Review Paper

Effects of Ergonomic Chairs on Workplace Musculoskeletal Health: A Systematic Review

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ABSTRACT

Purpose: This study aimed to review the impact of ergonomic chairs on clinical and biomechanical outcomes for seated workers.

Methods: We adhered to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines to determine article eligibility and evaluated methodological quality using the physiotherapy evidence database (PEDro) scale. The strength of the evidence was appraised using the grading of recommendations, assessment, development, and evaluations (GRADE) framework. A narrative synthesis was then conducted to summarize the extracted data in descriptive form.

Results: A total of 32 randomized controlled trials met the inclusion criteria and were included in the qualitative synthesis, involving 1,637 participants. The review showed that ergonomic chair designs have mixed results for pain reduction, with some improvements but not consistently across studies. Positive and consistent outcomes were observed in comfort enhancement. The impact on disability was not significant, while benefits were noted in reducing spinal shrinkage and altering muscle activation. Furthermore, ergonomic chairs influenced energy expenditure, body kinematics, and pressure distribution, while dynamic, custom-designed systems enhanced trunk muscle activation. An adjustable chair positively affected joint posture.

Conclusion: Ergonomic chairs, especially dynamic and adjustable ones, provide comfort and biomechanical support to seated workers; although, the benefits regarding pain reduction are inconsistent. These findings suggest that choosing ergonomically designed chairs is a positive step toward workplace wellness. Further research is needed to standardize designs and optimize interventions for various occupational settings.

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Highlights

• Ergonomic chairs improve seating comfort and positively influence biomechanical parameters.

• The evidence for pain reduction remains inconsistent across studies.

Plain Language Summary

Ergonomic chairs, especially those that are adjustable or allow movement, can make sitting at work more comfortable and better support the spine and muscles. They help reduce spinal compression, improve posture, and redistribute body weight and pressure while sitting. However, their effect on reducing pain is not consistent across studies, and they do not appear to significantly reduce disability. Overall, using a well-designed ergonomic chair is a helpful step toward a healthier workplace.

Introduction

Work-related musculoskeletal disorders (WMSDs) encompass a range of inflammatory and degenerative conditions resulting from occupational activities [1]. The 12-month prevalence of WMSDs in the neck, back, and upper limbs is reported to be 55-69%, 31-54%, and 15-25%, respectively [2]. Nearly a million workers stop working every year owing to musculoskeletal pain and loss of function [3, 4].

Factors that have been associated with symptoms of WMSD, both modifiable and non-modifiable risks, include genetic predisposition and structural deformities of the spine. Modifiable factors include posture, task nature, work demands, and the physical characteristics of the job [5]. Offices are workplaces where employees spend much of their time working in a seated position. With more than 45 million computers in the United States alone in the 1990s, concern about WMSDs grew [6]. Over 72% of the employees work in a sitting posture in Western countries [7]. It has been established that prolonged sitting in suboptimal posture is associated with WMSDs [5, 8].

Sedentary work may contribute to WMSDs of the spine, likely due to prolonged periods of low static activity in the trunk muscles. For instance, patients with low back pain (LBP) have been reported to exhibit atrophy of the lumbar multifidus and trunk muscles, which are inactive for approximately 30% of sitting time [9-11]. Additionally, patients with LBP often show a reduction in spinal range of motion, similar to other spinal conditions, such as spinal stenosis, disc prolapse, and degenerative disc disease [12].

The adjustments in the workplace typically focus on the work surface and the chair [13]. Since the chair directly affects body posture, patients experiencing WMSD symptoms from prolonged sitting are advised to adjust their chairs to use ergonomic features. Often, due to environmental constraints, changing the work surface is not feasible, and an adjustable work surface may not be economically viable [5, 13, 14]. Therefore, adjusting the chair is often the most accessible step to reduce the likelihood of WMSDs.

Active movements of the intervertebral discs and spinal muscles are superior to maintaining a single static posture [15, 16]. Continuous postural changes lead to variations in the activity of the posterior muscles, spinal loading, and trunk-thigh angle [17, 18]. These factors are essential for preventing sitting-related LBP, degenerative disc disease, and muscular dysfunction. A total of 24-39% of individuals with LBP report that walking alleviates their LBP [19, 20]. Therefore, dynamic movements between different sections of a chair should also be considered a potential ergonomic feature.

Although laboratory studies have been conducted on the impact of chair features, such as seat pan depth, lumbar and full back support, adjustable seat height, and lower arm support, on musculoskeletal symptoms in the back as well as the upper and lower extremities, no systematic review has evaluated the effects of these interventions on clinical and biomechanical outcomes. This study aimed to review the effects of ergonomic chairs on the clinical and biomechanical outcomes of individuals who work in a seated posture.

Materials and Methods

Search strategy

Two reviewers (Hanieh Khaliliyan and Mahmood Bahramizadeh) independently conducted parallel searches in three electronic databases, including PubMed, Scopus, and Web of Science on 29 October 2024, using the queries outlined in Table 1. These queries were constructed by the principal author (Mahmood Bahramizadeh) based on population, intervention, comparison, and outcome (PICO) items [21], with synonyms obtained from the MeSH database.

Study selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed for the study selection process [22]. After removing duplicate records, the remaining articles were screened according to the predefined eligibility criteria based on the PICOS framework. The study population (P) included individuals engaged in predominantly sedentary work performed in a sitting position. The intervention (I) consisted of chairs incorporating ergonomic design modifications. Comparisons (C) were made between the intervention group and either a control group or pre-intervention conditions. Outcomes (O) included all reported biomechanical and clinical measures. The study design (S) was restricted to randomized controlled trials (RCTs). In addition, only peer-reviewed articles published in English were considered eligible for inclusion.

The titles and abstracts of the articles were assessed against the inclusion criteria, followed by a second assessment of the full texts using the same criteria. The selection process was conducted independently by two reviewers, Hanieh Khaliliyan and Mahmood Bahramizadeh with any conflicts resolved through discussion.

