



The role of physical activity in workplace well-being: impacts on stress, productivity, and health: a narrative review

Carlo Rossi¹ · Valerio Giustino¹ · Antonino Patti¹ · Flavia Figlioli¹ · Alessandra Amato² · Domenico Savio Salvatore Vicari^{1,3} · Marco Gervasi⁴ · Alberto Canzone¹ · Mirka Lukic-Sarkanovic^{5,6} · Tatjana Trivic⁷ · Patrik Drid⁷ · Patrizia Proia¹ · Antonino Bianco¹

Received: 26 February 2024 / Accepted: 29 May 2025

© The Author(s), under exclusive licence to Springer-Verlag Italia S.r.l., part of Springer Nature 2025

Abstract

Purpose Stress is a condition that can manifest itself as a distortion of the normal functioning of the body and mind. A fair amount can be positive for the achievement of work objectives, but when it is excessive, it can have repercussions in the workplace, worsening the quality of the work itself. Considering the well-known benefits of physical activity (PA), it can improve and prevent this and other negative conditions to which a worker is subjected. Therefore, this narrative review aims to investigate the current situation on workplace stress and the effects of PA on workers' health in both sedentary and non-sedentary jobs to raise awareness that PA can improve workers' quality of life.

Methods To retrieve eligible articles on workplace stress and the effects of PA, a manual search was conducted on the following databases: PubMed, Google Scholar, and Web of Science. Articles published up to March 31, 2023 were included, with no limitation related to the start of the research period.

Results PA appears to provide numerous benefits to workers in the workplace, from physical to mental improvements.

Conclusions PA is of considerable importance in improving the quality of life of workers, reducing stress, and improving productivity.

Keywords Physical activity · Exercise · Public health · Lifestyle · Occupational jobs

✉ Carlo Rossi
carlo.rossi@unipa.it

¹ Sport and Exercise Sciences Research Unit, Department of Psychology, Educational Science and Human Movement, University of Palermo, Via Giovanni Pascoli 6, 90144 Palermo, Italy

² Department of Biomedical and Biotechnological Sciences, Section of Anatomy, Histology and Movement Science, School of Medicine, University of Catania, Catania, Italy

³ Department of Neurosciences, Biomedicine and Movement Sciences, University of Verona, Verona, Italy

⁴ Department of Biomolecular Sciences, Division of Exercise and Health Sciences, University of Urbino Carlo Bo, Urbino, Italy

⁵ Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia

⁶ Clinic for Anaesthesia and Intensive Care, Clinical Centre of Vojvodina, Novi Sad, Serbia

⁷ Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia

Introduction

Stress is a condition that can manifest itself as a distortion of the normal functioning of the body and mind. It can be caused by several factors, such as work and lifestyle. In moderate amounts, stress can be beneficial as it helps achieve personal and professional goals [1]. However, an excessive amount of stress can have negative effects on a worker's physical and mental well-being.

There are different methods for measuring stress, such as questionnaires for psychologic characteristics. Furthermore, physical measurements can involve the evaluation of physical parameters such as blood pressure. While, physiological measures can include the measurement of hormone levels [2]. There are several strategies to relieve stress, such as listening to music, engaging in various hobbies, and most importantly, practicing physical activity (PA).

Workplace stress is a global problem, and scientific literature is increasingly trying to understand it. Due to changes in the workplace, there has been an increase in work-related

issues and the definition of work-related stress is being referred to today as the 'disease of the century' [1]. The term "stress" is used to describe a sense of frustration, anxiety or nervousness that distorts normal mental and physical functioning, with negative consequences for the individual and for those who disturb him. In the past, the literature has attempted to define stress as "any condition that disturbs normal functioning" [3] or as "a non-specific response of the body to any demand" [4]. Recently, the National Association of Mental Health differentiated stress from pressure, which was often associated with it, by defining pressure as a subjective feeling of tension or arousal triggered by a specific potentially stressful situation, in particular when the pressure is high, stress arises [1]. Sedentary behaviors increase the risk of developing cardiovascular disease, highlighting the importance of an active and healthier lifestyle as outlined by new guidelines [5]. Public health bodies, such as the World Health Organization (WHO), emphasize the promotion of PA in workplaces as a crucial intervention to improve the health and well-being of the working population [6]. However, it is important to recognize that workplace health does not solely depend on PA. Work-related stress, often exacerbated by sedentary behavior and high demands, can lead to burnout a condition resulting from chronic emotional and interpersonal stress. This highlights the need for a more holistic approach to workplace health, addressing both physical and mental stressors. One of the factors to which work-related stress leads is the burnout, a response to chronic emotional and interpersonal stressors at work. It is described by the three dimensions of burnout, cynicism, and ineffectiveness at work. As an occupational stress syndrome, burnout is individual stress within the broader organizational context of work. Work burnout is one of the stressors to which a worker is often subjected. However, it is a long-term process that develops following prolonged exposure to chronic, acute, and/or excessive workplace stressors [7]. Work burnout develops gradually and results from a depletion of intrinsic energy over time [8]. It is characterized by physical, cognitive, emotional, and interpersonal exhaustion [9, 10]. This leads to a decline in the quality and quantity of work and both physical and mental health which can be dangerous not only for the individual worker but also for the productivity of the work itself. Moreover, burnout could also cause changes in the endocrine and/or immunologic system [11]. There are many other conditions to which a worker is subjected not to the best of his conditions. It is important to address the issue of obesity, as workplace sedentary behavior is a significant risk factor for weight gain and associated health complications. Lack of PA can contribute to metabolic disorders, emphasizing the need for strategies that encourage movement among workers. There is growing evidence that obesity and being overweight may be related, in part, to poor working conditions. In particular, the risk of obesity may increase in high-demand, poorly supervised work environments and for those who work long hours. In addition,

obesity can affect the risk of vibration-induced injuries and some occupational musculoskeletal disorders [12]. Indeed, adults spend a quarter of their lives at work, and the pressures and demands of work can influence their eating habits, leading to overweight and obesity [13–17]. Obesity can affect both job opportunities and performance, as well as alter the relationship between workplace exposure and health outcomes.

The effect of PA on occupational stress in the workplace can induce changes in physical and biologic factors, such as body temperature increase, adrenaline-positive increase, and sleep quality improvement [18]. In addition, there are changes in psychologic factors such as improved mood, physical perception, and body image [19]. Several studies suggest that involvement in PA predicts lower levels of future work burnout and depression [20–22]. PA has been shown to improve this negative condition and prevent various problems, such as obesity, endocrine disorders, and increased stress. PA seems to decrease these stressors to which the worker is subjected, in particular by leading him to improvements both at a physical level, such as postural improvements and reduction of back pain [23, 24], and improvements in mental health [25, 26]. In general, we can state that PA seems to play a crucial role in improving the quality of life of workers [27]. Workplace PA and leisure-time PA have distinct effects on stress management and employees' psychologic well-being. Park & Jang (2019) conducted a systematic review showing that workplace exercise interventions are linked to reduced occupational stress and improved quality of life among employees [28]. Similarly, Chu et al. (2014) analyzed the effects of leisure-time PA, demonstrating that structured exercise programs and yoga significantly reduce anxiety and depression symptoms. These findings highlight the importance of promoting both workplace PA and leisure-time PA to maximize their benefits for mental health and overall well-being. Future interventions should consider tailored approaches to integrate movement into work routines while also encouraging employees to remain physically active outside of work hours [29].

This narrative review aims to investigate the current situation related to physical and mental stress to which workers are subjected in the workplace and to evaluate the effects of PA on workers' health in both sedentary and non-sedentary jobs in order to raise awareness that PA can improve quality of life of workers, reducing the negative factors that often compromise workers' health.

Methods

To retrieve eligible articles, a manual search was conducted on the following databases: PubMed, Google Scholar, and Web of Science. Articles published up to March 31, 2023 were included, with no limitation on the start of the search

period. To identify suitable items, the following search strategy was adopted: (workers) AND (office worker) OR (teacher) OR (healthcare workers) OR (sedentary jobs) OR (non-sedentary jobs), ((health) OR (outdoor office work) OR (workplace) OR (office workers)) AND ((professional jobs) OR (stress) OR (behaviour) OR (public health) OR (exercise) OR (PA)). This search was extended using the bibliography within the selected texts. Articles published in English were taken into consideration. To summarize the findings of this review, we have divided the review into subsections, the first assessing the causes and measurements of stress in the workplace, the second introducing the topic of effects of PA in the workplace and the next two subsections clarifying aspects of different working conditions (effects of the PA on sedentary jobs, effects of the PA on non-sedentary jobs, effects of the PA on the endocrine system in the workplace). Two authors (CR and VG) conducted the literature search and finally resolved disagreements about including the article in discussions with a third researcher (AB). To identify duplicate studies, selected manuscripts from each database were loaded into EndNote software (EndNote version X8.1; Thompson Reuters, New York, USA). We have chosen to conduct a narrative review as it is an effective method of providing an overview of current knowledge in the literature on a given topic. Unlike systematic reviews or meta-analyses, which locate and analyze existing studies, a narrative review generally describes research findings on a topic in a more explanatory way. This allows to explain how a certain topic evolves and is studied over time, to discuss the trends emerging from research and to identify the main knowledge present in the existing literature [30].

