

Low back pain and sitting time, posture and behavior in office workers: A scoping review

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Abstract

Background: Office workers spend approximately two-thirds of their daily work time in a sitting position.

Objective: This scoping review aimed to identify and categorize key themes and knowledge gaps in research on how sitting time, posture, and behavior affect the risk of low back pain among office workers.

Methods: The authors conducted a comprehensive literature search in electronic databases [MEDLINE [via PubMed], SCOPUS, CINAHL, PEDro, and CENTRAL] from inception to March 2024, resulting in 22 studies involving 7814 participants. The methodological quality of these studies was assessed using the Mixed Methods Appraisal Tool (MMAT).

Results: Seventeen studies [77%] were rated as high quality, four studies [18%] as moderate quality, and one study [5%] as low quality. Thirteen studies assessed sitting time, ten assessed sitting posture, and thirteen assessed sitting behavior. Among the studies investigating sitting time, five showed no relationship with low back pain (LBP) prevalence, while eight demonstrated a relationship with LBP prevalence. For studies exploring sitting posture, seven found a relationship with LBP. Regarding studies on sitting behavior, only one showed no relationship between LBP prevalence, while twelve indicated a relationship.

Conclusions: Longer sitting time, poor sitting posture, fewer breaks and more static sitting in sitting behavior, were found to be associated with LBP. The strongest evidence for an association with LBP was found for sitting behavior. When considering workplace ergonomics and interventions for LBP, it is advisable to consider all factors, including sitting, posture and behavior.

Keywords

sitting positions, occupations, ergonomics, postural, low back pain

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Introduction

In contemporary workplaces, the prevalence of sedentary occupations has increased significantly due to advances in technology. This shift, characterized by prolonged sitting and computer-based tasks, has contributed to a rise in musculoskeletal problems, particularly low back pain (LBP), among office workers. On average, office workers spend approximately two-thirds of their workday in seated positions, often in continuous periods of 30 min or more.^{1–3} Prolonged sitting and immobile postures not only exacerbate musculoskeletal problems [such as LBP and neck pain, etc.] but are also associated with broader health consequences, such as metabolic and cardiovascular issues, ultimately reducing overall quality of life.⁴

Low back pain is a prevalent issue among office workers, with an annual prevalence ranging from 18% to

68% and a chronicization rate of approximately 27% over a one-year period.^{5–8} As LBP is the third leading cause of disability globally and imposes a significant economic burden, understanding its risk factors is crucial.^{9,10} Office workers, due to their prolonged sitting behaviors, represent

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a unique population for examining the links between sedentary lifestyles and LBP. Prolonged static sitting, characterized by limited movement and awkward postures, has been identified as a contributing factor to musculoskeletal pain and discomfort, particularly for office workers.¹¹

Sitting often involves a flexed spinal posture near the end of the range of motion, placing increased stress on the tissues surrounding the spinal joints.^{12–15} Research highlights the biological mechanisms underlying these pain processes, including inflammation and cytokine responses triggered by the stretching of posterior spinal tissues, heightened pain sensitivity in the presence of inflammation, stress on the peripheral regions of intervertebral discs due to spinal flexion, and reduced oxygenation resulting from prolonged low-level activation of erector spinae muscles during sitting.^{16–19} Experimental studies have demonstrated that prolonged sitting increases perceived pain, even in young and healthy individuals.^{20–22} Furthermore, sitting for more than five hours has been associated with a higher likelihood of back pain recurrence in patients with LBP.²¹

Existing literature demonstrates significant variability in findings regarding the relationship between sitting characteristics –such as duration, posture, and behavior– and the development of LBP. For instance, “sitting time” refers to the total duration spent seated,²³ whereas “sitting behavior” encompasses the frequency and extent of postural changes and breaks during sitting.²⁴ Dynamic sitting behaviors, involving regular postural shifts, may alleviate spinal pressure and reduce musculoskeletal strain compared to static sitting. Dynamic sitting refers to incorporating movement into sitting, such as fidgeting or upper body movements, which increases energy expenditure (e.g. >1.5 METs). In contrast, static sitting involves prolonged fixed postures with minimal movement, potentially causing increased spinal pressure and pain.²⁴ While there is no universal definition of optimal sitting posture, health professionals recommend avoiding forward head tilt, maintaining slight thoracic kyphosis, a straight lower thoracic region, and lumbar lordosis similar to standing posture.^{25,26} Evidence on the effects of sitting time, posture, and behavior on LBP is still inconsistent and limited.²⁷

Some studies have suggested that sitting for more than 7 h per day significantly increases the risk of low back pain.^{28,29} However, multiple systematic reviews have pointed out that the evidence is insufficient to establish a clear causal link between sitting time alone and the onset of low back pain.^{30–33} Research on sitting posture has focused on the concept of “ideal” postures, yet despite numerous studies,^{13,34–37} there is still no broad consensus on whether a “perfect” sitting posture exists or if such postures actually reduce musculoskeletal pain.³⁸ In fact, some research suggests that sustained efforts to maintain an “ideal” posture might have negative consequences.^{39,40} Several studies have suggested that the sitting behavior of

office workers may be more closely related to low back pain than previously understood. Specifically, it has been suggested that dynamic sitting –as opposed to static sitting– could offer more significant benefits in reducing musculoskeletal strain and preventing discomforts.^{41–43}

Despite recent studies, there is still insufficient evidence regarding the specific sitting-related factors, such as sitting time, posture, and behavior, that may influence the development of LBP in office workers. The multifactorial nature of LBP, coupled with the use of unreliable subjective measurement tools and short follow-up periods in many studies, contributes to the ongoing uncertainty and inconsistencies in the literature.^{27,32,33} Interestingly, despite these methodological limitations, many studies including systematic review and meta-analyses investigating the relationship between sitting and LBP have not specifically targeted office workers, who are particularly vulnerable to prolonged sitting in recent years. Most experimental measurements have been conducted on healthy subjects or, in some cases, include office workers but with a focus on those in physically demanding jobs or those who stand for long periods.^{6,11,12,16,19,30,33,44} Furthermore, existing meta-analyses generally examined sedentary sitting behavior in various segments of the population (children, students, individuals with sedentary sitting behavior outside of work, etc.)^{45–47} or evaluated various methods to reduce sitting time.^{48–50} This highlights the need for studies specifically focusing on the effects of sitting characteristics on LBP in office workers, differentiating them from previous studies. However, due to the variation in the evaluation methods in the studies on this subject and the fact that they mostly do not include objective methods and that the sitting characteristics in our study include a wide range of research questions, it was not possible to identify studies suitable for systematic review and meta-analysis. For these reasons, the authors conducted a scoping review to systematically examine the research in this area and identify existing knowledge gaps. The primary objective of this scoping review was to identify and categorize the main themes in the existing evidence on the impact of sitting time, posture, and behavior on the risk of low back pain in office workers. In addition to the primary objective, other aims included identifying gaps in knowledge and providing recommendations for future research and clinical practice.

Methods

Framework, protocol, and registration

Due to the broad research question and the diversity of evidence, a scoping review methodology was chosen. While this method is effective in synthesizing a wide range of literature and providing guidance for future studies, it may not allow for a structured synthesis of the findings. The 5-step methodological framework proposed by Arksey and

O'Malley⁵¹ and the guidelines for conducting scoping reviews by Levac et al.⁵² and the Joanna Briggs Institute⁵³ were followed. The authors used the recent Preferred Reporting Items for Systematic Reviews and Meta-Analysis - Extension for Scoping Reviews (PRISMA-ScR guidelines),⁵⁴ a checklist of reporting guidelines. Finally, for the reporting of this study protocol, the relevant items of the PRISMA Protocols (PRISMA-P) were followed for the reporting of this study protocol.⁵⁵ This study protocol was not registered in the PROSPERO database, as the database is not open for registration of scoping reviews.^{56,57}

Identifying the research question

The formulation of a clear research question serves as the basis for the design and reporting of a scoping review.^{52,58,59} The authors therefore developed the following research questions for the current scoping review:

- (i) Is sitting time, posture and behavior associated with low back pain in office workers? What is the evidence and conclusions on this issue?
- (ii) What are the reported barriers or limitations for studies investigating the association of sitting with low back pain in office workers?
- (iii) What literature gaps exist, and what suggested improvements can strengthen studies investigating the association between sitting and low back pain in office workers?

