DESIGN AND EVALUATION OF TEST RIG FOR MEASURING HIP FLEXOR STRENGTH IN STANDING POSITION

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

…………………….................................

(Dr. Isa Bin Halim)

ABSTRAK

Otot fleksor pinggul memainkan peranan penting dalam melakukan aktiviti harian dan kerja, terutamanya dalam industri pembuatan dan pembinaan seperti perancah naik/turun dan tangga. Aktiviti kerja ini berpotensi menyebabkan masalah kepada pergerakan pekerja jika fleksor pinggul menjadi lemah. Akibatnya, pekerja mungkin mengalami sakit di bahagian bawah belakang, dan kecekapan kerja dan produktiviti mungkin terjejas. Untuk mengelakkan akibatnya, pengamal ergonomik dan jurutera industri mempunyai data teknikal yang terhad berkaitan kekuatan lentur pinggul. Ini disebabkan ketiadaan pelantar ujian yang kukuh untuk mengukur kekuatan lentur pinggul. Oleh itu, objektif kajian ini adalah menentukan keperluan reka bentuk untuk membangunkan prototaip pelantar ujian untuk mengukur kekuatan fleksor pinggul dan menilai kebolehgunaan dan kefungsian prototaip pelantar ujian. Hasil analisis ini menunjukkan bahawa keperluan reka bentuk untuk pelantar ujian adalah stabil, saiz padat (tidak besar), kukuh, ringan dan mesra alam. Beberapa konsep kemudiannya dibangunkan melalui kaedah Pugh, dan satu konsep terbaik dipilih berdasarkan matrik saringan. Reka bentuk konsep terbaik telah diterjemahkan ke dalam lukisan kejuruteraan pada perisian CATIA dan dianalisis menggunakan perisian simulasi kejuruteraan ANSYS untuk menilai ubah bentuk dan tegasan maksimum pada struktur prototaip. Kemudian, kajian kebolehgunaan dan ujian kefungsian telah dijalankan untuk memastikan prototaip pelantar ujian dapat mengumpul data tentang kekuatan fleksor pinggul. Kajian ini mendapati kekuatan fleksor pinggul maksimum peserta lelaki dan perempuan ialah 347.8 N, dan 211.8 N, masing-masing. Mengikut prototaip fungsi pelantar ujian menggunakan skor Skala Kebolehgunaan Sistem (SUS) ialah 74.25 ditentukan sebagai kebolehgunaan julat yang boleh diterima. Berdasarkan keputusan yang diperoleh, kajian ini merumuskan bahawa data kekuatan fleksor pinggul adalah boleh dipercayai apabila menggunakan prototaip pelantar ujian ini. Prototaip pelantar ujian yang dibangunkan oleh kajian ini akan memberi makna kepada pengamal ergonomik untuk mengumpul data tentang kekuatan lentur pinggul supaya proses kerja dalam industri boleh direka bentuk secara ergonomik.

ABSTRACT

The hip flexor muscles play a significant role in performing daily and work activities, especially in manufacturing and construction industries such as ascending/descending scaffolding and ladders. These work activities are potentially to cause problem to workers' motion if the hip flexor is weakened. Consequently, the workers may experience pain in the lower back, thus work efficiency and productivity might be affected. To prevent these consequences, however, ergonomics practitioners and industrial engineers have limited technical data on the hip flexor strength. This is due to absent of a sturdy test rig for measuring the hip flexor strength. Therefore, the objectives of this study are to determine design requirements to develop a prototype of test rig for measuring hip flexor strength and evaluate the usability and functionality of test rig prototype. The result of this analysis revealed that the design requirements for the test rig were stable, compact size (not bulky), sturdy, light weight, and environmental-friendly. Several concepts are then developed through Pugh method, and one best concept was chosen based on the screening matrix. The best concept design has been translated into engineering drawing on CATIA software and analysed using ANSYS engineering simulation software to evaluate the deformation and maximum stress on the structure of the prototype. Then, usability study and functionality test were carried out to ensure the test rig prototype is able to collect data on hip flexor strength. This study found the maximum hip flexor strength of male and female participants was 347.8 N, and 211.8 N, respectively. According to the functionality prototype of test rig using System Usability Scale (SUS) score is 74.25 determined as an acceptable range usability. Based on the results obtained, this study concluded that the data of hip flexor strength was reliable when using this prototype of test rig. The test rig prototype developed by this study would be meaningful to ergonomics practitioners to collect data on hip flexor strength so that work process in industries can be designed ergonomically.

