



# Chairless Chairs for Orthopedic Surgery Purpose – A Literature Review

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## Abstract

Musculoskeletal disorders are often found in various types of work, including surgeons. Standing working position is immobile and rigid when performing surgical operations. The equipment used is less ergonomic which is the main parameter. The surgeon profession belongs to the category of the high-risk profession and has the potential to experience musculoskeletal disorders. Surgeons who suffer musculoskeletal disorders sense disease start from mild-to-severe due to the muscles receiving static loads frequently in the long-term. The emergence of musculoskeletal disorders can be caused by working environment conditions and standing position while working, causing injury to joints, vertebral discs, nerves, cartilage, tendons, and muscles. This paper describes in extensive the potential for reducing musculoskeletal problems with the use of a chairless chair for surgeons in carrying out operations. Musculoskeletal problems in surgery and the use of chairless chairs have been further explored to close the existing research gap.

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## Introduction

Work activity will cause a tiring body. As in an industry, one of which is in the production section of the workers working long hours dominantly standing, which can cause musculoskeletal disorders [1]. Musculoskeletal disorders are diseases that cause prolonged pain. Someone who suffers from musculoskeletal disorders feels complaints ranging from mild-to-severe if the muscles receive static loads repeatedly and for a long time [2], [3], [4]. The emergence of musculoskeletal disorders is related to the conditions of the work environment and the way of working it supports so that with these conditions, it can cause damage to muscles, nerves, tendons, joints, cartilage, and vertebral discs [5]. Musculoskeletal disorders often occur in health practitioners. This happens because the position of the body when working is less ergonomic and occurs for a long time and repeatedly.

Among health practitioners who are vulnerable in facing the threat of musculoskeletal disorders

are surgeons [6], [7]. In general, the type of work of a surgeon is characterized by a static and rigid body position in treating patients. Patients who are treated in an operating chair cause a surgeon to sit or stand bent over for a long time. This body position causes the practicing surgeon to often experience pain or discomfort in the neck, shoulders, and spine, which can result in, among other things, musculoskeletal disorders in the form of the lower back pain [8].

One of the causes of musculoskeletal disorders in surgeons is because orthopedic surgery only pays attention to comfort for the patients being treated, but does not pay attention to comfort for themselves when caring for their patients [9], [10], [11]. Surgeons assume that they must move toward the patient, rather than adjust the patient's sitting position on the operating chair. Most musculoskeletal disorders occur because the surgeon is unconsciously in an unsupportive body position when treating a patient [12].

During operating procedures on a patient, the surgeon sometimes bends over to the patient, moves

abruptly, and turning the body from side to side. All movements are repeated over a long time. It would cause musculoskeletal syndrome. Although working in a normal position can reduce or prevent the possibility of a musculoskeletal syndrome, most surgeons do not realize the importance of a well-positioned ergonomic system when treating patients [13], [14]. A good and correct posture requires good equipment too, for example, the ergonomic shape of the chair for the operator can support the spine in a comfortable position.

This paper will discuss the prevention of musculoskeletal disorders in orthopedic surgery with an ergonomic system, including the position of the surgeon, the position of the patient, and the equipment in the practice room.

## Ergonomics Problems for Surgeons

The position of the surgical team on the operating table as presented in Figure 1 varies depending on the habits and comfort of each hospital, generally, the surgeon (operator/chief surgeon) stands on the side of the operating table next to the instrument nurse (instrumentation/scrub nurse). The first assistant (assistant surgeon) stands in front of the operator and if there is a second assistant stands next to the first assistant in front of the instrumentation. Position changes are made if a retraction or maneuver is required for comfort. The surgical team can be in this position during the operation (4–8 h) and a standing position [15].

A work position is a posture that is formed naturally by the worker's body that interacts with work habits and facilities used in a job. The design of a work position and ergonomic work facilities need to be provided to prevent fatigue due to the work position and provide comfort and not reduce concentration during work [16]. Ergonomics are the science of the relationship between humans, the equipment used, and the work environment. An ergonomic work position is a work position that harmonizes between workers, types of work, and the environment [17]. Some things must be considered concerning body position in doing work, namely, a) all work should be done in a sitting position or standing position alternately, b) all unnatural body positions must be avoided, if this is not possible, efforts should be made so that the load reduced static, and c) the seat must be made in such a way that it does not burden but can provide relaxation to the muscles that are not used for work and do not cause stress on the back, waist, and thighs [18], [19], [20], [21], [22].