Search methods

Electronic databases, specifically MEDLINE (via PubMed), SCOPUS, CINAHL, PEDro, and CENTRAL (Cochrane Central Register of Controlled Trials), were used to search for literature from their inception to March 20, 2024. Studies were restricted to those written in English and peer-reviewed literature. The search strategy (e.g. Medical Subject Headings, keywords) was developed using the Population-Concept-Context (PCC) framework⁶⁰ in consultation with a librarian (A.A.M.) and content experts. The PCC framework, which provides guidance in setting precise and focused objectives and eligibility criteria for the scoping review, as well as the keywords and number of articles found in each search strategy, is provided in Appendix 1.

Study selection

The authors used the Peer Review of Electronic Search Strategies guidelines⁶¹ to construct, review and calibrate the search strategy in the PubMed/Medline database.⁶² Inclusion criteria were original studies with a qualitative, quantitative or mixed methods approach, regardless of

design. The Rayyan (free web-based tool; <https://www.rayyan.ai/>; Qatar Computing Research Institute, Qatar) was used to separate duplicate studies and review articles (Appendix 1).

The criteria for inclusion and exclusion criteria for studies in the scoping review were as follows:

- The study design is in English and includes peer-reviewed research (i.e. peer-reviewed publications and dissertations). Letters, abstracts, volumes, conference proceedings and posters were excluded.
- The study population was office workers, or those working with computers, visual display units, or visual display terminals. Home office workers were excluded.
- Outcome measures included pain intensity, incidence/prevalence of low back pain/discomfort, and assessing physical functioning scales, such as the Roland-Morris Disability Questionnaire and the Oswestry Disability Index (ODI), among others.
- The study assessed low back pain or discomfort as well as the sitting activity. Studies of LBP caused by specific underlying pathologies, such as tumors, fractures, infections, dislocations or osteoporosis, were excluded.
- Studies that included only office workers with chronic LBP in all groups and studies with an intervention in all groups were not included in the scope assessment because they were not included in the objectives of the present study. However, trials with a control group and interventions aimed at changing sitting time, posture and behavior were included in the scope assessment.
- This review included studies that examined the sitting behavior of office workers, including the number of sitting breaks and the frequency and magnitude of postural swings.

Prior to screening, all authors independently screened a random sample of 120 titles/abstracts to assess the applicability of the inclusion/exclusion criteria for the scoping review. All reviewers (A.Ö.A. and S.Ö.) achieved acceptable inter-rater agreement [92.5%–90%, $\kappa = 0.701$ – 0.709] with the senior author (N.A.).⁶³ In the screening process, conflicts were resolved by reaching a consensus first among the reviewers and then, if necessary, by reaching a consensus with the senior author. In the case of missing or unclear information, the corresponding authors were contacted by e-mail for clarification and to request the full text ($n = 9$), but only one response was received ($n = 1$). The screening process and reasons for exclusion are shown in the flowchart (Figure 1).

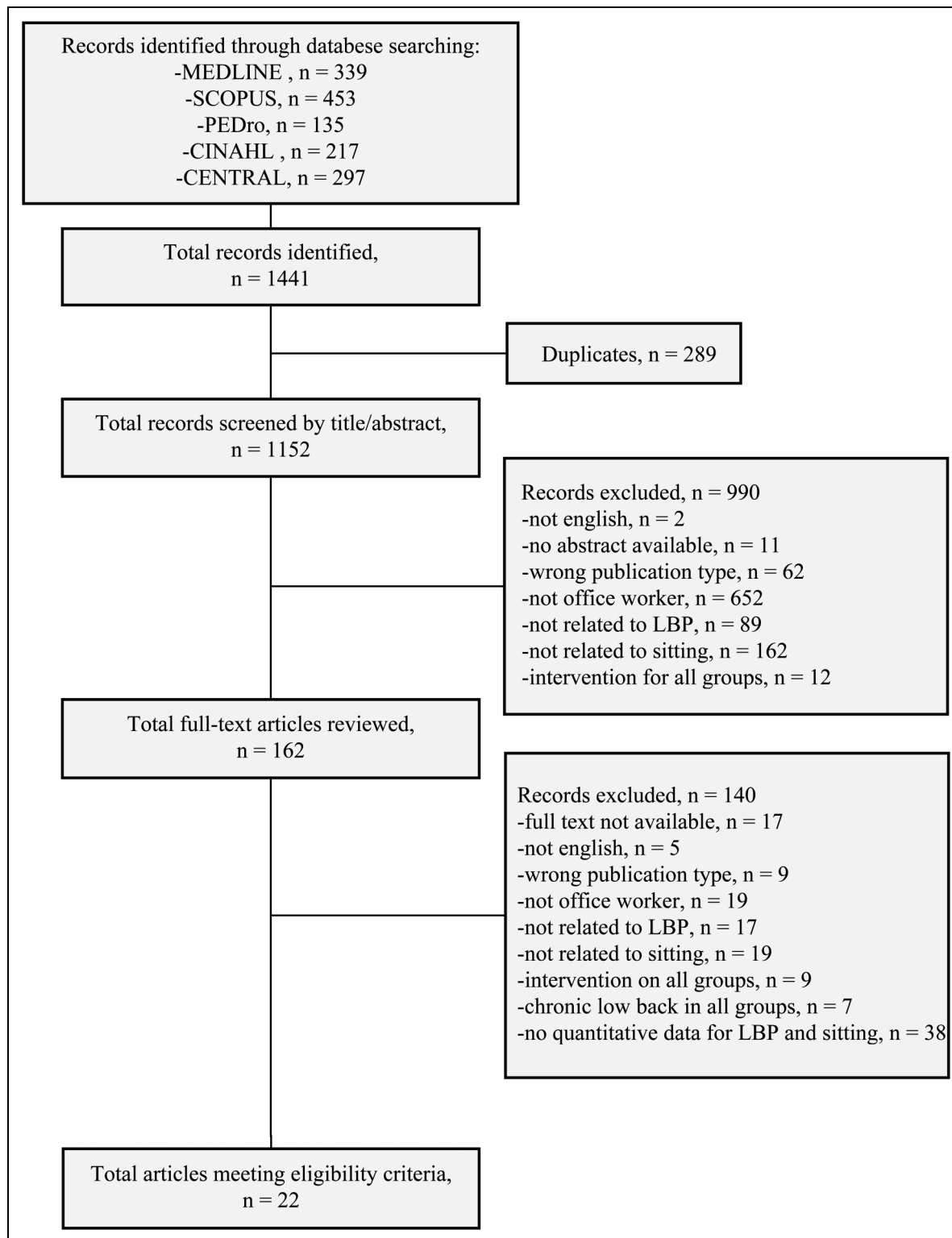


Figure 1. Flowchart in this study.