Methodological quality assessment

The 11-item criteria recommended by the physiotherapy evidence database (PEDro) score were used for quality assessment. Each item was rated as Yes or No and received a score of 1, except for the eligibility criteria. In this method, final quality was determined based on the total score (1-4: Poor, 5-6: Fair, 7-8: Good, and 9-10: excellent) [23]. Two reviewers (Hanieh Khaliliyan and Mahmood Bahramizadeh) performed this step; any conflicts were resolved with input from another reviewer (Majid Ansari).

Data extraction

We extracted the data in the form of standard Excel files (Microsoft Excel, software, version 2019, USA). The data items were author, year, study design, participant demographics, intervention, follow-up duration, outcomes, assessment tool, and key findings. Three reviewers (Hanieh Khaliliyan, Mahmood Bahramizadeh, and Francesco Chirico) double-checked the data entry; another author (kavita batra) checked the data, and in the case of inconsistency, she made the final decision.

Data analysis

The grading of recommendations, assessment, development, and evaluations (GRADE) system was used to assess the certainty of the evidence. The study limitations were downgraded when more than 25% of the samples were obtained using low-quality methods, as assessed by the PEDro score. Inconsistency was downgraded if effects were in opposing directions, while indirectness was downgraded if the participants, interventions, outcomes, or comparisons of the study did not align with the objectives of this review. Imprecision was downgraded when the sample size was below 400 or if only one study was included. Publication bias was downgraded when

Table 1. The search strategy used in the current review

Search Query	Database	Result
("ergonomic chair"[title/abstract] OR "ergonomic seating"[title/abstract] OR "office chair" [title/abstract] OR "adjustable chair" [title/abstract]) AND ("musculoskeletal outcomes" [title/abstract] OR "clinical outcome" [title/abstract] OR pain [title/abstract] OR function [title/abstract] OR satisfaction [title/abstract] OR compliance [title/abstract] OR "muscle strength" [title/abstract] OR "muscle activity" [title/abstract] OR posture [title/abstract] OR kinematic* [title/abstract] OR kinetic* [title/abstract] OR "biomechanical outcome" [title/abstract]) AND ("workplace" [title/abstract] OR "office" [title/abstract] OR occupation* [title/abstract])	PubMed	121
(TS=["ergonomic chair") OR "ergonomic seating" OR "office chair" OR "adjustable chair"]) AND (TS=["musculoskeletal outcomes" OR "clinical outcome" OR pain OR function OR satisfaction OR compliance OR "muscle strength" OR "muscle activity" OR posture OR kinematic* OR kinetic* OR "biomechanical outcome"]) AND (TS = ["workplace" OR "office" OR occupation*])	Web of Science	180
TITLE-ABS ("ergonomic chair" OR "ergonomic seating" OR "office chair" OR "adjustable chair") AND TITLE-ABS ("musculoskeletal outcomes" OR "clinical outcome" OR pain OR function OR satisfaction OR compliance OR "muscle strength" OR "muscle activity" OR posture OR kinematic* OR kinetic* OR "biomechanical outcome") AND TITLE-ABS ("workplace" OR "office" OR occupation*)	Scopus	310

PHYSICAL TREATMENTS

the proportion of significant studies displayed asymmetry [24]. A narrative analysis was performed since data pooling was unfeasible, as there were fewer than three studies with consistent methodologies for each outcome.

Results

Study selection

An automated search of the PubMed, Scopus, and Web of Science databases yielded 611 references. After removing duplicate entries and conducting an initial screening, 32 studies met our inclusion criteria (Figure 1).

Methodological quality assessment

Prior to discussion, reviewers Hanieh Khaliliyan and Mahmood Bahramizadeh demonstrated an agreement rate of 89% (314 out of 352) on the PEDro scores. The overall inter-rater reliability yielded a kappa coefficient of 0.79 with a standard error of 0.05. After resolving discrepancies through discussion, the reviewers reached complete consensus, achieving 100% agreement (352 out of 352). For this sample of 32 studies, the scores ranged from a minimum score of 1 to a maximum score of 10, with a general mean score of approximately 5. This mean

