CONCEPTUAL DESIGN OF EXOSKELETON CHAIRLESS CHAIR FOR SURGEON

AZIDE BIN JANGHISHAN

A report submitted

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DECLARATION

I declare that this project report entitled "Conceptual Design of Exoskeleton Chairless Chair for Surgeon" is the result of my own work except as cited in the references.

Signature: Azide

Name: AZIDE BIN JANGHISHAN

Date: 30/7/2021

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature: .....

Supervisor's Name: DR. MASJURI BIN MUSA @ OTHMAN

Date: 5/9/2021

DEDICATION

To my beloved mother and father

ABSTRACT

Surgery is the operation for the treatment due to disease or injury on the patients. Surgery operation involves cutting, abrading, suturing, physically changing body tissues, and organs. The long duration of a surgeon's working hours and sleep deprivation when doing an operation on patients makes the surgeon complicated to stay focus and forces surgeons to learn to manage the effects of physical and mental fatigue on their performance during the operation. The decision to take a break during an operation is often neglected because of concerns about extending the duration of an operation and condition of patient. In this situation, the surgeons are required to work under prolonged hours with significant pressure and often inadequate resources, which cause muscle fatigue and could potentially lead to musculoskeletal disorders (MSD). A product should be developed to assist surgeons in supporting them to avoid muscular injury while undergoing surgery. An innovation of chair is needed to reduce musculoskeletal symptoms among surgeons who are required to sit for a while or a small break after prolonged periods of standing during operation hours. Therefore, this project aims to design and develop a wearable exoskeleton chair (exo-chair) for the surgeon to provide body support and reduce muscle fatigue. The wearable exo-chair will be designed with a specific ergonomic design that reduces muscle strain at the lower back and leg regions. Although there are wearable chairs that are commercially available, it was not designed to meet a specific requirement for doctors and medical staff. The device will have mechanisms that allow doctors to switch actively between standing, sitting, and walking positions that could be a solution for MSD issues for medical doctors and surgeons when doing operation.

ABSTRAK

Pembedahan adalah operasi rawatan untuk penyakit atau kecederaan pada pesakit. Operasi pembedahan melibatkan seperti memotong, mengikis, menjahit, mengubah tisu badan, dan organ secara fizikal. Jangka masa yang lama dalam melakukan kerja pakar bedah dan kurang tidur ketika melakukan operasi pembedahan pada pesakit membuatka pakar bedah menjadi kesukaran untuk tetap fokus dan memaksa pakar bedah untuk belajar menguruskan kesan keletihan fizikal dan mental terhadap prestasi mereka semasa operasi pembedahan. Keputusan untuk berehat semasa operasi pembedahan sering diabaikan kerana kebimbangan mengenai tempoh operasi dan keadaaan pesakit tersebut. Dalam keadaan ini, pakar bedah diminta bekerja dalam tempoh yang lama, tekanan yang tinggi dan tenaga yang sering tidak mencukupi, ini akan menyebabkan keletihan otot dan berpotensi menyebabkan gangguan muskuloskeletal (MSD). Suatu inovasi harus dikembangkan untuk membantu pakar bedah dalam membantunya untuk mengelakkan kecederaan otot semasa menjalani pembedahan. Suatu inovasi kerusi diperlukan untuk mengurangkan simptom musculoskeletal (MSD) di kalangan pakar bedah yang diminta untuk duduk sebentar atau rehat kecil setelah lama berdiri pada waktu operasi. Oleh itu, projek ini bertujuan untuk merancang dan mengembangkan kerusi exoskeleton (exo-chair) yang boleh dipakai untuk pakar bedah untuk memberi sokongan badan dan mengurangkan keletihan otot. Kerusi exo yang boleh dipakai ini direka dengan rekabentuk ergonomik yang tertentu bagi mengurangkan masalah ketegangan otot di bahagian belakang dan kaki bawah. Walaupun ada kerusi yang boleh dipakai yang tersedia secara komersial, ia tidak memenuhi keperluan khusus untuk doktor dan kakitangan perubatan. Rekabentuk ini akan mempunyai mekanisme yang membolehkan doktor beralih secara aktif antara posisi berdiri, duduk, dan berjalan yang dapat menjadi penyelesaian masalah MSD untuk doktor perubatan dan pakar bedah semasa mellakukan pembedahan.