Quality assessment

The methodological quality of the articles was assessed using the Mixed Methods Appraisal Tool (MMAT)⁶⁴ and

independently rated by all authors using a customized version. The MMAT quality assessment was also used to identify consistent methodological weaknesses in the

existing evidence base and to generate recommendations for improving future studies. The MMAT quality summaries of the studies are shown in Appendix 2. The MMAT ratings were categorized as high (4–5 points), moderate (3 points) and low (1–2 points) quality, as in the study by Holt et al.⁶³

Data characteristics

The data abstracted from the included studies (study year, location, study design, population, which of sitting time/sitting posture/sitting behavior was investigated, method of data collection and main findings) are shown in Table 1. Data characteristic were collected by the lead author using a specially designed form developed and piloted by the study team. Any discrepancies in data collection were the subject of group discussion and resolution.

Results

Screening process

The search identified in 1441 articles. After removing duplicates [n=289], a total of 1152 articles were screened (Appendix 1). The screening process was carried out in three stages. The first stage involved a title search, which reduced the pool to 830 records. In the second stage, the abstracts of the remaining 830 papers were read. Papers that did not relate to office workers, low back pain and sitting were removed. Corresponding authors were contacted by email for clarification and, if necessary, to request a full review (n = 9). In the third stage of the remaining 162 studies, 145 with available full texts were read [A.Ö.A. and S.Ö.]. A total of 123 articles were excluded, resulting in a final database of 22 articles. Figure 1 shows the screening and elimination process to select relevant articles based on the eligibility criteria set by all authors.

Quality appraisal

Appendix 2 shows the MMAT ratings of the studies included in this analysis.^{63,64} Of the total number of studies, seventeen (77%) were rated as high quality ratings (score 4–5), four (18%) received moderate quality ratings (score 3) and one (5%) was rated as low quality (score 1).

Study characteristics

Characteristics of included studies and relationship of LBP with sitting time/posture/behavior were shown Table 1. Of the 22 studies,^{27,28,37,60,65–82} 13 were cross-sectional.^{28,65–67,69,70,72–76,78,81} One study was longitudinal study,⁷⁷ three were randomized controlled trials^{60,68,80} two

were pilot experimental studies,³⁷ and the remaining three were observational experimental studies.^{27,79,82} The total number of office workers included in the studies was 7814, with participants from 15 countries.

Sitting time. Five studies found no correlation between sitting time and LBP,^{66,67,69,70,72} while eight reported an association.^{28,60,73–75,77,81} The two studies that found an association were based on objective assessments of sitting time^{60,79} whereas the other studies relied on patients' self-reports.^{66,67,69,70,72} Additionally, the questions in the self-report questionnaires regarding sitting time varied. Some asked for the total sitting time in hours, while others focused on how many hours per day the patient spent using a computer. In one study⁶⁹ (n = 395), where no relationship was observed, groups above and below three hours of sitting time were compared, while in another study⁶⁶ (n = 648) groups above and below six hours of sitting time were compared. In Rehman et al.'s study,⁶⁷ sitting times were categorized into <5 h/day (n = 54), 5–7 h/day (n = 175), and ≥8 h/day (n = 177). Studies indicating that sitting is associated with low back pain reported sitting times of over seven hours per day (OR = 1.89, n = 254),²⁸ over four hours per day (n = 51),⁷⁴ over 6 h per day (n = 625),⁷³ an average 6.69 h per day and 30.82 h per week (n = 362),⁷⁵ and over 50 h per week (daily average over 8 h).⁸¹ In Mehta and Maru's study⁷⁷ (n = 200), sitting time over five hours a day was not associated with LBP visual analog scale scores, but it was associated with functional status.

Only Mehta and Maru⁷⁷ and Brakenridge et al.⁶⁰ used more objective assessment methods, such as the visual analog scale, to evaluate low back pain. All other studies relied on questions regarding the presence or absence of LBP, which were either developed by the researchers themselves or included in specialized questionnaires such as the Cornell Musculoskeletal Discomfort Questionnaire.^{27,28,37,65–76,78–82}

Sitting posture. Regarding sitting posture, three studies found no association with LBP prevalence,^{65,72,75} while seven indicated an association.^{66,69–71,73,76,78} To evaluate LBP, two studies used the Oswestry Disability Index,^{73,76} and one study⁷¹ used the Body Perceived Discomfort scale for quantitative assessment. Other studies only assessed the presence of LBP as either "present" or "absent",^{66,69,70,78} similar to the studies that assessed sitting time. In the studies by Kristensen and Jensen⁶⁵ (n = 2376) and Çelik et al.⁷² (n = 528) ergonomic office assessment was performed, while in the study of Başakçı Çalık et al.⁷⁵ (n = 362), poor sitting posture in the thoracolumbar region was scored. In the studies that found a relationship, ergonomic office evaluation,⁶⁶ poor posture and ergonomics awareness,^{69,73} sitting posture^{70,76,78} and asymmetrical/symmetrical sitting⁸⁰ were evaluated (Table 1).

Table 1. Characteristics of included studies.

Author, Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Kristensen and Jensen ⁶⁵ , 2005, Denmark	To identify work technique and ergonomic prognostic factors for musculoskeletal symptoms in office workers, and additionally in a subgroup of workers who perform highly repetitive and monotonous computer work.	2576 office workers Repetitive computer work groups [% of work time of computer (75%, 50%, 0-25%)] No data on gender and age	Sitting Posture	- Nordic musculoskeletal questionnaire Demographic data, ergonomics and work related properties (a self-reported standardized questionnaire)	Work speed was a prognostic factor for low back symptoms = 1.38 (1.08-1.76) and p = 0.03* No significant regression between properties of sitting posture and LBP prevalence (p > 0.05)	- Potential selection bias	Since it is uncertain whether there is selection bias in this study, further research is needed to determine the true effect of alternating between standing and sitting during office work.	- No
Spyropoulos et al. ⁶⁶ , 2007, Greece	Prevalence of low back pain (LBP) among Greek public office workers and an analysis of risk factors that could contribute to the development of LBP.	648 office workers Gender: 75.8% female Age: 61.8% ≤ 45 y/o, 33.4% ≥ 46 y/o	Sitting Time/ Sitting Posture	A standardized self-report questionnaire was developed to document the risk factors related to the development of lower back pain (LBP). Work ergonomics, psychosocial features, and personal characteristics were identified and associated with the prevalence of LBP. (LBP point-prevalence, LBP one year-prevalence, LBP two year-prevalence, LBP lifetime-prevalence).	33%, 37.8%, 41.8%, and 61.6% presented with point, one-year, two-year, and lifetime prevalence of LBP respectively. Sitting time (≤6 h and ≥6 h), back support, adjustable seating surface aren't significantly associated with prevalence of low back pain (p > 0.05). Body position in sitting (only LBP lifetime prevalence, p = 0.019), body distance from computer screen (≤50 cm and 50-100 cm, p < 0.05 for prevalence LBP one year, prevalence LBP two year prevalence, LBP lifetime prevalence).	- Limited generalizability to private sector workers. Influence of bureaucratic barriers on sample selection Use of a cross-sectional design that limits causal inferences.	Future research should include private office workers, explore alternative sampling methods, address the limitations of cross-sectional design, and examine the impact of exercise and smoking habits on lower back pain (LBP) prevalence.	No Yes

(continued)

Table 1. Continued.