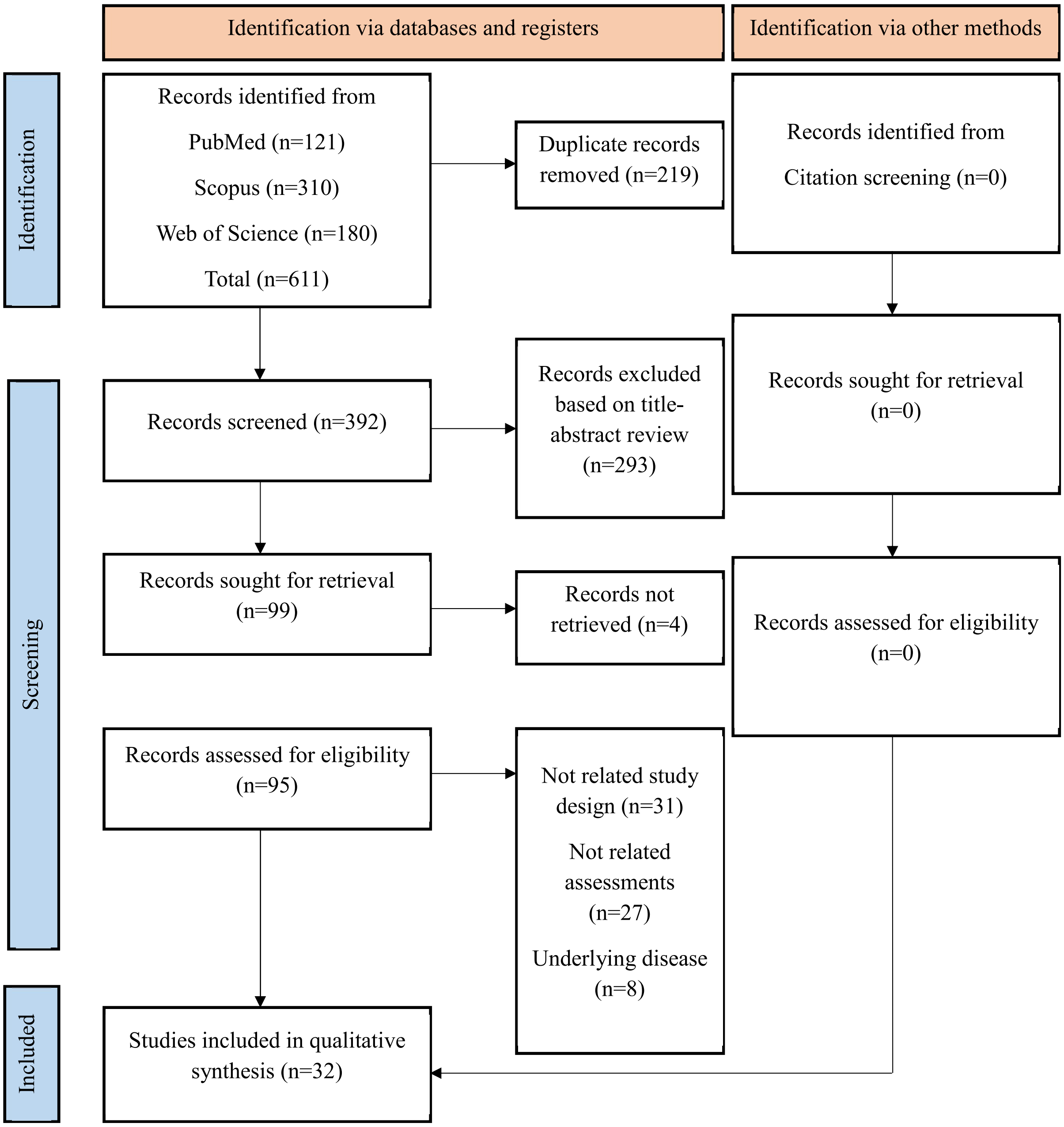

Figure 1. PRISMA flow diagram of study selection

indicates the overall quality level within the fair category, reflecting a moderate quality of evidence across the reviewed studies. The distribution of the quality levels further breaks down as follows: Three articles rated as excellent [30, 34, 50], representing 9.37%; 3 rated as good [26, 36, 44], which is 9.37%; and 19 articles rated as poor [9, 28, 31-33, 35, 38, 40, 41, 46-48, 50-56], making up 59.37%. Furthermore, 7 articles were rated fair [27, 29, 38, 40, 43, 44, 46], accounting for 21.87% of the total. Table 2 presents the methodological quality assessment.

Study characteristics

Table 3 summarizes the features of the 32 articles included in this review. In the present analysis, office chairs were categorized into three types: 1) Standard office chair (SOC), defined as a conventional swivel chair with basic adjustability (e.g. seat height, backrest), used as a control or baseline condition in studies such as [9, 26, 27, 28, 31, 32, 40, 45, 46, 48, 50, 51, 52, 53]; 2) Modified SOC, a standard chair enhanced with specific ergonomic accessories (e.g. lumbar support, forearm supports, acupressure backrests, or posture-sensing systems), as implemented in [26-29, 32-34, 36, 37, 44, 46, 49-51, 55, 56]; and 3) dynamic office chair (DOC), characterized by movable seat pans and/or backrests that allow active sitting (e.g. saddle chairs, exercise balls, chairs with 3D-moving joints, or frontal-plane movement mechanisms), evaluated in [9, 30, 34, 35, 38-40, 42, 43, 47, 48]. Note that some studies employed multiple chair types across experimental conditions [9, 26, 27, 34, 40, 46, 48], and categorization was based on the specific intervention arm described. The total number of participants varied across studies, ranging from 6 to 277. In total, 1,637 participants had a mean age of 32.3±8.33 years.

Effect of ergonomic chair on clinical outcomes

Table 4 presents the GRADE assessment of articles related to the effectiveness of ergonomic chairs on clinical outcomes.

Effect of ergonomic chair on pain

One study compared two ergonomic chair designs: Flat and curved. The flat chair was more effective at reducing pain, with a moderate improvement. People using it reported a noticeable drop in pain levels. The curved chair also helped reduce pain, but the improvement was smaller [26]. In a second study, when looking specifically at pain during activities, the flat chair had a very small effect; therefore, small that it may not have made a real difference. However, the curved chair in this case showed a moderate effect, suggesting it helped ease activity-related pain more than the flat chair [27]. A third study tested an acupressure backrest for one month, comparing it to no treatment. The results showed that this backrest had almost no effect on pain. The difference in pain levels between those who used it and those who did not was so small it likely would not be felt in real life [55].

Effect of ergonomic chair on comfort/discomfort

One study found that using an ergonomic chair did not have a significant impact on outcomes, as measured by the nordic musculoskeletal questionnaire [28]. However, the presence of forearm support in chairs significantly influenced musculoskeletal discomfort [29]. Comparing raising the right or left hip against a static chair with flexed hips and knees demonstrated a positive impact on comfort and satisfaction [46].

O'Keeffe et al. (2013) found that the use of a forward-inclined saddle chair was associated with a significant reduction in low back discomfort compared to SOC [39]. Furthermore, utilizing a dynamic seat, specifically a Pilates ball, significantly reduced scores on the General Discomfort Survey compared to a seat designed to ergonomic criteria [40]. Additionally, two-part cushions significantly reduced discomfort compared to static chairs, as measured by a discomfort-related questionnaire [42].

Effect of ergonomic chair on disability

Lengsfeld et al. (2007) investigated the impact of a chair with horizontal rotary movement compared to a standard chair. Their assessment included the Oswestry Disability Index, but the results did not demonstrate a significant effect [30]. Similarly, an acupressure backrest, as assessed using the roland-morris disability Questionnaire, also failed to show a significant effect [55]. Curran et al. (2014) studied a forward-inclined seat pan that allowed hip flexion, contrasting it with a controlled group maintained at a traditional 90-degree hip and knee angle. The Oswestry Disability Index results suggested a small, but potentially noteworthy, effect [44]. Finally, Roossien et al. assessed the efficacy of a smart chair against a no-intervention group, monitoring activity levels. Their findings, utilizing the Actigraph GT3X+, did not reveal a significant effect [56].

Effect of ergonomic chair on spinal shrinkage

Research indicates that dynamic chairs, particularly those allowing independent or fixed-ratio rotation of the backrest and seat, significantly reduce spinal shrinkage compared to traditional fixed chairs [9].