Results

Causes and measurements of stress in the workplace

The causes of stress can be divided into two categories based on their origin: internal causes and external causes (Fig. 1).

Internal causes refer to an individual's mindset and way of thinking. These causes originate from within the individual and can lead to stress. They are based on personal perception and often there is no real threat in the surrounding environment. A person may perceive a person or situation as threatening and feel stressed. Internal and external causes include several factors within an organization that affect an individual's performance. The study by Panigrahi et al. 2016 defines some causes [1], for example:

- **Job insecurity:** Fear of losing a job can cause chronic stress and affect the quality of work performed by an employee.
- **Working hours:** Irregular or excessively long working hours can cause physiological problems and stress for employees.
- **Control over work:** The degree of control an employee has over their work can affect the level of interest and stress. When an employee has little or no control over their job, they may feel less motivated and less stressed about trying to meet the expectations of superiors.
- **Managerial style:** The control exerted by managers affects employee stress. Managers with an autocratic control style provide very little freedom to employees in decision-making and planning. As a result, employees working under such managers experience high levels of stress due to minimal control over their work and highly restrictive measures.
- **Overwork and underwork:** Too much work to do in a short period or a lack of work and significant responsibilities can both cause stress. Excessive or insufficient expectations can put a strain on an individual.
- **Behavioral changes:** Situations that require changes in behavior or work approach can be stressful for an employee, as they may require adopting new or unfamiliar behavioral patterns.

These are just some of the leading causes of work-related stress. Sources of stress can vary according to the individual and the work context. It is important to recognize

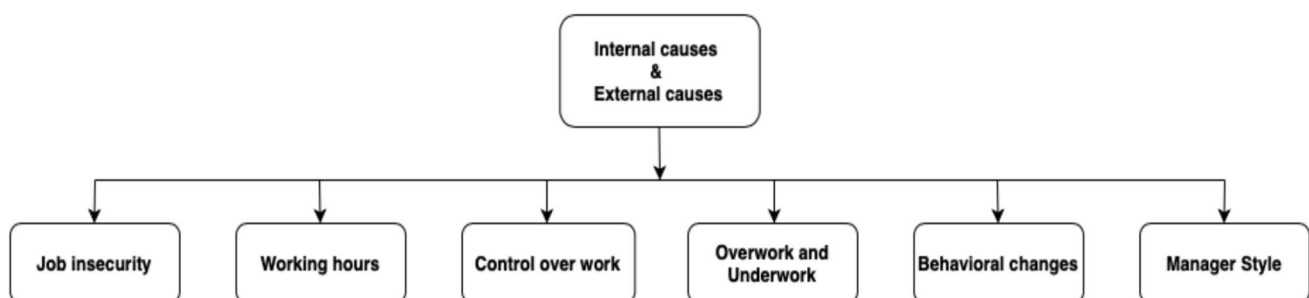


Fig. 1 Internal and external causes of work stress

these factors and implement stress management strategies to maintain employee well-being and promote a healthy work environment [31].

There are many methods in the literature to measure stress, i.e., quantify the response of a worker's body to a stressful situation [2, 32] (Fig. 2). Some of these measurements are:

- **Psychologic measures:** These measures measure stress based on psychologic observations, considering that each worker responds differently.
- **Physiological measurements:** When someone comes across a stress-inducing situation, the person's hypothalamic–pituitary–adrenal axis (HPA) which contains the hypothalamus, pituitary, and adrenal glands of the endocrine system is activated. Under stimulation, these glands produce their hormones, namely cortisol and catecholamines. Elevated levels of those hormones are found in the blood, urine and plasma of the person undergoing stress.
- **Blood pressure:** When a person is under stress, blood pressure is elevated from its normal range of 120/80 mmHg.
- **Vagal tone:** vagal tone is a parasympathetic nervous system response that leads to the prevention of heart rate reduction during sleep or rest. This means that during sleep the person's heart beats as hard as it does when awake.
- **Salivary alpha-amylase:** This enzyme in saliva is an important indicator of stress. Levels of this enzyme are elevated during exercise. And the link between catecholamine level and salivary alpha-amylase is proven. This enzyme can also be used to measure the activity of the parasympathetic nervous system. The connection between vagal tone and salivary alpha-amylase is linked to the regulation of the autonomic nervous system. Vagal tone, which reflects the activity of the vagus nerve, is associated with the modulation of stress and physiological responses. Salivary alpha-amylase, on the other hand,

is a biomarker of sympathetic nervous system activation, often used to measure the stress response [33].

- **Salivary cortisol:** Salivary cortisol represents the amount of cortisol not bound to any receptor. This concentration can pass through the blood–brain barrier and impair higher-order cognitive functions such as learning, memory, and emotional processing.

Effects of physical activity on workplace

PA can be defined as “all body movements that increase energy consumption beyond resting levels” [34]. Specifically, PA aims to promote well-being and improve the health of those who engage in it. According to the WHO, health is defined as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity” [35].

PA can occur spontaneously, such as during leisure time, transport (e.g., walking), or work, or it can be organized. It can also be further subdivided based on its purpose. For instance, exercise should not be confused with physical training. The former is primarily aimed at improving health and physical capacity, whereas physical training is focused on increasing an individual's maximum physical capacity and performance [34].

In the context of workers, we are primarily referring to physical exercise aimed at improving health and quality of life. However, PA can also be related to performance improvement, which can be applied back to the workplace, or/to prevention. Physical inactivity, to which workers are often subjected, is described as the absence of movement of the body, when energy consumption approaches resting levels, and therefore where multiple negative effects on health ensue. People who do not meet the recommendations for PA are considered physically inactive. prolonged periods of sitting time, with low energy expenditure refers to “sedentary” behavior.

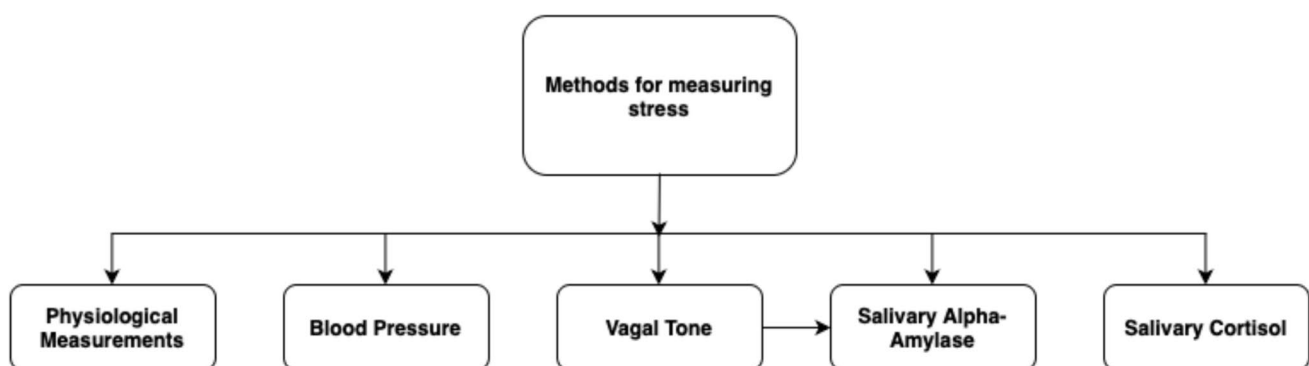


Fig. 2 Methods for measuring stress

PA can be organized according to age, gender, level of ambition, referring to the motivation, intensity and commitment a person devotes to their fitness goals, ranging from casual participation to structured training, weight, or other groupings, such as the work activity that an individual performs daily, and can therefore be individualized according to the needs of each subject. [34]. The literature suggests that PA lead to positive benefits and reduces the risk of chronic diseases and mortality [36]. Many studies suggest that a sedentary lifestyle is a major risk factor for non-communicable diseases, so being physically active forms part of workplace health promotion to avoid all negative effects related to a sedentary lifestyle [36]. This topic was also addressed in another systematic review which aimed to provide an overview of the effectiveness of workplace promotion interventions on chronic disease-related physical and mental health, concluding that resistance exercise leads to positive effects on the physical and mental health of the worker [26]. A recent systematic review by Prince et al. (2021) aimed to determine whether leisure-time physical activity (LTPA) by workers with sedentary behavior had the same health effects as occupational PA, concluding that LTPA provides non-trivial benefits and some more risk reductions significant mainly in workers performing work activities with low PA compared to work activities containing high PA [37]. Furthermore, PA performed in the workplace, i.e., yoga programs, would appear to be associated with a significant reduction in the worker's depressive symptoms and anxiety [38]. Physical inactivity can affect any worker regardless of the type of job. According to Saridi et al. (2019) even health-care workers, despite non-sedentary jobs, tend to be sedentary and should therefore be more aware of the importance of PA [27]. Sliter et al. (2014) investigated, through a survey, PA practice and frequently experienced stressors (patient stressors, staffing demands, and workload) and psychologic outcomes (depression, commitment, and life satisfaction) in a sample of 152 nurses. Authors found that nurses who engaged in regular PA had less stress than those who led a passive life outside of work [39]. Their findings imply that PA can prevent some of the negative consequences of work-related stressors [39]. Even teachers, due to their mainly sedentary work performance, such as the habit of using the computer or spending many hours in the classrooms, usually maintain a sedentary lifestyle which is often maintained even outside working life leading to musculoskeletal disorders such as low back pain [23]. Furthermore, high sedentary behavior in teachers is often associated with increased abdominal obesity, and high disruption of leisure-time sedentary behavior was associated with lower odds of hypertension among public school teachers [40]. The adult spends 60% of their daily hours at work. Hence, a positive and favorable work environment needs to avoid harmful effects on workers' health [41]. To avoid this, it is essential