Author, Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Cho et al. ²⁸ , 2012, Taiwan	Investigate the prevalence of musculoskeletal symptoms among office workers with high computer workload (<7 h, ≥ 7 h).	203 office workers Gender: 57.1% male Age: Male, 28.1 \pm 3.7 y/o; Female 27.7 \pm 3.6 y/o Low computer workload (<7 h, n = 84) High computer workload (≥ 7 h, n = 119).	Sitting Time	- Chinese Health Questionnaire Musculoskeletal Symptom Questionnaire Computer usage during weekend (h/day) Computer usage during working (h/day)	adjustable back support ($p < 0.05$ for prevalence LBP one year; prevalence LBP two year prevalence), are significantly associated with prevalence of low back pain. A high workload was significantly associated with lower back complaints (OR, 1.89).	- Low response rate leading to potential responder bias. Small sample size due to exclusion of ineligible participants. Focus on high computer workload users, potentially overestimating musculoskeletal symptoms. Use of a self-reported online survey, which may introduce biases. Lack of data from participants with extremely high workloads, possibly leading to unrepresentative findings.	Future studies should develop an intervention that addresses both physical and psychological issues to reduce musculoskeletal problems. Additionally, future research should use personal interviews and recruit participants from companies in Taiwan's science industrial parks, which may offer a more representative population	Yes - -
Rehman et al. ⁶⁷ , 2013, Canada	Identify the occurrence and outcomes of low back pain among computer users, examining their relationship to age, gender,	- 416 participants using computers for a minimum of five years Gender: 55.5% male Age: 22-55 y/o,	Sitting Time and Sitting Behavior	A self-reported questionnaire customized from Occupational Health and Safety Act of the Ministry of Labor, Ontario, Canada was employed.	- Work related backache was reported by 27.4% of participants The occurrence of LBP showed no significant relation to the duration of	- The study relied on self-reported descriptions of ergonomic conditions at participants' workstations, which were not independently verified	Future studies should focus on identifying modifiable, cost-effective factors that improve worker health and safety particularly through preventive measures	No - Yes

(continued)

Table 1. Continued.

Author; Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
	occupation, and the duration of computer use.	mean: 34.82 ± 8.07 Two groups on the basis of duration of computer use (5–9 yrs. and 10 yrs. or >) Three groups on the basis of length of use/day (<5 h, 5–7 h, 8 h or >) Three groups on the basis of consecutive h (1–2 h, 3–4 h, h or >)			computer usage (p = 0.5). Consecutive hours of work on the computer without any short breaks were associated with the occurrence of back pain or discomfort (p < 0.001). The occurrence of back pain and discomfort is noted to be higher in individuals spending more time on the computer; however, this observation lacks statistical significance (p = 0.9).	and may therefore be unreliable.	like ergonomics awareness. Additionally, research is needed to explore strategies for improving working conditions and reducing musculoskeletal disorders (MSDs).	Time Posture Behavior
Graves et al. ⁶⁸ , 2015, United Kingdom	Investigate the impact of a sit-stand workstation on sitting time, as well as vascular, metabolic, and musculoskeletal outcomes in office workers. Also, explore the acceptability and feasibility of the workstation."	47 office workers Gender: 79% female Age: Mean 38.6 ± 9.5	Sitting Behavior	Intervention: Sit-stand Workstation Control: Standard office chair Outcome: Workplace sitting time, behavioral, cardiometabolic and musculoskeletal outcomes (level of discomfort or pain at three sites (lower back, upper back, neck and shoulders) on a Likert scale from 0 (no discomfort) to 10 (extremely	At 8 weeks, in comparison to the control group, the intervention group experienced a positive reduction in sitting time [–80.2 min/8-h workday (95% CI = –129.0––31.4); p = 0.002], an increase in standing time [(72.9 min/8-h workday (95% CI = 21.2, 124.6); p = 0.007], and a decrease in total cholesterol	– Potential inaccuracy of self-reported activity data compared to accelerometers. Short study duration limits insights into the long-term effects of sit-stand workstations. Demographically homogenous sample, primarily White British women with higher education, which may reduce representativeness.	Future studies should investigate whether long-term use of sit-stand workstations leads to sustained reductions in workplace sitting and further improvements in cardiovascular and metabolic health. Additionally, research should explore the economic benefits for organizations and address factors like workstation design, social environment,	- - - Yes

(continued)

Table 1. Continued.

Author; Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Ardahan and Şimşek ⁶⁹ , 2016, Turkey	Examined the prevalence of musculoskeletal discomforts related to computer use in the workplace, along with personal and computer-related risk factors.	395 office workers Gender: 63.2% male Age: 50.3% < 46 y/o, 49.7% ≥ 46 y/o	Sitting Time/ Sitting Posture /Sitting Behavior	uncomfortable) (0.4 and 8 weeks). Daily computer usage duration (<7 h, ≥8 h), non-resting computer usage duration (<3 h/day, ≥3 h h/day) and (Cornell Musculoskeletal Discomfort Questionnaire, ergonomic knowledge were collected via face-to- face interviews	[-0.40 mmol/L (95% CI = -0.79, -0.003; p = 0.049). No adverse effects concerning musculoskeletal discomfort/pain were observed compared to controls, and improvements in flow-mediated dilation and diastolic blood pressure were observed (p > 0.05). %59.4 has LBP prevalence, Only ergonomic knowledge [0.6(0.36-0.92) and <0.001]* could cause risks on LBP. Daily computer usage duration and using a computer for three hours without taking any break couldn't cause risks on LBP (p > 0.05).	- The study was conducted at a single organization and some of the office workers were excluded.	work tasks, and habits that may influence workstation use.	No Yes No
Kaliniene et al. ⁷⁰ , 2016, Lithuania	Evaluate the prevalence of musculoskeletal pain in different anatomical areas and its associations with individual, and ergonomic, and psychosocial factors among	513 public service office workers Gender: %94.7 female Age: 23-29 y/o 10.7%, 30-39 y/o 17.7%, 40- 49 y/o 29.1%, 50-70 y/o 42.5%	Sitting Time/ Sitting Posture /Sitting Behavior	Demographic data, ergonomics and work related properties, Nordic Musculoskeletal Questionnaire and Copenhagen Psychosocial Questionnaire Rapid Upper Limb	56.1% has LBP prevalence Having a BMI of >25 kg/m ² [1.50 (1.24-4.28) and 0 < 05]* and higher RULA score [1.30 (1.03-1.65) and 0 < 05]* not taking a break every 2 h increased risk of	-		No Yes Yes

(continued)

Table 1. Continued.

Author, Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
	computer workers			Assessment [RULA] were collected	having low back pain ($p < 0.05$). Daily computer use duration (< 4 h/day, $4-6$ h/day, > 6 h/day) and computer work experience (1-5 years, 6-15 years, 16-36 years) were not associated ($p > 0.05$) with an increased risk of having low back pain.			
Zemp et al., ³⁷ 2016, Switzerland	Investigate how back pain influences sitting behavior in the office environment.	20 office workers Gender: %65 female Age: 27-57, mean 45 y/o	Sitting Behavior	Two standardized questionnaires (Korff Pain Intensity, Brief Pain Inventor) were used to evaluate short and long-term back pain in order to divide the subjects in to two groups (with and without back pain) Sitting behavior was analyzed by means of our in-house developed a textile pressure sensor mat	Experiencing low back pain within the last 24 h demonstrated a noticeable trend towards adopting a more static sitting behavior ($p < 0.05$).	- Low sample size and limited range of low back pain intensity levels.	Future studies should specifically recruit subjects with higher pain levels, examine how the exact location of back pain influences sitting behavior parameters, and explore the integration of a feedback system into SIT-CAT technology to increase awareness of sitting positions and behaviors.	- -
Akkarakittichoke and Jarwattanakul, ⁷¹ 2017, Thailand	Examine the seat pressure distribution characteristics during a one-hour sitting period among office workers, comparing those with and without chronic LBP	46 office worker 23 chronic LBP Gender: %78.2 female Age: mean 29.6 \pm 5.3 23 control Gender: %78.2 female Age: mean 29.6 \pm 5.1	Sitting Posture	l-h computer work, Sensor mat to evaluate seat pressure distribution, Body Perceived Discomfort scale	Workers with chronic LBP exhibited significantly more asymmetrical sitting compared to their healthy counterparts. All workers tended to adopt slumped sitting postures after 20 min of sitting during a 1-h period.	- Causal relationships cannot be drawn due to the cross-sectional design. Participant definitions for healthy and symptomatic cases may limit the scope of results. Controlled sitting posture in the study does not capture real-	Further research should examine the role of sitting characteristics, including task and posture, on the development of LBP in workers who sit for long hours. A prospective study design is needed to validate the current findings, and studies	- Yes -

(continued)

Table 1. Continued.