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Special thanks to all my peers, my beloved mother, father, and siblings for their moral support in completing this degree. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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F_x	Force x--axis
Fy	Force y--axis
M	Moment
τ	Sheer stress
σ	Tensile Stress
I	Moment of inertia
FOS	Safety of Factor (FOS)

Chapter 1

INTRODUCTION

1.1 Background

Nowadays, patient increase day by day because of disease and injury occur to our body. A surgeon needs to stand for a long time if the case involves severe operations, for example, organ transplant. Transplanting a liver can take eight to 10 hours, and the surgeon needs to be ready to operate whenever an organ is available. It can cause injury called Musculoskeletal Disorder (MSDS). MSDs are injuries or disorders that affect the human body's movement or musculoskeletal system such as muscles, tendon, ligament, nerves, disc, blood vessel etc. It occurs when an individual is exposed to the MSD risk factor. The body begins to fatigue and outruns their body's recovery system. It develops a musculoskeletal imbalance. Over time as the fatigue and imbalance of musculoskeletal continue, a musculoskeletal disorder develops. Another reason that occurs MSDs is when an individual performed prolonged and repeated gestures during work. Recent research on Musculoskeletal Pain in Gynecologic has shown that five anatomic regions worsened or caused the pain during performing surgery.

Nevertheless, wearing a flexible wearable or exo-chair is an option to overcome this injury. This product is the same as a light-weight mobile exoskeleton that allows people to sit anywhere in any working position compared to the traditional chair. This product consists of kinematic pairs that can withstand the weight of the users between continuous movement at any working position thus, it is capable of reducing the risk of the physical musculoskeletal disorder among the workers. Some of the wearable chairs are made on the exoskeleton concept, which has supporting apparatus on the outside of the body such as crabs, insects, and other arthropods. The additional external frame supports the bodyweight without wear out the muscles of the legs. However, there is also a wearable chair that consists of a pair of high-tech leg braces that wrap around legs and buttocks. The present invention provides support that would effectively allow the user to sit down whenever needed. Besides, it also provides a hydraulic powered chair for

the user for those people who must stand all day long to support their lower body. However, the user needs to push a switch to lock their position whether they want to stand or sit.

Based on the workplace for the surgeon, the exo-chair needs to be light and light-weight body support, which is convenient for the user to use without any restriction movement. The mechanism used also needs to be considered because the surgeon cannot use their hand to operate the chair. So, the chair must operate without using the surgeon's hand.

1.2 Problem Statement

Musculoskeletal disorder (MSDS) is common injuries that happen to humans because of trauma to an area repetition (falls, fractured, sprains, dislocation, etc.). Besides that, postural strain, repetitive movement, overuse ad prolonged immobilization. As nowadays, surgeons always involved with the operation that consumes a long time to finish the operations. Based on this event, a surgeon had to stand for a long time that will cause them to suffer MSDs at an early age. This injury will reduce their performance during works.

1.3 Aim & Objectives.

The purpose of this project is to develop a wearable exoskeleton-chair for the surgeon while they are performing their surgery. The device will be designed tailored to a sitting position, equipped with simple and easy to use a mechanical system and suitable for the surgeon.

1.4 Scope of the project

The scope of the project is to develop a conceptual design of a sitting device with a mechanical system that works in a different working position, which is suitable for the surgeon working environment. The conceptual design will only focus on the mechanical mechanisms of the sitting device only.

1.5 General Methodology

The actions that need to be carried out to achieve the objectives in this project are listed below and can be represented in a form of flow chart as shown in Figure 1.5.

i. Literature review
ii. Produce morphology chart.
iii. Design a conceptual design.
iv. Simulation Analysis and proposed solution
v. Report writing