Humans are designed to walk on two legs, but they are not designed to stand still for long periods. In humans, the center of gravity of the body is located above or close to the joints, so that when bending over,



Figure 1: Surgeon position during operation

the standing position can be maintained with minimal muscle activity [23], [24], [25], [26]. The surgeon when doing work is in a standing position that is less ergonomic because the surgeon has to bend over so that the load on the muscles becomes large [27]. In addition, the surgeon's right foot when working must step on the foot pedal so that the weight of the body is centered on the left foot as shown in Figure 2.

## The Use of Exoskeletons to Assist Human Activities

The concept and potential of the exoskeleton have been introduced and proposed for helping, supporting, and protecting a person's body in carrying out certain activities in the long-term [28]. In this context, the exoskeleton refers to a component that can expand or increase a person's physical abilities throughout the user [29]. Exoskeletons are also commonly referred to as wearable robots, super suits, or exosuits because the difference from robots, in general, makes these components that have an outer skeleton or shell that can be used on the human body [30], [31], [32]. The movement of the exoskeleton is expected to be able to follow the movements of the user with sophisticated position or force sensors with capable actuator control and signal processing.

Exoskeletons increase the wearer's ability to move and carry faster and heavier loads by exhibiting higher perseverance. The augmentation capability makes it meet needs in a wide range of military [33] industrial [34], and medical applications [35]. Then, for the construction industry, a full-body exoskeleton with multiple motors and an electrical system can turn the wearer become a superior workforce adequate of lift and manipulate more than 200 pounds safely [36]. Partially motorized exoskeleton suits, such as fitted arm exosuits [37] and chairless chairs [38], can reduce repetitive stress and muscle injury from repetitive arm movement and/or standing statically in the same position for long periods. Even passive exoskeletons, without the use of actuators, motors, or batteries, can still improve worker safety and reduce fatigue through sprint and counterweight technology [39]. Although it has great potential, a complete



Figure 2: The surgeon's right foot position during work

understanding of the status quo is still lacking in keeping up with the present external framework technology trends among the construction research community. This understanding has contributed greatly to the infiltration of the exoskeleton in the construction.

Exoskeletons are made with the aim of assisting with carrying, overhead, static holding, lifting, and other work activities. This tool provides convenience for the user by providing increased ability, strengthening endurance, and minimizing overly tense muscles, to enhance global work productivity and efficiency. From

the previous literature, Huysamen *et al.* [40] provide and evaluate a passive exoskeleton to support the upper extremities during static overhead work and reduce the risk of work-related musculoskeletal disorders. Furthermore, Elisheba *et al.* [41] designed chairless chairs to provide comfort for workers who need to work in awkward positions, such as bending over, crouching, and standing, for long periods.

In general, exoskeletons are classified into two types based on the use of a power supply to support the functions of the exoskeleton which are described in Table 1. Exoskeletons are categorized as "passive" if the product or prototype is supported by natural human movement through springs or counterweights. Meanwhile, the exoskeleton is categorized as "active" if the product or prototype is supported by an electric system, levers, pneumatic, hydraulic, or a combination of these technologies.

Table 1: Type of exoskeleton to help works in the legs area

Category	Type of Exoskeleton	Benefits provided from the previous studies
Passive	Chairless Chair [42], [43]	Reduce muscle stiffness in the lower half of the human body
Active	LegX [44]	Reduce rectus femoris and knee extensor
	Angel suit [45]	Reduce variation of pressure movement to balancing
	UMEx-oLEA [46]	Give torque assist and minimize muscular stress

## Chairless Chair as a Solution to Ergonomics Problems

Chairless chair is a "chair" that is an article of exoskeleton-like clothing, which allows the user to walk or move at a certain speed according to the device used while working as shown in Figure 3. This chair also helps to rest the leg muscles when working for a long time, and this innovative new chair helps comfort the thighs and back. Therefore, this tool will help increase productivity for workers who work long hours when the job is more dominant working standing. The working principle of this chairless chair is to use a hydraulic system which is a form of change or transfer of power using a conducting medium in the form of a liquid fluid to obtain a power greater than the initial power issued, where when the user sits down, the hydraulic will automatically withstand the body force that the tool wraps around the thigh, so it will reduce user fatigue and increase productivity. Several previous studies on chairless chairs are shown in Table 2.