Author; Year; Country	Study Design	Main Aim of Study	Population	Sitting Time/ Posture/ Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Brakenridge et al. ⁶⁰ , 2018, Australia	Cluster- randomized study	Explores changes in musculoskeletal pain among desk- based workers over three months of a workplace- delivered, sitting- reduction intervention.	153 office workers Gender: 54.2% male Age: mean 38.9 ± 8 y/o	Sitting Time/ Sitting Behavior	- Modified Nordic Musculoskeletal Questionnaire assessed pain intensity (0–9; none– worst possible) The activPAL3 (7 days, 24 h/day protocol) measured sitting and prolonged sitting in 30 min bouts at work.	Healthy workers demonstrated significantly more frequent postural shifts than those with chronic LBP during prolonged sitting ($p < 0.05$). Sitting reduction [0.84 (1.44, 0.25) and $p =$ 0.005]* and prolonged sitting reduction [−0.39 (−0.79, 0.00) and p = 0.050]* was associated with reduced LBP other effects were small and non-significant ($p > 0.05$).	- The lack of a control group Pain could limit sitting reduction, making causality unclear by introducing revers causality. Lack of validity and reliability for pain measures Limited participant re- consent prevented long-term evaluation.	Larger, more diverse studies with longer durations and frequent data collection are needed to better understand the link between sitting-time reduction and musculoskeletal pain. Future research should also include detailed movement data, such as video recordings, to improve intervention design and ensure maximum benefits while preventing harm.	Yes - Yes
Çelik et al. ⁷² , 2018, Turkey	Cross-sectional study	Determining the existence of pain in the musculoskeletal system among office workers and the reasons for it	528 office workers Gender: 51.1% female Age: mean 38.55 ± 9.79 y/o	Sitting Time/ Sitting Posture	Demographic data, ergonomics and work related properties (a self- reported standardized questionnaire) and the level of discomfort in body regions	The rate of pain complaints among female office workers for lower back (OR = 0.64, 95% CI: 0.45–0.91) Female or male office workers, there was no significant association between ergonomics and work related	-	No No -	

(continued)

Table 1. Continued.

Author; Year; Country	Study Design	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Bontrup et al. 27, Switzerland	Observational and experimental study	Relationship between back pain and occupational sitting. A textile pressure mat was used to evaluate and parameterize sitting behavior over a total of 400 h	64 office workers Gender: 62.5% female Age: mean 43 ± 13 y/o	Sitting Behavior	A textile pressure mat was used to evaluate and parameterize sitting behavior Chronic Pain Grade Questionnaire The Brief Pain Inventor	The mean work time was 6.2 ± 1.5 h Participants experiencing chronic pain and/or functional disability exhibited fewer transient periods and fewer movements per hour; slightly fewer position changes per hour; and longer periods of stable sitting compared to their counterparts without pain and/or functional disability (p < 0.05).	The study analyzed only one shift, which may not capture full sitting behavior. The lack of ergonomic adjustments due to workplace rotation could affect results. Lower back pain in call-center employees is influenced by sitting behavior, job tenure, fitness, and stress. Future research should address confounding factors and pain intensity. The findings may not apply to all office workers, as call-center employees are at higher risk for musculoskeletal disorders.	Future studies should consider factors like sedentary lifestyle, job tenure, working hours, fitness, and psychological stress. They should also assess pain intensity on a broader scale and include a more detailed classification of pain, especially for those with low to medium pain and disability.	-
Fanta et al. 73, Ethiopia	Cross-sectional study	Assess the prevalence and factors associated with low back pain among civil service sectors office workers	625 civil service sectors office workers Gender: 65.3% male Age: 20–60 y/o, mean 39.47 ± 8.9	Sitting Time// Sitting Posture// Sitting Behavior	Standardized Nordic Musculoskeletal Questionnaires and modified Oswestry through face to face interview	Being obese [6.3 (4.29–9.09)], having a smoking history [5.2 (2.57–10.82)], poor awareness of sitting posture [2.6 (1.61–4.30)], experiencing job stress [5.9 (3.44–10.25)], not taking rest breaks during the workday [3.2 (1.82–5.62)], sitting for more than 6 h per day [16.08 (14.4–19.3)], and	-	-	Yes

(continued)

Table 1. Continued.

Author, Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Study Design								Time Posture Behavior
Stanam et al. ⁷⁴ , 2019, USA	Assess computer use-related exposures, estimate the prevalence of musculoskeletal symptoms, and analyze the relationship between ergonomic exposures and musculoskeletal symptoms among university faculty and staff	51 full-time faculty and staff who use computers for at least 3 h/day on at least 4 days a week at their workplace. Gender: 76% female Age: 26–40 y/o 29%, 41–63 y/o 69%, not given 2%	Sitting Time/ Sitting Behavior	A questionnaire developed based on the modified Nordic Musculoskeletal Questionnaire	frequent computer use [4.3 (2.09–5.47)] are significantly associated with the presence of low back pain. LBP prevalence was 60.8% The high exposure group demonstrated a significant association with the prevalence of low back pain (p = .043). The risk of low back pain decreased (OR = 0.7) with an increase in frequency of breaks.	- The study only assessed computer usage in the workplace, but participants may have been exposed to computing devices outside of work, which could affect musculoskeletal symptoms MSS were self-reported, and physician diagnoses would have provided more accurate data The small sample size limits the statistical power, and a larger sample in future studies could improve the reliability of the results.	Future studies should include exposure to computers outside the workplace and explore the effectiveness of interventions like posture improvements, frequent breaks, and annual ergonomic assessments to address MSS in workplace settings.	Yes - Yes
Çalk et al. ⁷⁵ , 2020, Turkey	Investigate the relationship between work and how this affects pain duration and ADLs.	362 office workers Gender: 50.8% female Age: 37.35 ± 8.43	Sitting Time/ Sitting Posture	Daily working time (h/day), daily computer usage time (h/day), weekly computer usage time (h/week), total work time in the workplace (years), pain disturbed their activities of	64.1% has LBP prevalence Improper posture of the cervical and thoracolumbar regions during work time have no effect on LBP (p = 0.125), daily computer usage time had small	- The study relied on self-report methods for evaluating musculoskeletal pain and posture. Posture assessment was not conducted using more objective methods, such as	-	Yes No -

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Table 1. Continued.