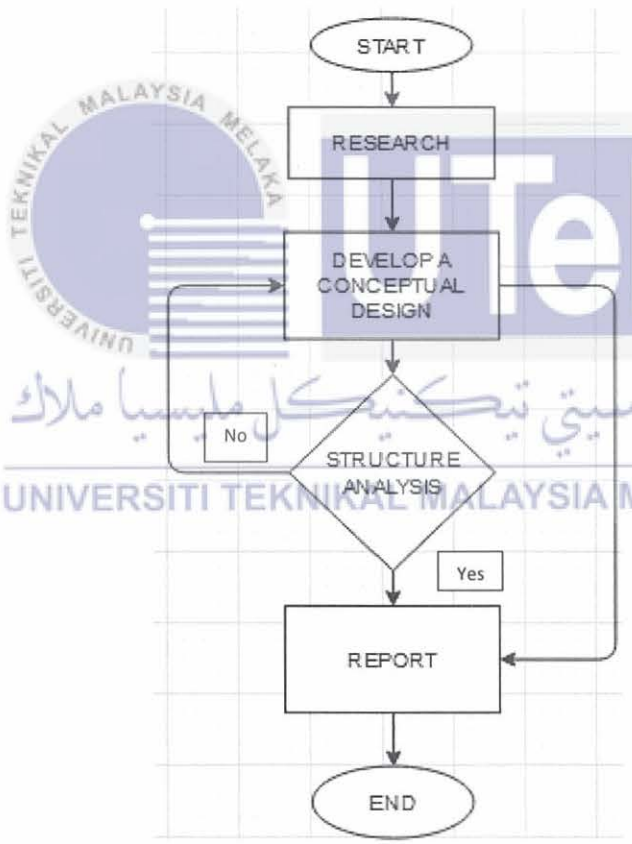

Figure 1.5: Flow chart of the methodology.

1.6 Summary

From this chapter, the objective of the project is clearly explained to design a conceptual to develop an conceptual design of a sitting device with a mechanical system that works in a different working position. A few suggestions will be provided in the report to improve the design.

Chapter 2

LITERATURE REVIEW

This chapter focused on the context of the project included in this section. A few guided examples of existing and the precious study of design of exoskeleton chairless chair in market are studied to realize the new improved conceptual design.

2.1 Surgical Environment

Surgery is the name commonly used to describe operations (called surgical techniques) requiring physical cutting or stitching of tissue for the treatment of diseases, disabilities or deformities. In modern medical treatment, distinguishing between surgical and medical procedures (commonly referred to as procedures that do not involve cutting or stitching) is not always easy. However, making that difference among them is not important as long as they are trained and experienced. (Mohabir, 2020).

As a surgeon, there is an operating room in which the operating team will operate the surgery. The operating team that consists of a chief surgeon, assistant surgeons, anesthesiologist, scrub nurse, and circulating nurse, as shown in Figure 2.1. Generally, the operation room requires a monitor displaying vital signs, an instrument table, and an operation light. The anesthetic gasses are piped into the anesthetic system. A catheter connected to the suction machine works to remove the blood and other fluids, which may prevent surgeons from seeing tissues. Fluids given by vein, started before the person enters the operating room.

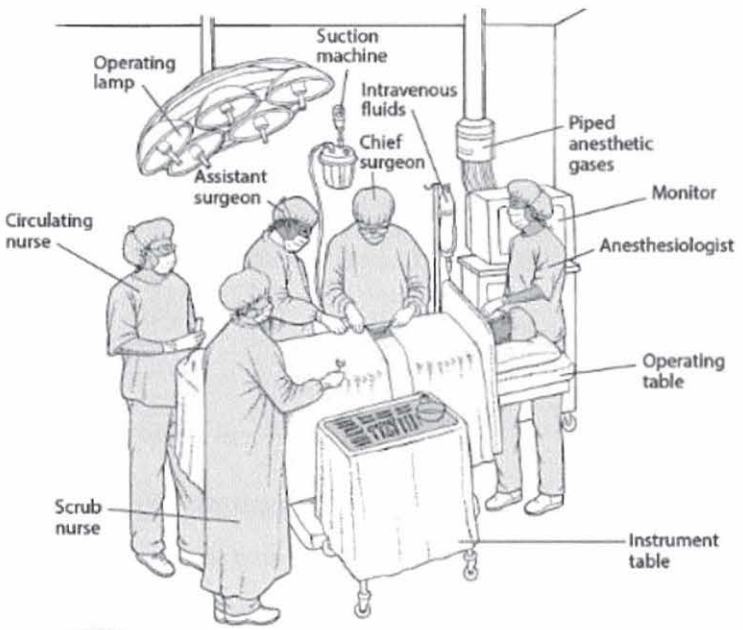

Figure 2.1: Surgical environment (Mohabir, 2020)