Chairless chairs are designed primarily for people who stand for long periods and experience fatigue in the lumbar region, where there are pain from the hips to the legs [55]. This is experienced by surgeons who stand and operate their wards for some. Using this chairless chair will increase the efficiency of the workers and also indirectly increase the productivity of the organization or company where they work [56]. It reduces their fatigue and stress by providing a perfect





Figure 3: Chairless chair. Picture adapted from: <https://www.noonee.com/>(© noonee AG)

working posture to the workers. Conventional chairs cannot be carried anywhere because of static, but this chairless chair is a wearable ergonomic therapy device [57], [58], [59]. Anyone can use it anywhere and anytime according to their needs and uses. The provision of conventional chairs will make workers rest longer but by providing chairs without chairs, workers will not rest much and work efficiently which will increase company productivity [60], [61]. Innovations have been made to use chairless chair for the purpose of the medical field, where surgeons account it in operation. Physiotherapists in rehabilitating people suffering from back pain due to illness, trauma, or any deficiency can also use a chairless chair.

Many musculoskeletal disorders are complained about by workers in factories that do not

provide adequate rest, so many researchers are looking for ways to overcome them [62], [63] [64]. Musculoskeletal disorders that include the upper and lower spine, shoulders, and wrists are risk factors for the surgeon profession [65]. In several previous studies, it is known that the prevalence of musculoskeletal disorders among surgeons ranges from 25% to 85% [66], [67], [68]. Several technical factors such as surgical units, work lights, and other equipment used are not ergonomic and non-technical factors such as the way and position when treating patients and the surgeon's lifestyle are risks that play an important role in the occurrence of musculoskeletal disorders in surgeons [69], [70], [71], [72], [73], [74]. Improving technical and non-technical risk factors can be done to prevent musculoskeletal disorders in surgeons.

Technical factors include improved by sitting position, standing position when treating patients, and ergonomic equipment (desk, surgical unit, and work lamp). Teamwork between surgeons and trained assistants handles the equipment so that the surgeon only concentrates on patient care [75], [76], [77], [78]. Non-technical factors such as time lag between one patient and another patient to rest their muscles, as well as a large practice room, need to be considered [79], [80]. Several preventive measures that are not related to the equipment used have a key role in reducing the incidence of musculoskeletal disorders in surgeons.

## Conclusion

The use of chairless chairs in orthopedic surgery has great potential to minimize muscle stiffness and problems with the musculoskeletal system. The activity of standing for a long time during surgery and various patient-focused positions makes the surgeon's condition less ergonomic. The previous works of the literature have also supported the use of chairless chairs as a type of exoskeleton in facilitating human activities in various aspects, such as military, industrial, and medical. Further development of the chairless chair in its application in the world of orthopedics needs to be developed in the future.

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Table 2: Research related to the chairless chair

Authors	Research findings
Bridger et al. [47]	Influence of the exoskeleton on the lower limbs when squatting
Capitani et al. [48]	Developing an exoskeleton to help construction workers
Elisheba et al. [41]	Design a chairless chair to reduce back pain in workers
Ippolito [49]	Optimizing the workplace using integrated exoskeleton technology
Irawan [50]	Design and manufacture chairless chairs based on local components
Kurnia [51]	Carry out the design and manufacture of chairless chair prototypes
Luger et al. [42], [43]	Simulates the physical load, posture, and discomfort of using an exoskeleton in industrial workers
Mogare et al. [52]	Develop a chairless chair that can be used by workers to work in a sitting and standing position
Siddha et al. [53]	Develop a chairless chair to reduce musculoskeletal disorder in the industrial field
Yan et al. [54]	Developing an exoskeleton to help workers in an industry
Zhu et al. [36]	Classifying exoskeletons that can be used in various types of work

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