Author, Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Kasumawati et al. ⁷⁶ , 2020, Indonesia	Determine the correlation between length of work and work posture with complaints of LBP among back-office employees	44 office workers Gender: No data Age: 75% ≤ 35 y/o, %25 > 35 y/o	Sitting Posture	daily living (ADLs) were collected Ovako Working Posture Assessment System (OWAS) method and LBP complaints are measured using the Modified Oswestry Low Back Pain Disability Questionnaire.	but positive correlation with LBP VAS (p < 0.01). 90.9% of participants needed to improve their work posture. There was a statistical relationship between age (p < 0.001), the length of work (Work > 8 h, p < 0.001), work posture (p = 0.009) with LBP complaints on back-office employees.	video-based 3D observation.	-	Yes
-								
Mehta and Maru ⁷⁷ , 2020, India	A comparison of 2009 versus 2019 surveys was done to understand cumulative trauma disorders trends and to find the significance of the number of people affected due to hours per day computer use.	200 Indian computer users (2009: 100; 2019: 100) 2009: Gender: 66% male Age: mean 31.2 ± 5.4 y/o 2019: Gender: 59% female Age: mean 33.2 ± 7 y/o Three groups on the basis of duration of computer use Group I: 1–3 h Group II: more than 3–5 h Group III: more than 5 h.	Sitting Time	Demographic data, personal lifestyle, occupational history including work demands and psychosocial factors at work, duration of computer use, symptom questionnaire for cumulative trauma disorders, functional assessment scale symptom questionnaire for cumulative trauma disorders, functional assessment scale and VAS assessed function and pain during/after computer use were collected via online survey.	2009: %24 for LBP prevalence 2019: %29 for LBP prevalence In 2019, a significant positive correlation (r = 0.215; P = 0.032) was found between computer use duration and functional performance, contrasting with the 2009 study (r = 0.001; P = 0.991). No significant correlation existed between computer use duration and pain intensity (VAS scores) in both 2009 (r = 0.078; P = 0.443) and 2019 (r = -0.085; P = 0.398).	-	Further research should focus on analyzing psychosocial factors and computer workstation design as contributors to cumulative trauma disorder (CTDs), as well as investigating the combined impact of handheld device use and computers on upper-limb CTDs.	Yes

(continued)

Table 1. Continued.

Author, Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Sahu et al., ⁷⁸ 2020, India	The effects of workstation design, posture and ergonomic awareness on the prevalence of pain for a year in the body among office workers	110 office workers Gender: 60% male Age: 21–58 y/o, mean 29.73 ± 6.09 y/o	Sitting Posture	A Questionnaire based on ergonomics for IT Professionals, Maastricht Upper Extremity Questionnaire and the Occupational Safety and Health Administration checklist	Incorrect posture and off-center monitor placement were linked to a higher prevalence of LBP (p < 0.05), but there was no significant correlation with other incorrect workstation adjustments (p > 0.05).	– Participants found the 98-item survey too lengthy. There may also be bias in reporting musculoskeletal complaints from the past year. The study did not account for psychosocial risk factors.	Future research could improve posture assessments and workstation evaluations by using more accurate tools like electrogoniometers and 3D motion analysis. A similar study could be conducted among IT professionals in North India to validate or compare the findings.	Yes - Yes -
Waongenngarm et al., ⁷⁹ 2020, Thailand	Examined the characteristics of perceived discomfort and postural shifts at different magnitudes during a 4-h sitting period and the association between perceived discomfort and number of postural shifts	40 office workers Gender: 72.5% female Age: mean 29 ± 3.9	Sitting Behavior	Subjects rated perceived body discomfort using Borg's CR-10 scale in, lower back. A seat pressure mat device was used to gather seat pressure data during sitting. Postural shifts were determined by analysis of the dispersion index of both ischial tuberosities from seat pressure data. The threshold for a postural shift was set at ± 10% and ± 20%	Discomfort across all body regions increased continuously during a 4-h prolonged sitting. (p < 0.05). In the first 2 h of sitting, the number of postural shifts, both small and large, increased. Following this period, only the count of larger postural shifts (with a 20% threshold) continued to increase (p < 0.05).	– Participants were recruited with convenience sampling and all had a normal BMI, limiting generalizability to other worker populations. The cross-sectional design prevents establishing a causal relationship between exposure and outcomes. Perceived discomfort was subjective, which could lead to inaccuracies in reporting. The study presented 44 correlations, raising the possibility of random data yielding significant results. The 20% threshold for	Further research is recommended to explore the effect of postural shifts at the 20% and other thresholds on trunk muscle activity and tissue viability. Additionally, studies should examine the impact of perceived discomfort characteristics and the frequency of postural shifts on the development of musculoskeletal disorders in workers who sit for long hours.	Yes - Yes

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Table 1. Continued.

Author; Year; Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting	
Akkarakitrichoke et al. ⁸⁰ , 2021, Switzerland	Investigate the efficacy of active break and postural shift interventions aimed to reduce sitting discomfort on recovery duration and recurrence of neck and low back pain among high-risk office worker	193 office workers A custom-designed apparatus was employed to deliver interventions Group 1 = active breaks (n = 47) Gender: 70.2% female Age: mean 31.6 ± 6.1 y/o Group 2 = postural shifts (n = 46) Gender: 74.5% female Age: mean 35.0 ± 7.7 y/o Control Group = placebo seat pad (n = 100) Gender: 79% female Age: mean 34.1 ± 5.3 y/o	Sitting Behavior	Incidence of neck and low back pain with pain intensity and disability level was recorded monthly. Main outcome measures were recovery time and recurrent rate of LBP VAS Roland-Morris Disability Questionnaire A processor recommended active breaks and postural shifts for each individual. Instructions about active breaks were sent from the processor to smartphone application	Participants of active breaks or postural shift interventions experienced a significantly shorter median recovery time (1 month, p = 0.001) compared to the control group (2 months). Both active breaks (p = 0.03) and postural shift (p = 0.01) interventions led to a 78% reduction in the recurrence rate of low back pain.	postural shifts was arbitrary and should be further explored with other thresholds for muscle activity and tissue viability. The study had a predominantly female participant group and baseline characteristics differed across study groups due to cluster randomization, which could cause imbalances. The study did not gather detailed information on participants' previous pain experiences, which may have influenced the outcomes. Biopsychosocial factors and diagnoses of nonspecific neck and low back pain were based on subjective assessments, risking potential bias. Participants had unequal follow-up times, which may affect the estimation of recovery rates. The control group's sitting behavior was not monitored, and the compliance of participants in the	Future studies should use pair-matched randomization or stratified methods, include previous pain experiences as a confounder, and incorporate objective physical examination data to improve accuracy. Additionally, research should validate the efficacy of active breaks and postural shifts on recovery and recurrence of neck and low back pain, particularly in individuals with poor sitting habits, and assess these interventions in normal office workers and other occupational groups.	- - -	Yes

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Table 1. Continued.

Author; Year, Country	Main Aim of Study	Population	Sitting Time/ Posture / Behavior	Method for Data Collection	Major Findings	Reported Limitations and/or Barriers	Reported Literature Gaps	Relationship of LBP with Sitting
Hossain et al., ⁸¹ 2021, Bangladesh	Identify the relationships of individual and occupational factors with LBP in Bangladeshi computer workers	468 office workers Gender: 95.1% male Age: 76.7% ≤ 30 y/o, 23.2% > 30 y/o	Sitting Time	The musculoskeletal scale of subjective health complaints was used to measure respondents' LBP level in the last 1 month Physical activity level Sitting time	LBP within the last month was 65.6% Significant positive associations were found for spending more than 50 h weekly in a seated position (AOR, 1.61; 95% CI, 1.05 to 2.49) with LBP	intervention groups during the follow-up period was not assessed, potentially impacting the internal validity of the study. - The study's cross- sectional design prevents establishing a causal relationship between the outcomes and independent variables. Self-reported responses introduce potential biases such as recall bias, although efforts were made to minimize this using validated questionnaires. Some data, such as pain levels, sitting hours, and work experience, were collected subjectively without objective measurement tools. Due to the COVID-19 pandemic, physical data collection was not possible, which may have affected the accuracy and reliability of the findings. Convenience sampling was used, which limits the ability to generalize the results to the broader population of online professionals.	-	Yes

(continued)

Sitting behavior. Only one study⁶⁹ did not find a relationship between working without a break for more than three hours and LBP, whereas eleven studies demonstrated a link between sitting behavior and LBP^{27,37,60,67,68,71,73,74,76,78,82} (Table 1). In the review, some studies evaluated sitting behavior using self-report questionnaires that asked whether short breaks were taken,^{67,69,70,73,74} while others used objective assessments such as pressure mats^{27,37,79,80,82} and activity monitoring devices.^{60,73} One study also assessed sitting behavior using devices that encouraged individuals to take breaks, such as a sit-stand workstation.⁶⁸ While most studies evaluated the presence or absence of low back pain,^{67,69,70,73,74} some measured pain intensity^{37,60,80} or discomfort levels using a Likert type scale.^{68,79,82}

Barriers and/or limitations for studies and literature gaps. Table 1 summarizes the barriers, limitations, and identified literature gaps reported in the included studies. Of the 22 articles reviewed, 19 identified reported specific barriers or limitations, while 3 did not (Table 1). Regarding literature gaps, 15 studies highlighted areas for future research and provided recommendations, while 7 did not (Table 1).