to introduce PA into the workplace [41]. Fortunately, in recent years, many studies have focused on this topic and knowledge is expanding. Furthermore, PA seems to lead to an increase in the productivity of each worker, together with a suitable structured environment, and a well-designed PA [42]. All this could lead to a more productive predisposition for the worker who, finding himself in favorable working conditions, would be able to work better, and therefore, the company would have a positive return.

Effects of physical activity on sedentary jobs

In the literature, a “sedentary job” is defined as an occupation where the amount of work and the total work time is spent more in a sitting position than in a moving and/or standing position. This is assessed with the help of a single question that is reported by the workers. Thus, workers who report sitting for most of the working day are counted as working and thus have a sedentary job. Conversely, workers who report on being on the move for most of the working day are counted as workers in a non-sedentary job [20, 43, 44]. The criteria for explaining the type of work (sedentary or non-sedentary) are defined according to the time a worker spends during the working day in motion (walking, moving objects) or in a static position (such as sitting). Based on the above, it is possible to underline the importance of PA and its central role in the well-being of the worker, emphasizing that the promotion of regular PA is of primary importance for psychophysical performance, social relationships, work performance, prevention of non-communicable diseases, absenteeism, and occupational injuries. Studies have shown that even small amounts of PA throughout the day, such as walking or stretching, can reduce blood pressure, and improve posture, and postural control, which is the ability of the nervous system to modulate the distribution of the body in space [45] and increase feelings of well-being [46, 47]. This can also boost energy and focus, improving productivity at work [48].

The back, neck, and spine are often subject to health disorders and musculoskeletal pain [49–51], with harmful consequences in terms of socioeconomic expenditure in terms of healthcare costs and lost working days [52]. Jobs involving monotonous and repetitive work, such as computer work are of particular concern [53]. The etiology of musculoskeletal pain symptoms is multifactorial with several occupational physical and psychosocial risk factors not fully defined [54–56]. Both specific muscle training and general exercise have shown beneficial effects on neck and low back pain [57–60]. However, there is a lack of knowledge on the effects of exercise on musculoskeletal disorders in other regions of the body, and on the preventive effect of exercise on the development of pain symptoms in individuals without disorders to prevent future recurrence.

Sipaviciene et al. (2020) analyzed the effects of different exercise programs on low back muscle function, multifidus cross-sectional area, functional disability, and low back pain in people with sedentary jobs. The authors concluded that 20 weeks of exercise programming for lower back muscle strengthening were effective in reducing low back pain, pain, and functional disability in people in sedentary work, especially by performing strengthening and stabilization work on the spine and measuring the cross-sectional area of the multifidus muscle was performed using an ultrasound system [24]. Indeed, in these workers, the time spent in a sedentary manner, throughout their careers, can have musculoskeletal and/or cognitive influences if not adequately compensated for by adequate PA [61]. Baker et al. [61] suggested that prolonged sitting may have negative consequences for musculoskeletal discomfort and cognitive function, and therefore breaks are recommended to interrupt prolonged sitting. As a result, office workers should improve their lifestyle, as they may spend up to two-thirds of their working day seated [25]. Nooijen et al. [25] evaluated multi-component interventions, incorporating individual, environmental, and organizational changes to increase PA and/or reduce sedentary behavior among office workers to improve mental health and cognition. They conducted a 24-month protocol and a measurement every 6 months including cardiovascular fitness, body composition, sleep, self-reported PA and sedentary behavior, other health habits and questionnaires. This multi-component intervention has proven to be positive for workers with a sedentary lifestyle [25]. The work's characteristics can affect the worker's lifestyle and free time, leading to negative consequences for the well-being of the worker [62]. The workplace should provide opportunities for PA and promote PA to reduce sedentary lifestyles. Smith et al. [63] in their review report that intervention efforts to increase occupational PA and reduce sedentary time may be more effective when targeting white-collar workers. Awareness of the importance of an active lifestyle for workers is starting to emerge in some countries and greater value is placed on PA in the workplace. For example, in Sweden, where an employee well-being PA program results in reimbursement of expenses, the association between PA, general health rating and self-efficacy with participation in a well-being program were evaluated and analyzed employees, concluding that a part of the workers in any case began to perceive important benefits for their health [64], and confirming the importance of PA for workers, even a simple mild but constant PA over time.

Another important key factor in the work is the quality of sleep. Regular PA could increase job satisfaction, sleep quality, and consequently quality of life for office workers. Exercise has been shown to reduce symptoms of insomnia and enhance sleep efficiency, which are often disrupted by the pressures of work [65, 66]. In particular, PA can help

alleviate the physiological and psychologic stress responses induced by work-related pressures, thereby promoting better sleep and overall recovery [67]. Aerobic exercises, such as walking, running, or cycling, have been found to be especially beneficial for workers who experience high levels of stress, as they not only improve sleep quality but also regulate circadian rhythms and stabilize the sleep-wake cycle [68]. However, it is important to note that the timing of exercise matters: intense PA in the evening, especially after a stressful workday, can sometimes interfere with sleep quality due to elevated body temperature and heightened alertness, which can exacerbate the effects of work-related stress [69]. Therefore, finding a balance in exercise routines is key to maximizing its positive effects on both stress reduction and sleep quality for workers. However, further studies should be conducted to fully evaluate the role of PA practice on work's aspects [70].

Since sedentary work also influences psychologic factors, it appears that in a multi-strategy intervention, with a clear emphasis on PA in the workplace, the use of theories of behavior change through a more active lifestyle may be indicative and may be a more effective intervention [71]. Even small changes to a daily routine, as taking the stairs instead of the elevator or going for a walk during breaks, can have health benefits. Employers can also encourage PA among their employees by providing access to exercise facilities and allowing for regular breaks during the working day. By promoting PA in the workplace, employers can improve the overall health and well-being of their employees, ultimately leading to a more productive and efficient workforce. Assessing the correct level of PA suitable for workers is not that straightforward, as often the assessment is subjective when instead an objective measurement would be more appropriate. Consequently, research on PA levels, especially in workers with a sedentary lifestyle, should consider using an objective measure to accurately ascertain a person's PA level [72]. Recent literature has shown that sedentary behavior in the workplace can be reduced through changes to the work environment, such as the introduction of active workstations [73]. An active workstation allows people to incorporate PA into a sedentary activity and can include different types of activities such as walking on a treadmill, pedaling a stationary bike, using an elliptical trainer, or simply standing at a desk height-adjustable [74]. A recent study modified the environment, specifically fixed desks with a standing workstation with to allow employees to switch between sitting and standing [75]. After 1 week, the intervention group significantly reduced their sitting time by 143 min per day compared to the control group [75]. Another study using treadmill desks instead reported a significant 9% reduction in sitting by more than 90 min at the end of a six-month intervention, although this effect dropped to

43 min at 12 months after the intervention, demonstrating the importance of constancy over time [76]. Portable pedal trainers have also been used to increase seated activity when needed, which is termed “active sitting”. One study reported a 60-min reduction in sitting time per day at the end of a 3-month intervention using these active sessions [77]. These studies suggest that sitting time can be reduced in the workplace by using active workstations.