Table 2. Characteristics of the included studies (n=32)

Author (y)	Study Design	No. and Mean Age (y) of Participants	Intervention vs Control	Follow up Duration	Outcomes and Assessment Tools	Key Findings
Wang et al. 2008 [26]	RCT	EG_1: n=84, mean age: 37.5 EG_2: n=98, mean age: 34.9 CG: n=111 mean age:36.9	EG_1: Curved chair (modified SOC) EG_2: Flat chair (modified SOC) CG: SOC	4 months	Pain intensity scores using 5-point numerical scale	The flat chair group had a significantly greater improvement in pain score compared to the control, where the average reduction of 0.43 points on the scale from 0-5 was experienced monthly, while the curved chair group improved only by 0.25 points
Gagnon et al. 2007 [27]	RCT	n=277, mean age: 37.4	EG_1: Curved chair (modified SOC) EG_2: Flat chair (modified SOC) CG: Miscellaneous items (modified SOC)	4 months	Pain intensity scores using 5-point numerical scale	Workers using the curved seat pan chair experienced a greater reduction in neck and shoulder pain compared to those using the flat seat pan and control groups
Amick et al. 2003 [28]	RCT	EG: n=132, mean age: 42 CG: n=132, mean age: 42	EG: Adjustable seat height, backrest height, and armrest height/Lumbar Support (modified SOC) CG: No intervention	12 months	Pain and discomfort were assessed using the Nordic Musculoskeletal Questionnaire	The EG demonstrated a significant reduction in musculoskeletal symptoms and disability compared to the control group
Cook et al. 2004 [29]	RCT	n=59, mean Age: 39	EG: Chair with forearm support (Modified SOC) CG: Chair without forearm support (SOC)	12 weeks	Pain and discomfort were assessed using the Nordic Musculoskeletal Questionnaire	The intervention group reported discomfort from 79% at week to 62% at week 6. During the same period, the percentage of the control group reporting increased discomfort rose from 71% to 75%. Overall, discomfort decreased from 75% to 45% by week 12. Specific reductions in neck, wrist, and forearm discomfort were statistically significant by week 12.
Lengsfeld et al. 2007 [30]	RCT	EG: n=124, mean age:40.1 CG: n=124, mean age: 40.1	EG: An office chair with a motor-driven seat that performs a horizontal rotary movement (DOC). CG: An identical chair without the rotary seat movement (SOC).	2 years	Disability due to lower back pain, assessed using the oswestry disability index; Lumbar pain score assessed using a 100mm visual analogue scale	This study did not find any significant therapeutic advantage in the use of the chair with micro-rotation as compared with a control chair.
Lee et al. 2021 [31]	RCT	EG: n = 32, mean age:28.8 CG: n = 32, mean age: 29.1	EG: Chair's size was adapted for each individual (SOC) CG: no intervention	36 weeks	Pain and discomfort were assessed using the Nordic Musculoskeletal Questionnaire	The SOC significantly reduced pain intensity in the neck, shoulder, upper back, and wrist/hand, with no reduction in lower back or elbow pain.
Legg et al. 2002 [32]	Crossover trial-RCT	EG: 42, mean age: NC Cg: 42, mean age: NC	CG: Standard shaped typist's chair (SOC) EG: Prototype multi-posture chair (modified SOC). After one week, they swapped chairs for the second week.	2 weeks	Comfort, acceptability, suitability for body build, and other factors related to their experience with the chairs were assessed with a questionnaire (100-point numerical scale)	The SOC was rated higher in terms of comfort and suitability.
Herbert et al. 2001 [33]	RCT	EG: n=36, mean age: NC CG: n=36, mean age: NC	EG: Adjustable seat pan height, padded seats, pneumatic adjustment mechanism, Enhanced Support for upper extremities) (modified SOC) CG: -	6 months	Joint position (videotape)	Declines in awkward postures were noted among a subgroup monitored via videotape.

Author (y)	Study Design	No. and Mean Age (y) of Participants	Intervention vs Control	Follow up Duration	Outcomes and Assessment Tools	Key Findings
O'Sullivan et al. 2011 [34]	Single session, repeated measures, crossover study	n=12, mean age: 23.3	EG: Chair with an unstable ball positioned according to the degree of movement, without a backrest (back App chair, modified SOC). CG: Standard office chair with wheels and no backrest (SOC).	Immediate	Lumbar posture was assessed using the wireless posture monitor Trunk muscle activation was assessed using surface electromyography with the Motion Lab System MA-300. Discomfort levels were assessed using the body part discomfort scale	'Back App' chair resulted in less lumbar flexion and lower trunk muscle activation without significant differences in discomfort compared to the standard chair.
Ellegast et al. 2012 [35]	Single session, repeated measures, crossover study	n=12, mean age: 35.7	-Simple adjustment mechanism for seat pans and backrests -Dynamic chair with pronounced seat pans inclination in both the forward and sideward directions -Dynamic chair with larger backrest inclinations and larger sideward seat pans inclinations. -Reference chair, 'normal' DOC, used as a basis for comparison in this study. -More advanced dynamic chair with three-dimensionally moving joint under the seat pan (all DOC)	100 minutes per chair	Measured EMG activity with surface myography, joint angles with motion lab CUELA system.	The differences between dynamic chairs and the reference chair regarding the mean values of muscle activation.
Dalager et al. 2024 [36]	Repeated measures, crossover study	n=6, mean age: 46	EG: Custom-built ergonomic chairs (modified SOC) CG: A regular office chair (SOC)	Time of surgical procedure	Muscle activity was measured through surface electromyography Evaluated ergonomic risks during surgery with Rapid Upper Limb Assessment	Slightly higher static activity in the left trapezius muscle when using the ergonomic chair compared to the SOC.
Van Dieën et al. 2001 [9]	Repeated measures, crossover study	n=10, mean age: 21	EG_1: Allowed independent rotation of back rest and seat in the sagittal plane (DOC), EC2: Allowed rotation in a fixed ratio of seat-to-back rest rotation (DOC) CG: A chair that does not move (SOC)	3 hours	Trunk Movement: Motion analysis Back Muscle Activity: Surface electromyography Spinal Shrinkage with Stadiometer Discomfort Ratings: Participants rated their perceived discomfort during the use of different chairs	Dynamic chairs indeed increased the gain in stature compared to fixed chairs Trunk kinematics and back muscle activity were more influenced by the task performed than by chair type.
Horton et al. 2010 [37]	Repeated measures cross-over study	n=30, mean age: 25	EG: An office chair with lumbar roll support (Modified SOC) CG: An office chair without lumbar roll support (SOC)	Single session	Changes in the craniovertebral angle were assessed with digitized photographs and analyzed with the NIH ImageJ software.	Significant differences in the mean craniovertebral angle were observed with lumbar roll support.
Synnott et al. 2017 [38]	Single session, repeated measures, crossover study design	n=15, mean age: NC	EG: Forward-inclined saddle chair (Modified SOC) CG: SOC	1 hour	Energy expenditure was assessed using breath-by-breath ventilation measurements (Jaeger Oxycon Mobile) and a body part discomfort scale with a six-point scale	Using a dynamic chair led to a notable rise in energy expenditure compared to sitting on a conventional office chair.
O'Keeffe et al. 2013 [39]	A single session, repeated measures, crossover design	n=21, mean age: 22.1	EG: Forward-inclined saddle chair (Modified SOC) CG: SOC	1 hour	Low back discomfort and overall body discomfort using a six-body part discomfort scale.	The DOC reduced low back discomfort without increasing overall body discomfort.