Discussion

This scoping review assessed the current evidence on the effect of sitting time, posture, and behavior on the risk of low back pain (LBP) in office workers. It found that prolonged sitting, poor posture, fewer breaks, and more static sitting were associated with LBP. Among these factors, sitting behavior (fewer breaks and more static sitting) showed the strongest association with LBP. Since most studies on sitting duration are cross-sectional, further objective, evidence-based research is needed. Sitting posture was the second most commonly associated factor with LBP.

Relationship between sitting time and LBP

Literature consistently shows that prolonged sitting can lead to adverse biomechanical changes in the lumbar spine, including a reduced lumbar lordosis, increased muscle activity, intradiscal pressure, and ischial compression.^{61,79} Evidence also suggests that prolonged flexion during sitting may result in redistribution of the nucleus pulposus within the annulus.⁸³ These findings suggest a plausible biological relationship between sitting time and LBP. Despite this, some systematic reviews have reported mixed results regarding the association between sitting time and LBP.^{31–33,44,84,85} However, it is important to note that these systematic reviews were conducted before the widespread use of computers, which has significantly increased sitting time in modern society. In addition, these reviews did not focus exclusively only on office

workers, a population particularly susceptible to the effects of prolonged sitting.

To address these limitations, the current scoping review focused exclusively on office workers and identified thirteen studies examining the relationship between sitting time and LBP. Of these studies, five found no association between sitting time and LBP.^{66,67,69,70,72} However, it should be noted that the first study categorized daily sitting time as above and below three hours, which may be too low a threshold to detect an association.⁶⁹ Additionally, in the study by Çelik et al. most office workers (82.6%) worked for six hours or less, with a mean sitting time of 4.64 ± 2.21 h, which may have led to an underestimation of the results.⁷² The remaining three studies examined sitting time above six hours and found no association.^{66,67,70} In contrast, eight studies reported a positive association between sitting time and LBP.^{28,60,73–75,77,79,81} These studies found that sitting for at least four hours⁷⁴ and six to eight hours per day^{28,73,75,81} was associated with an increased risk of LBP. Additionally, functional impairment was observed for sitting more than five hours.⁷⁷ Further supporting the role of sitting time in LBP, the only non-cross-sectional randomized controlled trial by Brakenridge et al.⁶⁰ showed that a reduction in sitting time was associated with a decrease in LBP. However, it is important to note that all studies, except Brakenridge et al. were cross-sectional, which limits the ability to determine causality. It is important to note that, with the exception of the studies by Mehta and Maru⁷⁷ and Brakenridge et al.,⁶⁰ other research did not take into account the severity of LBP in their assessments. Instead, these studies classified LBP simply as present or absent.^{27,28,37,65–76,78–82} This approach may have led individuals with low pain intensity (e.g. visual analog scale < 3) to overlook their low back pain, resulting in an inaccurate classification as part of the pain-free group.

In the meta-analysis by Mahdavi et al.,⁴⁵ which aimed to investigate the relationship between sedentary behavior and its indicators with LBP among adults and children, it was shown that sedentary behavior is a risk factor for LBP in office workers, identified as a subgroup (OR = 1.23). However, this meta-analysis also demonstrated an association between excess weight and smoking with LBP. Unfortunately, in the current scoping review, we did not specifically address the confounding effects of these factors. In a meta-analysis evaluating whether sit-stand workstations can reduce LBP by decreasing sitting time,⁴⁸ it was found that these workstations may indeed help to reduce low back pain. Similarly, a 2019 Cochrane review reported that workplace interventions aimed at increasing standing or walking time might reduce musculoskeletal pain among sedentary workers, although these effects were not statistically significant.⁸⁶ In a cross-sectional study examining the relationship between objectively measured sitting time (total daily, occupational, and leisure

periods) and low back pain among blue-collar workers, a positive association was found between sitting duration and LBP intensity, even among blue-collar workers.⁸⁷ These findings support the results of our current scoping review, where we observed an association between longer sitting time and LBP in office workers.

Relationship between sitting posture and LBP

The relationship between sitting posture and LBP is a complex and multifaceted issue. While it is often assumed that maintaining a specific 'correct' posture is key to preventing LBP, the evidence to support this notion is limited. In fact, awkward sitting positions, such as both upright and slumped sitting positions, have been shown to provoke LBP in some individuals.⁸⁸ Slumped sitting induces a 'flexion relaxation' response in the paraspinal muscles, potentially increasing the load on passive spinal structures.⁸⁹ Conversely, upright and more lordotic sitting postures are associated with increased trunk muscle activity, potentially leading to trunk muscle fatigue.^{39,88} Despite prevailing beliefs among both physiotherapists and the general public about the importance of correct posture, there is limited strong evidence to support the idea that avoiding incorrect posture effectively prevents low back pain, or that any particular spinal curvature is strongly correlated with pain.^{26,32,90,91}

In this scoping review, three studies investigating the relationship between sitting posture and LBP found no association.^{65,72,75} These studies relied on self-reported questionnaires to assess sitting posture and postural risk, which may have introduced bias and contributed to the lack of association. In contrast, seven studies found a positive association between sitting posture and LBP.^{66,69–71,73,76,78} Of these, only two used self-reported questionnaires to assess sitting posture,^{66,78} while the others found associations through ergonomic office training,^{69,73} ergonomic assessment by a health professional,^{70,75,76} or an experimental study evaluating asymmetrical sitting posture using a specially designed pillow containing a force plate.⁷⁴

The relationship between awkward postures and LBP remains contentious, with varying findings across studies. For example, a meta-analysis by Griffith et al.⁹² found that awkward or non-neutral postures were associated with increased LBP risk, with odds ratios (OR) ranging from 1.14 (95% CI: 1.08–1.21) to 2.03 (95% CI: 1.26–2.49). Supporting this, systematic reviews by da Costa and Vieira,³⁰ Lis et al.,⁸⁴ and Nelson and Hughes⁹³ suggested that awkward postures, particularly when combined with prolonged sitting or lifting, increase the risk of LBP. However, Roffey et al.⁸⁸ found no strong evidence for a causal relationship. An umbrella review by Swain assessing various physical exposures including prolonged sitting,

awkward postures, bending, and twisting found limited consensus regarding their association with LBP and highlighted the need for higher quality studies.⁹⁴ Overall, the evidence from this scoping review suggests that maintaining an ergonomic office environment and optimal posture may be associated with a reduced risk of LBP, consistent with the literature.

Relationship between sitting behavior and LBP

Reducing static sitting, increasing breaks, making sitting more mobile sitting and encouraging in-office exercises to increase physical activity have emerged as a promising strategy to reduce the LBP prevalence. With the exception of one cross-sectional study that found no association between LBP and sitting behavior,⁶⁹ the remaining twelve studies consistently demonstrated an association between sitting behavior and LBP^{27,37,60,67,68,71,73,74,76,78,82} in the present scoping review.