Effects of physical activity on non-sedentary jobs

For non-sedentary jobs, for example, manual jobs, we mean a type of job for which “a particularly intense and continuous psychophysical effort is required, conditioned by factors that not even suitable measures can prevent”. Despite differences in the level of PA between physically non-sedentary and sedentary jobs, the literature reporting the effectiveness of interventions usually does not distinguish between physically non-sedentary and sedentary [78]. Currently, the correlation between non-sedentary jobs and PA has not been extensively addressed in the literature, so we do not have a key answer on the effects of PA on work ability in these workers [78]. Thus, the literature needs further studies to make this correlation [78]. However, Badarin et al. [79] evaluated the correlation between musculoskeletal pain and non-sedentary jobs, i.e., heavy load handling versus poor physical performance capacity of the worker, concluding that non-sedentary jobs often have higher risks due to poor work capacity physique of the worker, which could be improved through exercise. The literature suggests that it is necessary to minimize non-sedentary jobs, optimize the work capacity of the worker and address the problem of muscle soreness in the workplace, possibly by carrying out PA on an appropriate schedule during and outside working hours [80]. Another study evaluated the correlation between PA and muscle soreness after heavy lifting. Specifically, women had a higher risk of chronic low back pain with jobs that involved lifting than women with sedentary jobs. Furthermore, men are more resistant than women to lifting loads and must be engaged in particularly non-sedentary jobs to develop a greater risk of chronic low back pain [81]. Regular PA can improve cardiovascular health, increase muscular strength and endurance, and reduce the risk of injuries. Furthermore, PA can enhance mood, reduce stress, and increase job satisfaction among workers. Employers can encourage PA among their employees by providing access to on-site gyms or fitness classes, offering incentives for participation in PA, and promoting active breaks throughout the workday. By prioritizing PA in the workplace, employers can create a healthier and more productive

workforce, ultimately benefiting both the individual and the organization offering the job.

Effects of physical activity on the endocrine system in the workplace

The importance of this system is to produce additional hormones in the thyroid, adrenals, and gonads, and secrete them into the serum as the body requires these compounds for many pain-control functions, including protection and regeneration of injured tissue, immunologic activity, and metabolic controls [82–85]. Another fundamental issue for workers' health is the problems to which are subjected at the level of the endocrine system. The literature currently focuses mainly on the HPA axis. However, despite the numerous studies in the literature, it cannot be concluded that clear effects are observed on the function of the HPA axis in stressed subjects [11]. The effects of chronic stress could be observed when measuring more acute responses to stress than in hormone levels in the resting state [11]. Other hormones, such as thyroid hormones, prolactin and growth hormone (GH) in stressed workers, still fail to give a clear and comprehensive conclusion.

Grossi et al. [86] demonstrated that one of the main effects of stress, burnout leads to an increase in inflammatory responses and oxidative stress among women. Numerous studies have reported that various biochemical and pathophysiological factors are responsible for occupational, environmental, and workplace depression [87, 88]. Workers subjected to occupational stress undergo pathophysiological changes that lead to changes in stress hormones, stress-sensitive proteins, and other significant variables [89]. Cortisol, stress hormones, PTH (parathyroid hormone), HO-1 (heme oxygenase-1), and cytokines have been used as a panel of markers for the assessment of workplace stress conditions [89]. Existing literature needs further study and cannot yet confirm any reliable immunologic or endocrinological changes related to burnout [90, 91]. However, PA at work can significantly influence the endocrine system, improving hormone regulation and reducing the negative effects of stress [92]. According to a study published, exercise activates the hypothalamic–pituitary–adrenal (HPA) axis, modulating the secretion of cortisol and catecholamines [92]. In addition, the regular practice of PA at work can improve insulin sensitivity and promote the release of anabolic hormones such as GH and insulin-like growth factor (IGF-1) [93]. PA could improve physiological hormone balance and decrease endocrine burnout. In conclusion, PA has a significant impact on the endocrine system in the workplace. Regular PA can improve insulin sensitivity, reduce inflammation, and promote the release of hormones that regulate mood and energy levels. Employers can encourage healthy behaviors by promoting PA and encouraging breaks

to stretch and move during the workday. By promoting a healthy work environment, employers can support the general health and well-being of their employees.

Summary

This narrative review aimed to explore the current state of work-related stress and to analyze the impact of PA on the health of workers in both sedentary and non-sedentary jobs. Through this investigation, it is intended to promote greater awareness of the importance of PA as an effective tool for improving employees' well-being and quality of life. The literature seems to agree with the fact that PA can be effective for reducing stress in the workplace and workers [1, 39, 94]. To provide a clearer overview of the impact of PA and sedentary behavior in workers, two tables have been included. Table 1 presents studies demonstrating the positive effects of PA on workers' health and well-being, while Table 2 highlights research indicating the negative consequences of sedentary work on various physical and psychologic parameters.

The worker who leads a sedentary life outside of work can be subject to a series of issues, such as cardiovascular, endocrine, and musculoskeletal disorders [82, 95, 96]. This is further supported by numerous studies which have shown a link between sedentary behavior and an increased risk of several health problems, including obesity, type 2 diabetes, and high blood pressure [97, 98]. However, in accordance with the scientific literature, it can be stated that an active lifestyle with regular PA [99], leads to several benefits for both sedentary and non-sedentary workers. Workplace PA provides numerous benefits for both sedentary and non-sedentary workers. Studies have shown that engaging in physical exercise during work hours or through company-sponsored initiatives can significantly reduce the risk of chronic diseases, including cardiovascular disease, cancer, and type 2 diabetes [97, 100]. Regular workplace exercise programs have also been found to enhance mental health and cognitive function while lowering the risk of musculoskeletal disorders [101]. Regular exercise has also been shown to reduce the risk of chronic disease [102, 103]. In addition, regular exercise has been shown to improve mental health and cognitive function, as well as reduce the risk of musculoskeletal disorders [95, 104]. Beyond the physical benefits, workplace exercise programs contribute to fostering a positive work culture. Employees who engage in regular PA report higher job satisfaction and improved social interactions with colleagues, leading to a more cohesive and motivated workforce [105]. Furthermore, companies that prioritize employee wellness through PA initiatives often experience enhanced talent retention and recruitment, as workers are increasingly seeking employers who support their overall well-being [106].

Employers can implement various strategies to encourage physical activity, such as offering gym memberships, organizing group fitness sessions, or incorporating movement-friendly office designs. Research suggests that even small changes, such as encouraging walking meetings or providing standing desks, can have a significant impact on employee health and productivity [101].

Thus, incorporating physical activity into work environments is a crucial strategy for safeguarding employee health, fostering a healthier and more productive workplace, and ultimately contributing to long-term business success. For sedentary workers, regular PA can help counteract the negative effects of prolonged sitting and increase overall fitness and well-being [107]. Incorporating PA into workday, such as taking regular breaks to get up and move around or participating in workplace exercise programs, has been shown to improve health outcomes and work productivity [42]. For non-sedentary workers, PA can help prevent musculoskeletal injuries and reduce the risk of developing chronic diseases associated with a sedentary lifestyle outside of work [79]. However, it is important to note that certain types of PA may be more beneficial to different types of workers. For example, workers who perform heavy manual labor may benefit from strength training and stretching exercises to prevent injury, while workers who spend most of their time seated may benefit from aerobic exercise to improve health cardiovascular.

In addition, it is important to note that the implementation of PA in the workplace must consider the unique needs and preferences of individual workers. For example, some workers may prefer group exercise classes, while others may prefer individual workouts or outdoor activities. In addition, interventions may need to be tailored to specific work environments, such as factories or offices, to ensure they are feasible and effective [108]. In addition, employers may need to consider providing incentives or support systems, such as wellness programs or access to healthy food options, to encourage workers to adopt and maintain healthy behaviors [109]. By adopting a comprehensive and personalized approach to promoting PA in the workplace, employers can help improve the overall health and well-being of their employees while increasing productivity and reducing healthcare costs [101]. It's also important to consider the role of technology in promoting PA in the workplace. For example, wearable fitness trackers can help workers monitor their PA levels while providing personalized feedback and suggestions for improvement [109]. By leveraging technology and promoting flexible working arrangements, employers can create a more supportive and inspiring work environment that encourages healthy behaviors and improves overall well-being [101]. Ultimately, by investing in the health and well-being of their employees, employers can create a more productive, engaged, and successful workforce [109] (Fig. 3)

Table 1 Main results of studies on the effects of physical activity in workers

First author, year	Type of study	Sample	Outcomes	Main results
Forberger et al., 2022	Review	–	Risk factors for non-communicable diseases	Workplace motivation incentives have increased physical activity levels and reduced sedentary behavior, contributing to lower risks of non-communicable diseases
Ramezani et al., 2022	Review	–	Motivation and support	The application of behavior change theories, particularly self-determination theory, has enhanced the effectiveness of workplace physical activity interventions by fostering motivation and external support
Barone Gibbs et al., 2021	Original Article	300	blood pressure and hypertension	A 3-month sedentary behavior reduction intervention improved blood pressure and cardiovascular health in 300 office workers with untreated high blood pressure
Galof et al., 2021	Original Article	115	Back pain	This study examined the relationship between computer usage habits and back pain in 115 participants, highlighting the significance of an ergonomic workspace and regular physical activity for employee well-being
Mänttari et al., 2021	Review	–	Work ability	Different types of physical activity appear to improve work-related skills, yet few interventions have effectively enhanced work ability among employees engaged in physically demanding jobs
Prince et al., 2021	Review	–	Worker health	Leisure-time physical activity (LTPA) is beneficial for all workers, but the risk reduction is more pronounced among those with sedentary jobs than those performing physically demanding tasks, suggesting the need for tailored interventions
Sipaviciene et al., 2020	Original Article	70	Low back pain	A 20-week lumbar stabilization and muscle-strengthening exercise program significantly reduced low back pain (LBP) and functional disability among sedentary workers, with effects lasting for 12 weeks post-intervention
Grimani et al., 2019	Review	–	Absenteeism	Workplace health promotion initiatives positively influenced absenteeism, improving both organizational structure and the physical work environment
Nooijen et al., 2019	Original Article	330	Mental health and cognition	Increasing physical activity or reducing sedentary behavior enhanced mental health and cognitive functions among office workers
Proper et al., 2019	Review	–	Physical and mental health	Workplace health promotion programs yielded improvements in employees' fitness, psychologic well-being, stress management, and reductions in health issues such as back pain, anxiety, and depression
Saridi et al., 2019	Original Article	180	Quality of life	This study identified a positive correlation between physical activity and healthcare workers' quality of life, suggesting that maintaining an adequate level of physical activity enhances overall well-being