2.2 Prolonged standing

According to the Oxford Dictionary, standing is referring to maintain an upright position, supported by one's feet while prolonged is continuing for a long time or longer than usual. In this report, prolonged standing was described as the working state in which the operator continues to hold a standing working posture for more than 50% of the total working hours during the complete working shift. However, in long-standing situations (static position with minimal movement), this active posture occurs in workplace injuries. Long-standing leads to physiological discomfort, muscle fatigue, pain and may also contribute to the development of severe health hazards such as musculoskeletal disorders (MSDs) with a particular focus on regions such as the back, leg, and foot of the operator. Constrained standing working conditions, such as prolonged standing work or static working position, can often cause leg edema to grow due to muscle fatigue and discomfort (Standing et al., 2020) (Smith, 2020)

2.2.1 Control measures

In respect to the negative impact of prolonged standing, research and safety mechanisms should be viewed as a priority such that related accidents may be avoided or reduced. Within the area of ergonomics, engineering controls and administrative controls have been proven to be a successful means of minimizing the incidence of occupational injuries in the industrial workplace (Abdus Samad & Shelke, 2016).

2.2.2 Administrative Controls

Engineering controls refer to the use of engineering strategies to reduce the risk of industrial accidents, such as the use of anti-fat mats and ergonomic footwear designed to reduce muscle fatigue in the legs relating to workplace floor conditions. Several interventions have been reported to improve occupational health due to prolonged standing exposure. However, a good design of attire for a long-standing job has had beneficial results. (Abdus Samad & Shelke, 2016)

2.2.3 Engineering Controls

For scenarios where engineering controls are impossible to implement due to a number of constraints, work-rest strategies are more generally implemented by administrative controls to reduce the chance of prolonged standing. The work-rest schedule has been identified as the most successful method to minimize work-related injuries. Based on Jaap and Huub (1998), they have demonstrated that having longer breaks can be more effective in reducing the possibility of leg swelling correlated with prolonged standing (Ali et al., 2017).

2.3 Musculoskeletal disorders (MSD)

Musculoskeletal Disorder, MSD, is one of the leading causes of occupational injury and disability in industrially developing countries. MSD is one of the major problems encountered by ergonomists in various workplaces around the world, including the medical and health sector (In et al., 2018). Moreover, MSD represents one of the most common and important occupational health problems in working populations, being responsible for a substantial impact on the quality of life and incurring a major economic burden in compensation costs and lost wages. In that case, MSD decreases productivity at work due to sick leave, absenteeism, and early retirement, and are also costly in terms of treatment and individual suffering (Erick & Smith, 2011). Medical is expected to work long hours under significant pressure with inadequate resources, while exposed to the risk of infection in close contact with patients. Studies show that healthcare workers across the globe, such as physical therapists, nurses, and doctors, are known to suffer a higher risk of MSD and can be represented in Figure 2.3.1.

Figure 2.3.1: Musculoskeletal disorders (MSD)

Resource ("Musculoskeletal Disorders on the Rise- Ehs Today," (Langdon D, 2013) n.d.)

Musculoskeletal pain can be an occupational health issue for medical professionals, especially surgeons and dental surgeons, who maintain static postures through precision hand and wrist movements (Stomberg et al., 2010). MSDs have also been reported to be more common in subjects performing heavy physical work, particularly those in work involving

kneeling and squatting (Rambabu & Suneetha, 2014). It shows that the surgeons who mostly work under time pressure. Based on the researcher, the results confirmed that physical and psychosocial factors were strongly associated with the musculoskeletal symptoms in surgeons. These musculoskeletal symptoms have the potential to worsen in the future, with rapid developments and increasing the implementation of minimally invasive surgery (Szeto et al., 2009). It was concluded that MSD among the workers might be related to the stressful work posture, long-duration jobs, nature of jobs and the use of ill-fitted hand tools (Kar & Dhara, 2007).

Besides that, MSD is classified as soft tissue injuries and disorders, such as muscles, tendons, ligaments, and joints. MSD causes the movement of the human body or musculoskeletal systems, such as muscles, tendons, ligaments, nerves, and blood vessels. When an individual has been exposed to a risk factor to MSD, the body starts to become fatigued and outruns the body's recovery mechanism. It will produce a musculoskeletal imbalance. Over time, as the fatigue and imbalance of musculoskeletal continue, a musculoskeletal disorder develops. Another reason that occurs MSDs is when an individual performed prolonged and repeated gestures during work. Figure 2.3.2 shows that a study found that lower back body region was the highest prevalence of MSD compared to other areas in the human body (Anita et al., 2014). It shows that MSD was prevalent among the workers, and the highest prevalence, according to the body region, was found in the lower back region and shoulders.