Womersley and May⁹⁵ found that individuals with LBP tend to sit for long, uninterrupted periods in a relaxed posture, suggesting that sitting habits may play a role in LBP risk. Other studies show that individuals with LBP typically exhibit fewer micromovements, leading to a more static sitting behavior.^{37,96} Despite efforts to define an "optimal" posture, even "ideal" positions may lead to fatigue if maintained for too long,³⁹ highlighting the benefits of regular, small postural changes.⁴¹ Dynamic sitting, involving periodic postural shifts, has shown physiological benefits such as reducing spinal load⁴¹ and preventing spinal shrinkage,⁹⁷ and may also help prevent posterior disc damage through low-intensity movements.⁴³ Consistent with these findings, the present scoping review also supports the association between static sitting behavior and LBP.

Limitations and or barriers for studies included in the scoping review

Studies investigating the relationship between sitting and LBP among office workers, as evaluated in this scoping review, face several common barriers and limitations. A frequent issue is the reliance on self-reported data from online survey.^{28,66,77,78,81} Low response rates in online surveys can lead to response bias, limiting the generalizability of the findings. Furthermore, office workers with high workloads often lack sufficient time to complete these surveys, which may result in the underrepresentation of this group.²⁸ Self-reported surveys are also prone to recall bias, as participants may not accurately remember or report their sitting habits and associated discomfort.^{28,65–67,70,73–75,77,78,81} Cross-sectional studies, prevalent in this field, can only identify correlations, not causality, limiting our understanding of how specific sitting parameters

contribute to LBP.^{28,65–67,69,70,73–78,81} Additionally, many studies focus on narrow populations, such as office workers from specific companies or institutions, reducing the applicability of the results to other office worker groups.^{27,28,66,68,69,71,74,80}

Furthermore, most studies rely on subjective reports of ergonomic conditions rather than objective assessments^{65,72,75} weakening the reliability of the findings. Additionally, many studies fail to consider important psychosocial factors^{27,37,78,80} or conduct thorough computer workstation analysis.^{67,78} Additionally, non-office-related activities, such as use of devices outside the workplace, are often not accounted for, though they may contribute to musculoskeletal pain.⁷⁴ Lastly, the self-reported diagnosis of low back pain, without confirmation by healthcare professionals, may effect the accuracy of the data.⁷⁴

Literature gaps and suggested improvements for studies included in the scoping review

To advance research in this field, addressing several methodological and conceptual gaps is crucial. Validated and reliable questionnaires should be prioritized to ensure the accuracy of self-reported data, as discrepancies in data collection methods can significantly impact findings. Increasing sample sizes and recruiting participants from diverse populations will improve the generalizability of the results. Integrating personal interviews with participants can provide more context deeper insights than online surveys, which often lack depth.²⁸ Moreover, longitudinal studies and regression analyses are necessary to establish causal relationships between workplace factors and musculoskeletal issues. Given the reliance on self-reported sitting durations in hourly intervals,^{28,65–67,70,72–74,77,78,81} future research should incorporate randomized controlled trials with objective, long-term follow-up assessments.

Future studies should also focus on objectively evaluating ergonomic workplace standards, using advanced data collection methods such as video recordings to accurately monitor postural changes and movement patterns.⁶⁰ These methods can offer a comprehensive understanding of how dynamic sitting behaviors influence musculoskeletal health. Additionally, other potential contributors, including body weight, smoking, and psychosocial factors, should be systematically analyzed to identify modifiable risk factors for LBP.^{27,37,66,71,78} Importantly, many studies fail to account for pain severity when assessing LBP. Future research should address this by stratifying participants based on pain severity and ensuring LBP diagnoses are verified by healthcare professionals.²⁷ Such approaches will enhance the precision of findings and the development of targeted interventions to reduce LBP in workplace settings.

These recommendations highlight the need for a multidisciplinary approach to research in this field, combining ergonomic assessments, psychosocial evaluations, and

robust methodologies to ensure reliable, actionable outcomes. By addressing these gaps, future studies can provide a stronger foundation for developing interventions that reduce LBP prevalence and enhance workplace health standards worldwide.

Barriers and limitations in the scoping review

Several confounding variables exist between the aims of this scoping review and the assessed relationships. One significant factor is that the assessments regarding the presence of low back pain and sitting time/posture are based on self-reports indicating either presence or absence. In such questions, participants may have a tendency to provide socially desirable answers. This may result in a tendency to under-report or misreport the severity of low back pain and sitting times in comparison to those measured by an objective method, thus introducing a potential risk of bias.⁹⁸ Additionally, variations in office working conditions across countries and sectors, along with individual biopsychosocial factors such as stress and job satisfaction, limit the generalizability of the findings. The lack of detailed analysis of demographic (e.g. age, gender, body mass index) and clinical factors (e.g. comorbidities, injuries) further risks introducing bias by failing to account for these as confounders. Even with adjusted variables, unmeasured or unknown factors may still influence the observed associations, making it challenging to discern whether findings reflect true relationships or are artifacts of these confounding variables.

Although a systematic search strategy was employed, some relevant studies may have been missed, including those excluded due to publication types (e.g. editorials, blogs). Many included studies lacked objective assessments of sitting behavior and back pain, potentially limiting the comprehensiveness of their findings. The authors did not exclude studies based on quality ratings that would affect the validity of the reported findings. The generalizability of our findings may be somewhat limited because the scoping review did not include all possible working conditions. Additionally, the reliance on cross-sectional data poses a significant limitation, as these studies cannot establish causality between sitting behaviors and LBP. While this review included a range of settings, interventions, and age groups, unexplored working conditions may produce different results.

In addition, LBP is multifactorial in nature in the general population, making it difficult to draw firm conclusions. The inconsistency and lack of evidence in the literature linking sitting and LBP are largely attributed to this complexity, compounded by the use of unreliable subjective measurement tools, short follow-up durations, and other methodological weaknesses.^{27,32,33} Unfortunately, this scoping review was unable to exclude studies with such flaws, as there is a scarcity of objective, randomized

controlled trials with long-term follow-up specifically focusing on office workers, which constitute the main limitation of this review.

Studies on sedentary behavior in the general population suggest that adults spend an average of 5 to 8 h per day sitting, while more objective measures estimates that this duration may be higher, ranging from 7.7 to 11.5 h; for example, accelerometer-based studies report that adults sit for an average of 8.2 h per day (range: 4.9–11.9 h).^{48,84,85,92,93} Sitting in an office setting is often more static and limited by breaks compared to leisure-time sitting, and may thus contribute to musculoskeletal disorders. Notably, 60% of office workers report physical discomfort, which is believed to be associated with sedentary time. Furthermore, prolonged static sitting has adverse effects not only on the musculoskeletal system but also on cardiovascular and metabolic health.^{30,65,66} In contrast, leisure-time sitting allows for more flexibility, enabling individuals to incorporate physical activity and breaks as needed. This distinction highlights the importance of considering the temporal and physical structure of sitting in both work and leisure environments when evaluating its health impacts.^{88,94} Addressing this gap, future research should explore these contextual differences and underlying mechanisms.


Conclusion

The current scoping review found that longer sitting time, poor sitting posture, fewer breaks during sitting and more static sitting were associated with LBP. The strongest evidence for an association with LBP was found for sitting behavior (fewer breaks and more static sitting). The second strongest evidence was found for sitting posture as it showed more objective assessment and evidence than sitting duration. Studies on sitting duration are mostly cross-sectional. However, there is a need for future randomized controlled trials of all sitting characteristics, with objective assessment methods, biopsychosocial assessment of the complex nature of low back pain and long-term follow-up.

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Not applicable.

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