Author (y)	Study Design	No. and Mean Age (y) of Participants	Intervention vs Control	Follow up Duration	Outcomes and Assessment Tools	Key Findings
Luna-Ávila et al. 2019 [40]	RCT	n=30, mean age: 21.8	EG: A DOC (a Pilates ball) CG: An ergonomic chair (SOC)	45 minutes	Posture, comfort, and satisfaction as key variables were assessed with the General Discomfort Survey questionnaire (five-level Likert scale)	The dynamic seat facilitated more movement but could lead to discomfort over prolonged use.
Vos et al. 2006 [41]	Repeated measures, crossover	n=24, mean age: NC	EG: 100 trunk-thigh angles with arm rest 100 trunk-thigh angles without armrest 110 trunk-thigh angles with armrest 110 trunk-thigh angles without armrest 120 trunk-thigh angles with armrest 120 trunk-thigh angles without armrest CG: Traditional static chairs	Single session	Pressure data collection with digital sensors, analyzed the data with X-sensor software system.	Chair design significantly influenced the pressure distribution more than postural changes.
Cardoso et al. 2021[42]	Repeated measures design	n=30, mean age: NC	EG: Active sitting using chairs designed to promote movement (two-part cushion, and wide cushion) (DOC) CG: Traditional static chairs (SOC)	1 hour	Pressure pads for COP measurement X-Sensor software for pressure assessment Surface electromyography for muscle activity measurement Discomfort with Subjective Discomfort Questionnaire	There were differences in perceived discomfort between active and static chairs, with active chairs potentially reducing discomfort during prolonged sitting.
Kuster et al. 2020 [43]	Repeated measures design	n=10, mean age: 32.2	EG: DOC (was designed to facilitate movement in the frontal plane) CG: Traditional sitting methods (SOC)	Two sessions	Trunk muscle activation (surface electromyography) Trunk Temporal activation pattern (motion capture system)	Dynamic sitting may improve muscle activation patterns compared to static sitting. Participants showed increased activation of trunk muscles during use of the dynamic chair.
Curran et al. 2014 [44]	RCT	n=12, mean age: 41.7	EG: Forward-inclined seat pan Allows a hip flexion angle of 55°, Adjustable stability component, Height adjustable (Modified SOC) CG: Controlled at a 90° hip and knee angle, ensuring feet are firmly on the floor	NC	LBP, disability (oswestry disability index), psychological distress (numerical rating scale)	No significant interaction between the effects of a backrest and low back discomfort was observed.
Van Geffen et al. 2010 [45]	Repeated measures design	n=18, mean age: 22.6	EG: Decoupled pelvis adjustment (SOC) CG: Standard sitting posture	NC	Back pressure distribution with pressure mapping device Body kinematics with a camera motion capture system (VICON, Oxford, UK)	Decoupled pelvis adjustment significantly influences lumbar motion.
Channak et al. 2024 [46]	Repeated-measures design	n=30, mean age: 36.0	EG: Dynamic seat cushions (cushion-elevate right hip and cushion-elevate left hip) (SOC) CG: Static chair (hip and knee positioned in 90 degrees flexion)	1 hour	Number of postural shifts (seat pressure mat device) Trunk muscle activation (surface electromyography) Spinal discomfort (Borg CR-10 scale) Typing task performance (words per minute) Comfort and satisfaction score (interview-based questionnaire with a 5-point Likert scale)	Increased discomfort scores in the control condition compared to the dynamic cushions; no significant differences in typing performance across conditions.

