours per week is presented in Figure 3, fitting the results of the studies reported in Figure 2(b) and computing the confidence interval. The red line in Figure 3 is represented by the following equation, correlating the risk (percentage) in function of the working hours per week ( $h_w$ ):

$$Risk(\%) = (2.6 \pm 0.8) \cdot h_w - (6 \pm 30)\%$$

The  $r^2=0.64$ , indicating that almost two thirds of the variance in the measure of risk is determined by the duration of working time.

#### 4. Discussion

Biomechanical risk assessment methods recommend workplace conditions under which nearly all workers may be repeatedly exposed, day after day, without developing work-related disorders. Over the years, methods have been developed to assess job exposure comprising multiple tasks, such as the HAL-ACGIH (TLVs and BEIs, 2018) and the Revised Strain Index (Garg et al., 2017). Some methods (e.g., the HAL-ACGIH) make it explicit that the assessment results apply when the work is performed from 4–8 h per day. Other methods allow risk assessment when the exposure to risk factors has a limited duration related to the daily work shift, such as the NIOSH method (NIOSH, 1994). Alternatively, the frequency of exposure might not be daily, but the work tasks

could be allocated over fewer days per week. This issue was well addressed by Bonfiglioli et al. (2007) showing that, for the same daily exposure to manual work as measured by the HAL-ACGIH method, the risk of developing symptoms (and becoming cases) of CTS in part-time cashiers working six hours/day, three days/week was the same as the control cases (office workers), while it increased significantly in full-timers (six hours/day, six days/week).

Indeed, in a retrospective examination, Lavender et al. (2012) found that low back injuries were reduced when the recovery time between consecutive lifts was longer. This finding is related to exposure hours and indirectly related to daily working hours. Despite the absence of a universally accepted definition of part-time employment, and the varying thresholds of working hours that define part-time status across countries, our report underscores the necessity of longitudinal studies to further our understanding of this subject (International Labor Organization, 2016). Moreover, since many potential causes of MSDs include not only physical and biomechanical risk factors but also psychosocial risk factors (e.g., high work demands and low autonomy), these factors deserve to be considered as confounders in longitudinal studies (OSHA, 2021).

Our preliminary mathematical analysis highlights a linear correlation of the biomechanical risk with weekly working hours: within the range 20–40 h/week, we estimated a 3% risk increase for each working hour. This finding envisions a positive outcome provided by reducing the weekly working hours while highlighting the need for longitudinal studies with targeted case definition, exposure assessment, duration, and distribution of

weekly hours of work, controlling possible confounders, mandatory for developing a reliable predictive model. Our study can help to better understand how different work schedules can impact the workload in manual tasks and to evaluate the benefit of reducing the weekly working hours as an effective organizational intervention to improve occupational health and safety.

## Author contributions

CRedit: **Francesco S. Violante**: Conceptualization, Project administration, Supervision, Writing – review & editing; **Francesca Graziosi**: Data curation, Investigation, Methodology, Writing – original draft; **Yohama Caraballo-Arias**: Investigation, Writing – review & editing; **Francesco Decataldo**: Data curation, Formal analysis, Investigation, Writing – original draft; **Roberta Bonfiglioli**: Conceptualization, Methodology, Project administration, Writing – review & editing.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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