Table 1 (continued)

First author, year	Type of study	Sample	Outcomes	Main results
Heuch et al., 2017	Original Article	14,915	Low back pain	Low levels of physical activity at work were associated with an increased risk of developing chronic back pain. Among 14,915 participants, varied work activity levels influenced the incidence of chronic back pain over an 11-year period
Smith et al., 2016	Review	–	Adverse health outcomes	Occupational physical activity and sedentary behavior correlated with multiple factors, including age, gender, education, work environment, and organizational conditions
Ganedahl et al., 2015	Original Article	2,500	General health ratings	Swedish workplace wellness programs were linked to increased physical activity, self-efficacy, and improved employee health
Chu et al., 2014	Review	–	Mental health, depressive, anxiety	Workplace physical activity initiatives contributed to better mental health outcomes, reducing stress and symptoms of anxiety and depression
Shulte et al., 2007	Review	–	Obesity	Sedentary behavior heightened obesity risks, negatively affecting work performance and increasing healthcare costs
Williams et al., 2007	Review	–	Muscle strength and endurance, functional ability, quality of life	Resistance exercises improved muscle strength, endurance, body composition, and overall quality of life for workers
Brown et al., 2005	Original Article	9,207	Depressive symptoms	Physical activity was associated with a lower risk of depressive symptoms in middle-aged female workers, supporting its protective effects on mental health

Conclusions

PA plays a fundamental role in enhancing workers' quality of life by reducing stress and improving productivity. PA contributes positively to the prevention of non-communicable diseases and mitigates the adverse effects of inactivity in sedentary occupations. At the same time, in non-sedentary work environments, PA aids in injury prevention and fosters better work efficiency. Both scenarios illustrate the significant impact of PA on mental health, reinforcing workers' well-being and reducing occupational stress. Chronic work-related stress, when unaddressed,

can contribute to burnout and disengagement from the workplace, further emphasizing the need for proactive interventions.

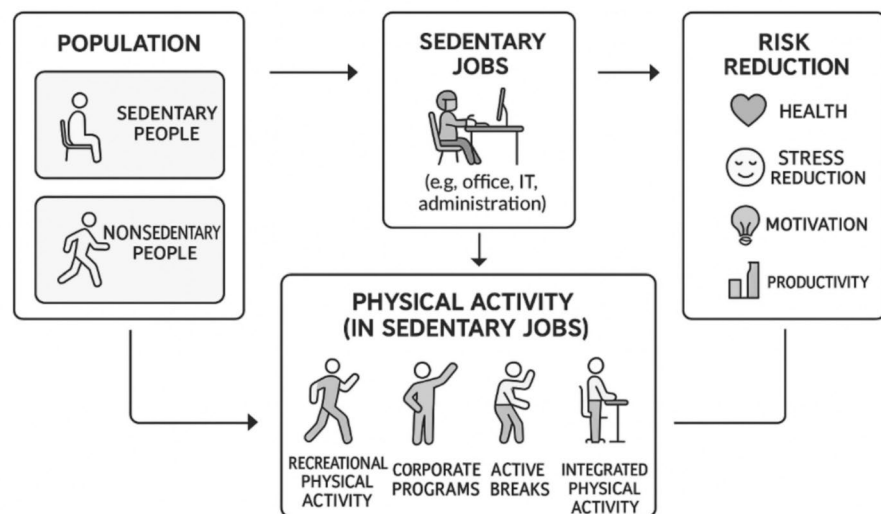
This narrative review serves as a knowledge foundation for this critical subject, providing insights that can guide future systematic reviews and meta-analyses. Despite the extensive literature available, the relevance of this topic remains high for the global workforce. We encourage further research to comprehensively explore each dimension of PA in workplace settings, ensuring continued advancements in employee health and well-being.

Table 2 Main results of studies on the effects of different conditions experienced by workers who adopt a sedentary lifestyle (without physical activity)

First Author, year	Type of study	Sample	Outcomes	Main results
Badarin et al., 2022	Original Article	9.419	Musculoskeletal pain	Musculoskeletal pain and strenuous work are associated with reduced self-reported physical work capacity, suggesting that these factors negatively impact workers' perceptions of their physical abilities. Additional risk factors should be considered, and regular exercise may help mitigate these effects
Jonsdottir et al., 2019	Review	–	Endocrine and immune system	Burnout is linked to alterations in endocrine and immune system function, indicating that chronic stress and exhaustion negatively impact hormonal and immunologic responses, contributing to adverse physical and mental health effects
Baker et al., 2018	Original Article	20	Musculoskeletal discomfort and cognitive function	Prolonged sitting during office-based computer work leads to short-term musculoskeletal discomfort and cognitive decline, including neck, back, and upper extremity pain. Factors such as workstation ergonomics and regular exercise play a role in mitigating these effects
Sanchez-Villegas et al., 2008	Original Article	10.381	Mental disorders	Regular physical activity (PA) is associated with a reduced incidence of mental disorders, whereas excessive sedentary behavior correlates with an increased risk. Maintaining an active lifestyle supports mental health and prevents psychological conditions
Bernaards et al., 2006	Original Article	1.747	Psychologic disorders (depression and emotional exhaustion)	Vigorous leisure-time PA may have a protective effect against psychologic disorders, including depression and emotional exhaustion, in working populations
Grossi et al., 2003	Original Article	20	Immune, endocrine, and metabolic correlates of burnout	Burnout in women is associated with physiological changes, including altered levels of stress hormones such as cortisol and increased inflammatory responses, suggesting systemic dysregulation due to chronic stress
Yamada et al., 2001	Original Article	189	Psychologic fatigue	Implementing 12-h shifts increases psychologic fatigue and unhealthy weight gain in workers, particularly in cleanroom environments, indicating the need for caution when adjusting work schedules
Geliebter et al., 2000	Original Article	85	Increased body weight	Shift work is associated with weight changes, with night shift workers experiencing greater weight gain than those who work during the day. Additional research is needed to fully understand these effects
Enzmann et al., 1998	Original Article	320	Burnout	Burnout is a multidimensional construct, encompassing emotional exhaustion, depersonalization, and reduced personal accomplishment, highlighting the complexity of measuring and addressing workplace stress

Table 2 (continued)

First Author, year	Type of study	Sample	Outcomes	Main results
Niedhammer et al., 1996	Original Article	469	Increased body weight	Night work exposure is linked to weight gain and an increased risk of overweight, suggesting that shift workers require targeted health interventions
Knutsson et al., 1992	Original Article	53	Quality of sleep	The "healthy worker effect" influences the relationship between shift work and health outcomes, as shift workers tend to have better baseline health characteristics, which may affect findings regarding sleep quality

Fig. 3 Consequences of physical activity compared to workers

Author contributions Conceptualization, C.R., A.P., V.G. methodology, A.B., A.P. review and editing, P.P, F.F., M.L.S. investigation, A.A., M.G., P.D. writing, C.R., T.T., A.B., A.C. supervision, A.P. A.B. project administration, A.P. All authors have read and agreed to the version of the manuscript.

Funding This research received no external funding.

Availability of data and materials Not applicable. No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no conflict of interest.

Transparency statement The lead author Carlo Rossi states that this manuscript is an honest account, done as truthfully as possible, and that all participating authors have made contributions considering the importance of the topic, given its worldwide impact.