Author (y)	Study Design	No. and Mean Age (y) of Participants	Intervention vs Control	Follow up Duration	Outcomes and Assessment Tools	Key Findings
Ecemiş et al. 2023 [47]	Single group, repeated measures design	n=15, mean age: 22.92±3.40	EG: Ergonomic office chair (DOC) CG: Standard office chair	1hour	Muscle activation of thoracic erector spinae, transversus abdominis/ internal oblique, and upper trapezius measured using surface electromyography	Ergonomic chairs may enhance trunk muscle activation, potentially reducing the risk of musculoskeletal disorders in prolonged sitting
Kingma et al. 2009 [48]	Crossover design with repeated measures	n=10, mean age: 21.7	EG: Seated on an exercise ball. CG: A SOC.	2 hours	Electromyography for muscle activity Stadiometer for measuring spinal shrinkage	Sitting on the exercise ball resulted in increased trunk motion compared to the office chair. Spinal Shrinkage: Greater spinal shrinkage was observed after sitting on the exercise ball.
Makhsous et al. 2003 [49]	Crossover design with repeated measures	Participants: 15, mean age: 30.4	EG: Adjustments to ischial and back support (modified SOC). CG: Standard seating conditions without adjustments.	NC	Contact pressure (Pressure scanner) Muscular activity in the back muscles (surface electromyography) Sacral inclination and lumbar lordosis (radiography image) Intervertebral space of the lumbar (radiography image)	Contact Pressure Redistribution: Significant decrease in pressure under the ischial tubercles and increased load on thighs (P=0.001). Muscle Activity: Decreased muscular activity in the lumbar region when using an adjusted back support. Lumbar Lordosis: Increased total and segmental lumbar lordosis when using the backrest (P<0.001). Intervertebral Disc Height: Increased lumbar intervertebral disc heights were noted under adjusted conditions.
Park et al. 2011 [50]	Repeated measures	n=11, mean age: 23.8	EG: Posture-sensing air seat device (modified SOC) CG: Standard chair (SOC)	20 minutes	Trunk flexion and lateral flexion angles (flexible electro goniometer) Muscle Activity (Electromyography measurements of erector spinae and internal oblique muscles)	Reduced Trunk Flexion: Significant reduction in mean trunk flexion when using the Posture-Sensing Air Seat Device compared to the standard chair. Reduced Lateral Flexion: Lateral flexion was significantly less with the Posture-Sensing Air Seat Device. Increased Muscle Activity: Higher levels of muscle activity (erector spinae and internal oblique muscles) were observed when using the Posture-Sensing Air Seat Device.
Yoo 2012 [51]	Crossover design with repeated measures	n=14, mean age: 29.1	EG: Chair with an unstable dual foot support (two wobble boards) (modified SOC) CG: Chair without the foot support (SOC)	15 minutes	Trunk flexion angle (A 3D motion analysis system) Muscle activities of the rectus femoris, L4 erector spinae, and external oblique (surface electromyography)	The unstable dual foot support significantly improved posture by decreasing trunk flexion and increasing muscle activity.
Vlaovic et al. 2008 [52]	Crossover design with repeated measures	n=36, mean age: 32.37	EG_1: Chairs (SOC) with the PU foam seat filament (PU-foam) EG_2: Chairs with the filament of cold-casted PU foam EG_3: Chairs with the combination of the pocketed micro springs and the layer of cold-cast PU foam CG_1: Chairs with the seat having a framed net	Two days	Comfort and discomfort levels were assessed through 17 statements	Significant differences in chair evaluations based on comfort and discomfort

Author (y)	Study Design	No. and Mean Age (y) of Participants	Intervention vs Control	Follow up Duration	Outcomes and Assessment Tools	Key Findings
Beers et al. 2008 [53]	Repeated measures design	n=24, mean age: 26.3	EG_1: office chair (SOC) EG_2: therapy ball CG: standing	One session	Energy expenditure (a heart rate monitor (Polar Vantage XL, Lake Success, NY) Comfort, fatigue, liking of postures, and productivity were measured by total words typed.	Using a therapy ball or adopting a standing posture raised energy expenditure by approximately 4.0 kcal per hour relative to sitting in a standard office chair.
Ericson et al. 1989 [54]	Repeated measures design	n=8, mean age: 30.5	CG: Conventional chair (horizontal seat) EG_1: Ullman chair (forward-sloping front half), EG_2: Balans chair (forward-sloping seat with knee support) (all SOC)	3 hours	Spinal shrinkage was measured as a change in stature height	Significant shrinkage was observed with the Balans chair compared to the conventional chair.
Purepong et al. 2015 [55]	RCT	EG: 32, mean age: 36.7 Cg: 32, mean age: 38.5	EG: An acupressure backrest for one month (SOC) CG: No intervention, but participants could consult a physical therapist.	12 weeks	Pain measured through the visual analog scale (0–10). Disability was assessed with the roland-morris disability questionnaire (0–24).	The smart chair did not significantly change sitting behavior or reduce musculoskeletal discomfort.
Roossien et al. 2017 [56]	Repeated measures design	n=45, mean age 43.1	EG: A smart chair providing tactile feedback on sitting behavior Modified (SOC) CG: Included monitoring without feedback (SOC)	12 weeks	Sitting duration and posture were measured using the smart chair. Local Musculoskeletal Discomfort was assessed via questionnaires Activity tracked with Actigraph GT3X+	The smart chair did not significantly change sitting behavior or reduce musculoskeletal discomfort.

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Abbreviations: RCT: Randomized controlled trial; EG: Experimental group; CG: Control group; SOC: Standard office chair; DOC: Dynamic office chair; NC: No comment.

Effect of ergonomic chair on biomechanical outcomes

Table 4 presents the GRADE assessment of articles related to the effectiveness of ergonomic chairs on biomechanical outcomes.

Effect of ergonomic chair on muscle activation

One study comparing a dynamic chair with a three-dimensionally moving joint beneath the seat pan to a standard DOC showed no clear significant impact on trunk muscle activation [35]. Dalager et al. (2024) found that a custom-built ergonomic chair had a positive effect on left trapezius muscle activity compared to conventional office chairs [36]. Ecemiş et al. (2023) compared an ergonomic office chair to a SOC, noting positive effects on the transversus abdominis/internal oblique and the upper trapezius [47].

Kingma et al. reported that seated posture on an exercise ball resulted in greater lumbar muscle activation than a SOC [48]. Makhsous et al. (2003) found that adjustments to ischial and back support decreased muscular activity in the back muscles compared to standard seating conditions [49]. The posture-sensing air seat device showed a positive effect on muscle activity when compared to a standard chair [50]. A chair equipped with an unstable dual-foot support (wobble board) demonstrated a significant decrease in normalized electromyography (EMG) for the rectus femoris, lumbar multifidus, and external oblique muscles compared to a chair lacking foot support [51]. Finally, a DOC designed to promote movement in the frontal plane increased trunk muscle activity compared to traditional static chairs [43].

Effect of ergonomic chair on energy expenditure

One study indicated that using a forward-inclined saddle chair significantly increased energy expenditure compared to using a SOC [38]. However, a study by Beers et al. (2018) found that using a DOC resulted in lower energy expenditure compared to standing [53].