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

References

- Panigrahi C (2016) Managing stress at workplace. *J Manag Res Anal* 3:154–160
- Lukan J, Bolliger L, Pauwels NS, Luštrek M, Bacquer DD, Clays E (2022) Work environment risk factors causing day-to-day stress in occupational settings: a systematic review. *BMC Public Health* 22:240
- Arnold HJ (1982) Moderator variables: A clarification of conceptual, analytic, and psychometric issues. *Organ Behav Hum Perform* 29:143–174
- Selye H (1956) The stress of life
- Barone Gibbs B, Conroy MB, Huber K, Muldoon MF, Perera S, Jakicic JM (2021) Effect of reducing sedentary behavior on blood pressure (RESET BP): rationale, design, and methods. *Contemp Clin Trials* 106:106428. <https://doi.org/10.1016/j.cct.2021.106428>
- Abdin S, Welch R, Byron-Daniel J, Meyrick J (2018) The effectiveness of physical activity interventions in improving well-being across office-based workplace settings: a systematic review. *Public Health* 160:70–76
- Schwarzer R, Greenglass E (1999) A Social-cognitive perspective: a theoretical position paper. In: Understanding and preventing teacher burnout: a sourcebook of international research and practice, p 238. <https://doi.org/10.1017/CBO9780511527784.016>

8. Hallsten L (2005) 34 burnout and wornout: concepts and data from a national survey. Research companion to organizational health psychology, p 516. <https://doi.org/10.4337/9781845423308>
9. Enzmann D, Schaufeli WB, Janssen P, Rozeman A (1998) Dimensionality and validity of the burnout measure. *J Occup Organ Psychol* 71:331–351. <https://doi.org/10.1111/j.2044-8325.1998.tb00680.x>
10. Shirom A (2003) Job-related burnout: a review. <https://doi.org/10.1037/10474-012>
11. Jonsdottir IH, Sjors Dahlman A (2019) Mechanisms in endocrinology: endocrine and immunological aspects of burnout: a narrative review. *Eur J Endocrinol* 180:R147–R158. <https://doi.org/10.1530/EJE-18-0741>
12. Schulte PA, Wagner GR, Ostry A, Blanciforti LA, Cutlip RG, Krajinak KM, Luster M, Munson AE, O’Callaghan JP, Parks CG et al (2007) Work, obesity, and occupational safety and health. *Am J Public Health* 97:428–436. <https://doi.org/10.2105/AJPH.2006.086900>
13. Yamada Y, Kameda M, Noborisaka Y, Suzuki H, Honda M, Yamada S (2001) Excessive fatigue and weight gain among clean-room workers after changing from an 8-hour to a 12-hour shift. *Scand J Work Environ Health*. <https://doi.org/10.5271/sjweh.620>
14. Niedhammer I, Lert F, Marne MJ (1996) Prevalence of overweight and weight gain in relation to night work in a nurses’ cohort. *Int J Obes Relat Metab Disord* 20:625–633
15. Geliebter A, Gluck ME, Tanowitz M, Aronoff NJ, Zammit GK (2000) Work-shift period and weight change. *Nutrition* 16:27–29. [https://doi.org/10.1016/S0899-9007\(99\)00228-2](https://doi.org/10.1016/S0899-9007(99)00228-2)
16. Knutsson A, Akerstedt T (1992) The healthy-worker effect: self-selection among Swedish shift workers. *Work Stress* 6:163–167. <https://doi.org/10.1080/02678379208260350>
17. Di Lorenzo L, De Pergola G, Zocchetti C, L’Abbate N, Basso A, Pannacciulli N, Cignarelli M, Giorgino R, Soleo L (2003) Effect of shift work on body mass index: results of a study performed in 319 glucose-tolerant men working in a Southern Italian industry. *Int J Obes Relat Metab Disord* 27:1353–1358. <https://doi.org/10.1038/sj.ijo.0802419>
18. Williams MA, Haskell WL, Ades PA, Amsterdam EA, Bittner V, Franklin BA, Gulanick M, Laing ST, Stewart KJ (2007) Resistance exercise in individuals with and without cardiovascular disease: 2007 update: a scientific statement from the American Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity, and Metabolism. *Circulation* 116:572–584. <https://doi.org/10.1161/CIRCULATIONAHA.107.185214>
19. Yeung RR (1996) The acute effects of exercise on mood state. *J Psychosom Res* 40:123–141. [https://doi.org/10.1016/0022-3999\(95\)00554-4](https://doi.org/10.1016/0022-3999(95)00554-4)
20. Benaards C, Jans M, Van den Heuvel S, Hendriksen I, Houtman I, Bongers P (2006) Can strenuous leisure time physical activity prevent psychological complaints in a working population? *Occup Environ Med* 63:10–16
21. Brown WJ, Ford JH, Burton NW, Marshall AL, Dobson AJ (2005) Prospective study of physical activity and depressive symptoms in middle-aged women. *Am J Prev Med* 29:265–272. <https://doi.org/10.1016/j.amepre.2005.06.009>
22. Sanchez-Villegas A, Ara I, Guillen-Grima F, Bes-Rastrollo M, Varo-Cenarruzabeitia JJ, Martinez-Gonzalez MA (2008) Physical activity, sedentary index, and mental disorders in the SUN cohort study. *Med Sci Sports Exerc* 40:827–834. <https://doi.org/10.1249/MSS.0b013e31816348b9>
23. Galof K, Šuc L (2021) Exploring teachers’ back pain concerning their habits, rules, leisure activities, and physical activity breaks at work. *INQUIRY J Health Care Organ Provis Financ* 58:00469580211060256. <https://doi.org/10.1177/00469580211060256>
24. Sipaviciene S, Kliziene I (2020) Effect of different exercise programs on non-specific chronic low back pain and disability in people who perform sedentary work. *Clin Biomech (Bristol, Avon)* 73:17–27. <https://doi.org/10.1016/j.clinbiomech.2019.12.028>
25. Nooijen CFJ, Blom V, Ekblom O, Ekblom MM, Kallings LV (2019) Improving office workers’ mental health and cognition: a 3-arm cluster randomized controlled trial targeting physical activity and sedentary behavior in multi-component interventions. *BMC Public Health* 19:266. <https://doi.org/10.1186/s12889-019-6589-4>
26. Proper KI, van Oostrom SH (2019) The effectiveness of workplace health promotion interventions on physical and mental health outcomes—a systematic review of reviews. *Scand J Work Environ Health* 45:546–559. <https://doi.org/10.5271/sjweh.3833>
27. Saridi M, Filippopoulou T, Tzitzikos G, Sarafis P, Souliotis K, Karakatsani D (2019) Correlating physical activity and quality of life of healthcare workers. *BMC Res Notes* 12:208. <https://doi.org/10.1186/s13104-019-4240-1>
28. Park S, Jang MK (2019) Associations between workplace exercise interventions and job stress reduction: a systematic review. *Workplace Health Saf* 67:592–601
29. White RL, Vella S, Biddle S, Sutcliffe J, Guagliano JM, Uddin R, Burgin A, Apostolopoulos M, Nguyen T, Young C (2024) Physical activity and mental health: a systematic review and best-evidence synthesis of mediation and moderation studies. *Int J Behav Nutr Phys Act* 21:134
30. Rother ET (2007) Systematic literature review X narrative review. *Acta paulista de enfermagem* 20:v–vi
31. Nowrouzi B, Nguyen C, Casole J, Nowrouzi-Kia B (2017) Occupational stress: a comprehensive review of the top 50 annual and lifetime cited articles. *Workplace Health Saf* 65:197–209
32. McCart AL (2023) Stress management strategies for the workplace: a case study in evaluating employers using the centers for disease control health scorecard. *J Manag* 10:7–12
33. Nater UM, Rohleder N (2009) Salivary alpha-amylase as a non-invasive biomarker for the sympathetic nervous system: current state of research. *Psychoneuroendocrinology* 34:486–496
34. Malm C, Jakobsson J, Isaksson A (2019) Physical activity and sports—real health benefits: a review with insight into the public health of Sweden. *Sports* 7:127
35. Organization WH (2023) Why physical activity?
36. Forberger S, Wichmann F, Comito CN (2022) Nudges used to promote physical activity and to reduce sedentary behaviour in the workplace: results of a scoping review. *Prev Med* 155:106922. <https://doi.org/10.1016/j.ypmed.2021.106922>
37. Prince SA, Rasmussen CL, Biswas A, Holtermann A, Aulakh T, Merucci K, Coenen P (2021) The effect of leisure time physical activity and sedentary behaviour on the health of workers with different occupational physical activity demands: a systematic review. *Int J Behav Nutr Phys Act* 18:100. <https://doi.org/10.1186/s12966-021-01166-z>
38. Chu A, Koh D, Moy F, Müller-Riemenschneider F (2014) Do workplace physical activity interventions improve mental health outcomes? *Occup Med* 64:235–245
39. Sliter KA, Sinclair R, Cheung J, McFadden A (2014) Initial evidence for the buffering effect of physical activity on the relationship between workplace stressors and individual outcomes. *Int J Stress Manag* 21:348
40. Delfino LD, Tebar WR, Tebar FCSG, De Souza JM, Romanzini M, Fernandes RA, Christofaro DGD (2020) Association between sedentary behavior, obesity and hypertension in public school teachers. *Ind Health* 58:345–353

41. Santos IL, Miragaia D (2023) Physical activity in the workplace: a cost or a benefit for organizations? A systematic review. *Int J Workplace Health Manag* 16:108–135. <https://doi.org/10.1108/IJWHM-04-2021-0076>
42. Grimani A, Aboagye E, Kwak L (2019) The effectiveness of workplace nutrition and physical activity interventions in improving productivity, work performance and workability: a systematic review. *BMC Public Health* 19:1676. <https://doi.org/10.1186/s12889-019-8033-1>
43. Mahmood I, Khan MR, Rahman MK, Chowdhury MH (2009) A comparison of lipid profile between sedentary and non sedentary workers. *TAJ J Teach Assoc* 22:10–14
44. Yeasmin F, Nessa A, Rahman M, Huq M, Afroz L, Sharmin T, Akhter T, Rukunuzzaman M, Ferdous A (2023) A comparative study of body mass index and blood pressure between sedentary and non-sedentary workers. *Mymensingh Med J MMJ* 32:61–64
45. Thomas E, Rossi C, Petrigna L, Messina G, Bellafiore M, Şahin FN, Proia P, Palma A, Bianco A (2023) Evaluation of posturographic and neuromuscular parameters during upright stance and hand standing: a pilot study. *J Funct Morphol Kinesiol* 8:40
46. Lusk SL, Hagerty BM, Gillespie B, Caruso CC (2002) Chronic effects of workplace noise on blood pressure and heart rate. *Arch Environ Health Int J* 57:273–281
47. McCraty R, Atkinson M, Tomasino D (2003) Impact of a workplace stress reduction program on blood pressure and emotional health in hypertensive employees. *J Alternative Complement Med* 9:355–369
48. Taylor WC (2011) Booster Breaks: an easy-to-implement workplace policy designed to improve employee health, increase productivity, and lower health care costs. *J Work Behav Health* 26:70–84
49. Ferrari R, Russell AS (2003) Regional musculoskeletal conditions: neck pain. *Best Pract Res Clin Rheumatol* 17:57–70
50. Sjøgren P, Ekholm O, Peuckmann V, Grønbaek M (2009) Epidemiology of chronic pain in Denmark: an update. *Eur J Pain* 13:287–292
51. Andersen LL, Christensen KB, Holtermann A, Poulsen OM, Sjøgaard G, Pedersen MT, Hansen EA (2010) Effect of physical exercise interventions on musculoskeletal pain in all body regions among office workers: a one-year randomized controlled trial. *Man Ther* 15:100–104
52. Henderson M, Glozier N, Elliott KH (2005) Long term sickness absence. *330:802–803*
53. Juul-Kristensen B, Kadefors R, Hansen K, Byström P, Sandsjö L, Sjøgaard G (2006) Clinical signs and physical function in neck and upper extremities among elderly female computer users: the NEW study. *Eur J Appl Physiol* 96:136–145
54. Council N (2001) the Institute of Medicine: musculoskeletal disorders and the workplace: low back and upper extremities. In: Panel on musculoskeletal disorders and the workplace. Commission on Behavioral and Social Sciences and Education
55. Punnett L, Wegman DH (2004) Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *J Electromyogr Kinesiol* 14:13–23
56. Andersen JH, Haahr JP, Frost P (2007) Risk factors for more severe regional musculoskeletal symptoms: a two-year prospective study of a general working population. *Arthritis Rheum* 56:1355–1364
57. Hayden J, Van Tulder MW, Malmivaara A, Koes BW (2005) Exercise therapy for treatment of non-specific low back pain. *Cochrane Database Syst Reviews*
58. Ylinen J (2007) Physical exercises and functional rehabilitation for the management of chronic neck pain. *Eura Medicophys* 43:119
59. Andersen LL, Kjaer M, Sjøgaard K, Hansen L, Kryger AI, Sjøgaard G (2008) Effect of two contrasting types of physical exercise on chronic neck muscle pain. *Arthritis Care Res* 59:84–91
60. Blangsted AK, Sjøgaard K, Hansen EA, Hannerz H, Sjøgaard G (2008) One-year randomized controlled trial with different physical-activity programs to reduce musculoskeletal symptoms in the neck and shoulders among office workers. *Scand J Work Environ Health* 34:55–65
61. Baker R, Coenen P, Howie E, Williamson A, Straker L (2018) The short term musculoskeletal and cognitive effects of prolonged sitting during office computer work. *Int J Environ Res Public Health*. <https://doi.org/10.3390/ijerph15081678>
62. van As S, Beckers DGJ, Veling H, Hoofman W, Kompier MAJ, Geurts SAE (2022) Sedentary work and participation in leisure-time physical activity. *Int Arch Occup Environ Health* 95:509–525. <https://doi.org/10.1007/s00420-021-01750-7>
63. Smith L, McCourt O, Sawyer A, Ucci M, Marmot A, Wardle J, Fisher A (2016) A review of occupational physical activity and sedentary behaviour correlates. *Occup Med (Lond)* 66:185–192. <https://doi.org/10.1093/occmed/kqv164>
64. Ganedahl H, Zsaludek Viklund P, Carlen K, Kylberg E, Ekberg J (2015) Work-site wellness programmes in Sweden: a cross-sectional study of physical activity, self-efficacy, and health. *Public Health* 129:525–530. <https://doi.org/10.1016/j.puhe.2015.01.023>
65. Kredlow MA, Capozzoli MC, Hearon BA, Calkins AW, Otto MW (2015) The effects of physical activity on sleep: a meta-analytic review. *J Behav Med* 38:427–449
66. Wang H, Xin X, Pan Y (2025) The best approaches and doses of exercise for improving sleep quality: a network meta-analysis and dose-response relationship study. *BMC Public Health* 25:1371
67. Xie Y, Liu S, Chen X-J, Yu H-H, Yang Y, Wang W (2021) Effects of exercise on sleep quality and insomnia in adults: a systematic review and meta-analysis of randomized controlled trials. *Front Psychiatry* 12:664499
68. Cheng R, Yang L, Kang S-J (2025) A study on the relationship between high school students' sleep quality, physical exercise, academic stress, and subjective well-being. *BMC Psychol* 13:1–16
69. Saidi O, Davenne D, Lehorgne C, Duché P (2020) Effects of timing of moderate exercise in the evening on sleep and subsequent dietary intake in lean, young, healthy adults: randomized crossover study. *Eur J Appl Physiol* 120:1551–1562
70. Arslan SS, Alemdaroğlu İ, Karaduman AA, Yılmaz ÖT (2019) The effects of physical activity on sleep quality, job satisfaction, and quality of life in office workers. *Work* 63:3–7
71. Ramezani M, Tayefi B, Zandian E, Soleimanvandi Azar N, Khalili N, Hoveidamanesh S, Massahikhaleghi P, Rampisheh Z (2022) Workplace interventions for increasing physical activity in employees: a systematic review. *J Occup Health* 64:e12358. <https://doi.org/10.1002/1348-9585.12358>
72. Sitthipornvorakul E, Janwantanakul P, van der Beek AJ (2014) Correlation between pedometer and the Global Physical Activity Questionnaire on physical activity measurement in office workers. *BMC Res Notes* 7:1–6
73. Manini TM, Carr LJ, King AC, Marshall S, Robinson TN, Rejeski WJ (2015) Interventions to reduce sedentary behavior. *Med Sci Sports Exerc* 47:1306
74. Torbeyns T, Bailey S, Bos I, Meeusen R (2014) Active workstations to fight sedentary behaviour. *Sports Med* 44:1261–1273
75. Alkhajah TA, Reeves MM, Eakin EG, Winkler EA, Owen N, Healy GN (2012) Sit-stand workstations: a pilot intervention to reduce office sitting time. *Am J Prev Med* 43:298–303
76. Koepp GA, Manohar CU, McCrady-Spitzer SK, Ben-Ner A, Hamann DJ, Runge CF, Levine JA (2013) Treadmill desks: a 1-year prospective trial. *Obesity* 21:705–711