Table 3. PEDro methodological quality

Author, year	Eligibility Criteria	Random Allocation	Concealed Allocation	Similar Baseline Prognosis	Blinded Subject	Blinded Therapist	Blinded Assessor	Less Than 15% Withdrawals	Intention to Treat Analysis	Statistical Comparison- Between Group	Point and Variability Measures	Score	Quality level
Wang et al. 2008 [26]	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	7	Good
Gagnon et al. 2007 [27]	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	5	Fair
Amick et al. 2003 [28]	Yes	No	No	Yes	No	No	No	Yes	No	Yes	Yes	4	Poor
Cook et al. 2004 [29]	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6	Fair
Lengsfeld et al. 2007 [30]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Excellent
Lee et al. 2021 [31]	Yes	No	No	No	No	No	Yes	Yes	No	No	Yes	3	Poor
Legg et al. 2002 [32]	Yes	Yes	No	Yes	No	No	No	No	No	Yes	no	3	Poor
Herbert et al. 2001 [33]	No	No	No	Yes	No	No	No	No	No	Yes	Yes	3	Poor
O’Sullivan et al. 2011 [34]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Excellent
Ellegast et al. 2012 [35]	Yes	No	No	Yes	No	No	No	No	No	Yes	Yes	3	Poor
Dalager et al. 2024 [36]	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7	Good
Van Dieën et al. 2001 [9]	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes	3	Poor
Horton et al. 2010 [37]	Yes	No	No	Yes	No	No	Yes	Yes	No	Yes	Yes	5	Fair
Synnott et al. 2017 [38]	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4	Poor
O’Keeffe et al. 2013 [39]	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6	Fair
Luna-Ávila et al. 2019 [40]	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4	Poor
Vos et al. 2006 [41]	No	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4	Poor
Cardoso et al. 2021 [42]	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes	6	Fair
Kuster et al. 2020 [43]	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	5	Fair
Curran et al. 2014 [44]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8	Good
Van Geffen et al, 2010 [45]	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes	6	Fair
Channak et al. 2024 [46]	Yes	No	No	Yes	No	No	No	Yes	No	Yes	Yes	4	Poor
Ecemiş et al. 2023 [47]	Yes	No	No	No	No	No	Yes	Yes	No	No	Yes	3	Poor
Kingma et al. 2009 [48]	Yes	No	No	No	No	No	No	Yes	No	Yes	Yes	3	Poor
Makhsous et al. 2003 [49]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	Excellent
Park et al. 2001 [50]	Yes	No	No	Yes	No	No	No	Yes	No	Yes	Yes	4	Poor
Yoo 2012 [51]	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4	Poor

Author, year	Eligibility Criteria	Random Allocation	Concealed Allocation	Similar Baseline Prognosis	Blinded Subject	Blinded Therapist	Blinded Assessor	Less Than 15% Withdrawals	Intention to Treat Analysis	Statistical Comparison- Between Group	Point and Variability Measures	Score	Quality level
Vlaovic et al. 2008 [52]	Yes	No	No	No	No	No	No	No	No	Yes	no	1	Poor
Beers et al. 2008 [53]	Yes	No	No	Yes	No	No	No	No	No	Yes	Yes	3	Poor
Ericson et al. 1989 [54]	Yes	No	No	No	No	No	No	No	No	Yes	Yes	2	Poor
Purepong et al. 2015 [55]	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4	Poor
Roossien et al. 2017 [56]	Yes	No	No	Yes	No	No	No	Yes	No	Yes	Yes	4	Poor

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Table 4. Assessment of the evidence for the impact of a SOC, modified SOC, and DOC on clinical outcomes

Outcomes		No. (%) No. of Articles	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Quality of Evidence (GRADE)
For SOC	Pain	677(7)	Serious	Not serious	Not serious	Serious	None	⊕⊕◯◯
	Discomfort/ comfort	389(13)	Serious	Not serious	Not serious	Not Serious	None	⊕⊕⊕◯
	Disability	89(3)	Not serious	Not serious	Not serious	Serious	None	⊕⊕⊕◯
	Spinal shrinkage	28(3)	Serious	Not serious	Serious	Serious	Reporting bias	⊕◯◯◯
For modified SOC	Pain	552(4)	Serious	Not serious	Not serious	Not Serious	None	⊕⊕⊕◯
	Discomfort/ comfort	293(7)	Serious	Not serious	Not serious	Serious	None	⊕⊕◯◯
For DOC	Pain	124(1)	Not serious	Not serious	Not serious	Serious	None	⊕⊕⊕◯
	Discomfort/ comfort	184(3)	Serious	Not serious	Not serious	Serious	None	⊕⊕◯◯
	Disability	124(1)	Not serious	Not serious	Not serious	Serious	None	⊕⊕⊕◯
	Spinal shrinkage	1(10)	Serious	Not serious	Not serious	Serious	None	⊕◯◯◯

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Abbreviations: GRADE: Grading of recommendations, assessment, development, and evaluations; SOC: Standard office chair; DOC: Dynamic office chair.

Effect of ergonomic chair on body kinematics

The findings across multiple studies indicate that ergonomic chair features have a significant positive impact on posture-related outcomes [33, 34, 37, 45, 49-51]. Adjustments, such as lumbar support, pelvis movement, posture-sensing systems, and unstable footrests, were consistently associated with improved spinal and joint alignment. Notably, the largest effects were observed with interventions targeting lumbar posture and head-neck alignment, such as lumbar roll support and the Back App chair [34, 45, 49-51]. These features not only enhance sitting posture but may also help prevent musculoskeletal strain associated with prolonged seated work [33].

Table 5. Assessment of the evidence for the impact of a SOC, modified SOC, and DOC on biomechanical outcomes

Outcomes		No. (%) No. of Articles	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Quality of Evidence (GRADE)
For SOC	Trunk Muscle Activation	133 (9)	Serious	Not serious	Not serious	Serious	Reporting bias	⊕○○○
	Body Kinematic	110(7)	Serious	Not serious	Not serious	Serious	None	⊕⊕○○
	Energy Expenditure	56(2)	Serious	Not serious	Serious	Serious	Reporting bias	⊕○○○
	Pressure Distribution	120(5)	Serious	Not serious	Serious	Serious	Reporting bias	⊕○○○
For Modified SOC	Trunk Muscle Activation	43(4)	Serious	Not serious	Not serious	Serious	None	⊕⊕○○
	Body Kinematic	26(2)	Serious	Not serious	Not serious	Serious	None	⊕○○○
	Energy Expenditure	15(1)	Serious	Not serious	Not serious	Serious	None	⊕○○○
	Pressure Distribution	15(1)	Serious	Not serious	Not serious	Serious	None	⊕○○○
For DOC	Trunk Muscle Activation	77(5)	Serious	Not serious	Not serious	Not Serious	None	⊕⊕⊕○
	Body Kinematic	32(3)	Serious	Not serious	Not serious	Serious	None	⊕⊕○○

SOC: Standard office chair; DOC: Dynamic office chair.