77. Carr LJ, Karvinen K, Peavler M, Smith R, Cangelosi K (2013) Multicomponent intervention to reduce daily sedentary time: a randomised controlled trial. *BMJ Open* 3:e003261
78. Mänttari S, Oksa J, Lusa S, Korhakangas E, Punakallio A, Oksanen T, Laitinen J (2021) Interventions to promote work ability by increasing physical activity among workers with physically strenuous jobs: a scoping review. *Scand J Public Health* 49:206–218. <https://doi.org/10.1177/1403494820917532>
79. Badarin K, Hemmingsson T, Hillert L, Kjellberg K (2022) The impact of musculoskeletal pain and strenuous work on self-reported physical work ability: a cohort study of Swedish men and women. *Int Arch Occup Environ Health* 95:939–952. <https://doi.org/10.1007/s00420-021-01816-6>
80. Sundstrup E, Seeberg KGV, Bengtson E, Andersen LL (2020) A systematic review of workplace interventions to rehabilitate musculoskeletal disorders among employees with physical demanding work. *J Occup Rehabil* 30:588–612. <https://doi.org/10.1007/s10926-020-09879-x>
81. Heuch I, Heuch I, Hagen K, Zwart J-A (2017) Physical activity level at work and risk of chronic low back pain: a follow-up in the Nord-Trøndelag Health Study. *PLoS ONE* 12:e0175086. <https://doi.org/10.1371/journal.pone.0175086>
82. Tennant F (2013) The physiologic effects of pain on the endocrine system. *Pain Ther* 2:75–86
83. Akil H, Shiomi H, Matthews J (1985) Induction of the intermediate pituitary by stress: synthesis and release of a nonopioid form of β -endorphin. *Science* 227:424–426
84. Chrousos GP (1995) The hypothalamic–pituitary–adrenal axis and immune-mediated inflammation. *N Engl J Med* 332:1351–1363
85. Bateman A, Singh A, Kral T, Solomon S (1989) The immune-hypothalamic–pituitary–adrenal axis. *Endocr Rev* 10:92–112
86. Grossi G, Perski A, Evengård B, Blomkvist V, Orth-Gomér K (2003) Physiological correlates of burnout among women. *J Psychosom Res* 55:309–316
87. Quick JCE, Tetrick LE (2011) *Handbook of occupational health psychology*. American Psychological Association, Worcester
88. Rausch SM, Auerbach SM, Gramling SE (2008) Gender and ethnic differences in stress reduction, reactivity, and recovery. *Sex Roles* 59:726–737
89. Tumane RG, Pingle SK, Gaikwad AS, Ravichandran B (2023) Impact of occupational stress and its associated factors on cognitive, hormonal and stress responsive protein in mining based industrial workers
90. Morera LP, Gallea JI, Trógolo MA, Guido ME, Medrano L (2020) From work well-being to burnout: a hypothetical phase model. *Front Neurosci* 14:527103
91. Jonsdottir IH, Sjörs Dahlman A (2019) Mechanisms in endocrinology: Endocrine and immunological aspects of burnout: a narrative review. *Eur J Endocrinol* 180:R147–R158
92. Athanasiou N, Bogdanis GC, Mastorakos G (2023) Endocrine responses of the stress system to different types of exercise. *Rev Endocr Metab Disord* 24:251–266
93. Constantini N, Hackney AC (2013) *Endocrinology of physical activity and sport*. Springer, Berlin
94. Kouvonen A, Vahtera J, Oksanen T, Pentti J, Väänänen AK, Heponiemi T, Salo P, Virtanen M, Kivimäki M (2013) Chronic workplace stress and insufficient physical activity: a cohort study. *Occup Environ Med* 70:3–8
95. Skamagki G, Carpenter C, King A, Wählin C (2023) How do employees with chronic musculoskeletal disorders experience the management of their condition in the workplace? A meta-synthesis. *J Occup Rehabil* 1–11
96. Kivimäki M, Kawachi I (2015) Work stress as a risk factor for cardiovascular disease. *Curr Cardiol Rep* 17:1–9
97. Hamilton MT, Hamilton DG, Zderic TW (2014) Sedentary behavior as a mediator of type 2 diabetes. *Diabetes Phys Act* 60:11–26
98. Dadvand P, Villanueva CM, Font-Ribera L, Martinez D, Basagaña X, Belmonte J, Vrijheid M, Gražulevičienė R, Kogevinas M, Nieuwenhuijsen MJ (2014) Risks and benefits of green spaces for children: a cross-sectional study of associations with sedentary behavior, obesity, asthma, and allergy. *Environ Health Perspect* 122:1329–1335
99. Kuiper G, Enmark E, Pelto-Huikko M, Nilsson S, Gustafsson J (1996) Cloning of a novel receptor expressed in rat prostate and ovary. *Proc Natl Acad Sci* 93:5925–5930
100. Friedenreich CM, Ryder-Burbidge C, McNeil J (2021) Physical activity, obesity and sedentary behavior in cancer etiology: epidemiologic evidence and biologic mechanisms. *Mol Oncol* 15:790–800
101. Schaller A, Stassen G, Baulig L, Lange M (2024) Physical activity interventions in workplace health promotion: objectives, related outcomes, and consideration of the setting—a scoping review of reviews. *Front Public Health* 12:1353119
102. Durstine JL, Gordon B, Wang Z, Luo X (2013) Chronic disease and the link to physical activity. *J Sport Health Sci* 2:3–11
103. Kuijpers W, Groen WG, Aaronson NK, van Harten WH (2013) A systematic review of web-based interventions for patient empowerment and physical activity in chronic diseases: relevance for cancer survivors. *J Med Internet Res* 15:e2281
104. Donnelly JE, Hillman CH, Castelli D, Etnier JL, Lee S, Tomporowski P, Lambourne K, Szabo-Reed AN (2016) Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Med Sci Sports Exerc* 48:1197
105. Marin-Farrona M, Wipfli B, Thosar SS, Colino E, Garcia-Unanue J, Gallardo L, Felipe JL, López-Fernández J (2023) Effectiveness of worksite wellness programs based on physical activity to improve workers' health and productivity: a systematic review. *Syst Rev* 12:87
106. Quintiliani L, Sattelmair J, Sorensen G (2007) The workplace as a setting for interventions to improve diet and promote physical activity. World Health Organization, Geneva, pp 1–36
107. Nooijen CF, Blom V, Ekblom Ö, Ekblom MM, Kallings LV (2019) Improving office workers' mental health and cognition: a 3-arm cluster randomized controlled trial targeting physical activity and sedentary behavior in multi-component interventions. *BMC Public Health* 19:1–10
108. Jirathananuwat A, Chaiyakunapruk N, Pongpirul K (2015) Promoting physical activity in the workplace: a scoping review of systematic reviews: Areeya Jirathananuwat. *Eur J Public Health* 25(ckv174):073
109. Jirathananuwat A, Pongpirul K (2017) Promoting physical activity in the workplace: a systematic meta-review. *J Occup Health* 59:385–393

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.

Terms and Conditions

Springer Nature journal content, brought to you courtesy of Springer Nature Customer Service Center GmbH (“Springer Nature”).

Springer Nature supports a reasonable amount of sharing of research papers by authors, subscribers and authorised users (“Users”), for small-scale personal, non-commercial use provided that all copyright, trade and service marks and other proprietary notices are maintained. By accessing, sharing, receiving or otherwise using the Springer Nature journal content you agree to these terms of use (“Terms”). For these purposes, Springer Nature considers academic use (by researchers and students) to be non-commercial.

These Terms are supplementary and will apply in addition to any applicable website terms and conditions, a relevant site licence or a personal subscription. These Terms will prevail over any conflict or ambiguity with regards to the relevant terms, a site licence or a personal subscription (to the extent of the conflict or ambiguity only). For Creative Commons-licensed articles, the terms of the Creative Commons license used will apply.

We collect and use personal data to provide access to the Springer Nature journal content. We may also use these personal data internally within ResearchGate and Springer Nature and as agreed share it, in an anonymised way, for purposes of tracking, analysis and reporting. We will not otherwise disclose your personal data outside the ResearchGate or the Springer Nature group of companies unless we have your permission as detailed in the Privacy Policy.

While Users may use the Springer Nature journal content for small scale, personal non-commercial use, it is important to note that Users may not:

1. use such content for the purpose of providing other users with access on a regular or large scale basis or as a means to circumvent access control;
2. use such content where to do so would be considered a criminal or statutory offence in any jurisdiction, or gives rise to civil liability, or is otherwise unlawful;
3. falsely or misleadingly imply or suggest endorsement, approval, sponsorship, or association unless explicitly agreed to by Springer Nature in writing;
4. use bots or other automated methods to access the content or redirect messages
5. override any security feature or exclusionary protocol; or
6. share the content in order to create substitute for Springer Nature products or services or a systematic database of Springer Nature journal content.

In line with the restriction against commercial use, Springer Nature does not permit the creation of a product or service that creates revenue, royalties, rent or income from our content or its inclusion as part of a paid for service or for other commercial gain. Springer Nature journal content cannot be used for inter-library loans and librarians may not upload Springer Nature journal content on a large scale into their, or any other, institutional repository.

These terms of use are reviewed regularly and may be amended at any time. Springer Nature is not obligated to publish any information or content on this website and may remove it or features or functionality at our sole discretion, at any time with or without notice. Springer Nature may revoke this licence to you at any time and remove access to any copies of the Springer Nature journal content which have been saved.

To the fullest extent permitted by law, Springer Nature makes no warranties, representations or guarantees to Users, either express or implied with respect to the Springer nature journal content and all parties disclaim and waive any implied warranties or warranties imposed by law, including merchantability or fitness for any particular purpose.

Please note that these rights do not automatically extend to content, data or other material published by Springer Nature that may be licensed from third parties.

If you would like to use or distribute our Springer Nature journal content to a wider audience or on a regular basis or in any other manner not expressly permitted by these Terms, please contact Springer Nature at

onlineservice@springernature.com