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Effect of ergonomic chair on pressure distribution

In one study, a trunk-thigh angle of 110 degrees resulted in a moderate positive effect size on pressure distribution compared to SOC [41]. Another study investigated modifications to the ischial and back support on a prototype chair, revealing a negative effect compared to unadjusted conditions [49].

Discussion

This review evaluated 32 studies examining the effects of chairs on clinical and biomechanical musculoskeletal outcomes in sedentary workers. The chair interventions were analyzed both generally and by chair type (specifically SOC, modified SOC, and DOC).

The studies showed significant heterogeneity in the population, intervention, comparison, outcomes, and follow-up time. Evidence on the effects of chairs on clinical and biomechanical outcomes, such as pain, discomfort/comfort, disability, spinal shrinkage, trunk muscle activation, body kinematics, energy expenditure, and pressure distribution, ranged from very low to moderate quality among sedentary workers. Additionally, these interventions showed effect sizes ranging from not significant to highly significant for the clinical and biomechanical outcomes. The findings from 1,637 participants highlight a complex interplay among chair designs and their impact on health-related measures.

Chair design and clinical outcomes

The results regarding pain reduction are conflicting, with some ergonomic chair designs demonstrating significant improvements, while findings are not consistently positive across all studies [26, 27] (SOC: Low-quality; modified SOC: Moderate quality; and DOC: Moderate quality [Table 4]). This variability may be attributed to differences in study design, participant demographics, and intervention durations. In contrast, the results regarding the effect of ergonomic chairs on comfort/discomfort are consistent and indicate positive outcomes [28, 29, 39, 40, 42, 46] (SOC: Moderate-quality; modified SOC: Low-quality; DOC: Low-quality [Table 4]). The intervention's impact on disability was not significant [30, 44, 55, 56] (SOC: Moderate-quality; and DOC: moderate quality). Additionally, the intervention resulted in reduced spinal shrinkage [37, 48, 49, 54] (SOC: Very low quality; and DOC: Very low quality [Table 4]).

In a similar review, Van Niekerk et al. conducted a systematic review across various occupations and noted discomfort in several body regions. Various works encounter distinct working environments that affect employees' well-being. However, the methodologies of the two studies differ, yet their results confirm each other [57].

When selecting a chair, both the seat height and seat pan depth must be adjusted to the user's anthropometric dimensions [58]. When this is not matched correctly by the chair, the postural muscles' ability to support it may be impaired, possibly leading to unusual stress on the neuromuscular system and discomfort [59].

Chair design and biomechanical outcomes

The use of ergonomic chairs has a significant impact on muscle activation [35, 36, 43, 47-51] (SOC: Very low, modified SOC: Low quality, and DOC: Very low quality [Table 5]), energy expenditure (SOC: Very low, modified SOC: very low quality, as indicated in Table 5), body kinematics (SOC: Low, modified SOC: Very low quality, and DOC: Low quality [Table 5]), and pressure distribution (SOC: Very low, modified SOC: Low quality [Table 5]). Dynamic chairs and custom-designed ergonomic systems demonstrate increased trunk stability and decreased muscle activation compared with conventional chairs. More specifically, chair designs like forward-inclined saddle chairs increase energy expenditure [39, 54]. Adjustable features of the ergonomic chair are positively associated with joint posture [33, 34, 37, 45, 49-51].

The chair seat pans, designed with forward-tilting seats that relieve ischial pressure and combined with lumbar support, were associated with increased lumbar lordosis [49]. Some researchers recommended sustained neutral lumbar lordosis during sitting for LBP. Some studies attempted to modify an office chair to maintain neutral spinal alignment and prevent poor sitting posture [60, 61]. However, some studies found increased trunk muscle activation and greater comfort. Certain research indicates that fatigue onset aligns with a low level of trunk muscle activation, around 2–5%, maintained for as brief as 30 minutes in healthy individuals [62].

Methodological considerations, limitations, and recommendations for future research

A lack of robust methodology, especially regarding concealed allocation and blinding, is evident in these studies. The general characteristics were small sample sizes and/or short follow-up periods in the majority of these studies, making it difficult to generalize reliable findings. Investigations into the biomechanical and physiological mechanisms underlying how ergonomic chairs may affect pain and discomfort, and related health outcomes, are needed across more varied user groups and working settings to estimate wider generalizability and benefits.

Conclusion

The results regarding the effect of ergonomic chairs on pain reduction are mixed. While some chair designs indicated benefits, others did not yield uniformly positive results. By contrast, the effects of ergonomic chairs on comfort and discomfort are consistently positive. The interventions had no impact on disability, while evidence for a reduction in spinal shrinkage is of very low quality.

The use of dynamic chairs and individually designed ergonomic systems has been shown to increase trunk muscle activation when compared with conventional chairs. Forward-leaning saddle chairs increase energy expenditure, while adjustable features in ergonomic chairs improve joint posture.

Ethical Considerations

Compliance with ethical guidelines

The complete protocol for this systematic review is available on PROSPERO (registration code: CRD42024598129).

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Authors' contributions

Conceptualization, methodology and resources: Hicham Khabbache and Mahmood Bahramizadeh; Validation: Mahmood Bahramizadeh; Formal analysis: Mahmood Bahramizadeh, Hicham Khabbache, Kavita Batra, Majid Ansari and Morteza Faghih Jouibari; Investigation: Mahmood Bahramizadeh, Hicham Khabbache and Farhad Ghaffari; Data collection: Hanieh Khaliliyan; Writing the original draft: Hanieh Khaliliyan, Mahmood Bahramizadeh and Majid Ansari; Writing review and editing: Kavita Batra, Mahmood Bahramizadeh and Hanieh Khaliliyan; Supervision: Mahmood Bahramizadeh; Final approval: All authors.

Conflict of interest

The authors declared no conflicts of interest.

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