DEDICATION

Only

my beloved father, Abdul Talib

my appreciated mother, Salbiah Ismail

my adored brother, Aiman, Adam and AIkal

my adroble friend, Wan, Jane, Beng, Mar and Fiza

for giving me moral support, money, cooperation, encouragement and also understandings

Thank You So Much & Love You All Forever

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LIST OF ABBREVIATIONS

ACE	-	American Council on Exercise
ANP	-	Analytic Network Process
BOM	-	Bill of Materials
CAD	-	Computer Aided Design
EMG	-	Electromyography
FKP	-	Fakulti Kejuruteraan Pembuatan
HOQ	-	House of Quality
MVC	-	Maximum Voluntary Contraction
PIV	-	Particle Image Velocimetry
QFD	-	Quality Function Deployment
SOP	-	Standard Operating Procedure
SVC	-	Submaximal Voluntary Contraction
TRIZ	-	Theory of Inventive Problem Solving
SUS	-	System Usability Scale

LIST OF SYMBOLS

cm	-	Centimetre
m	-	Metre
°	-	Angle
s	-	Second
RM	-	Ringgit Malaysia
mm	-	Millimetre
τ-	Torque	
Nm	-	Newton Metre
N	-	Newton
Ncm	-	Newton Centimetre
+	-	Addition
-	-	Subtraction
=	-	Equal

CHAPTER 1

INTRODUCTION

The first chapter presents the background of the study, problem statement, objectives, scope of the study, the significance of the study, and report of the organization. The background of the study elaborates how the test rig is significant to the manufacturing industry and construction sector. The problem statement describes a problem in the industry that inspired the concept for this project. Additionally, the problem statement highlights the limitations of the existing prototype and existing test rig. The objectives represent this project’s main goal, while the scope of the study shows the limitation and approaches used to create this project. The significance of this study shows how this test rig prototype will collect the data on hip flexor strength in a standing position. Finally, the organisation's report explains how this report is carried out in total.

1.1 Background of Study

Working with scaffolds is highly associated with severe injuries in the construction industry since less priority has been focused on health issues. This equipment is often used as a workstation on construction sites for temporary structures and to repair or clean structures. Professional exhaustion is becoming more of an issue in the construction sector as projects get more intricate and time and cost constraints become more extreme. However, the building sector has dedicated inadequate attention to health hazards and ergonomics issues. For example, when employees climb scaffolds using their hands and feet, they must keep their bodies as close to the frame as possible, which is ergonomically hazardous.

Figure 1.1: A worker climbing the scaffolds (Webb, 2017)

In addition, the muddy area also plays a role in the workplace of construction which sludge or mud can pose several hazards. Mud is a mixture of various soil types that typically form after raining or near the water source. It can cause problems for workers in the construction area as accidents may happen, including slipping, tripping, or falling. Workers in the construction industry will impact the ergonomic risk factor. Sometimes, when they climb the scaffolds, the lower body, the hip flexor muscle, needs to pull up their leg to climb up from scaffolding and muddy areas. As shown in Figure 1.2, the boot is stuck in a muddy area, whereas it requires high torque exertion of the hip.

Figure 1.2: Boots stuck in a muddy area (Strommen, 2018)

Subsequently, designing a scaffolding and effective safety boot needs to study the ergonomic, which involves designing and optimizing products, workplaces, or systems for people to reduce discomfort and risk of injuries. For instance, when the workers climb the scaffolding with the heavy safety shoes, either the size of the ladder and distance of the ladder is ergonomic or not. The group of muscle hip strength, which is gluteal, adductor, iliopsoas and lateral rotator, cause movement at the hip joint. The iliopsoas is the strongest group of muscles in the hip flexor, which connect the spine to the femur and help pull the thigh towards the torso or raise your knees to chest.

The hip flexors perform an important mechanical function, which is why, if not done correctly, even basic abdominal crunches may sometimes wear them out. The hip flexors are important in human movement because it creates stability. The hip flexors, along with the other 'main' muscles of the torso and glutes, play an essential part in maintaining the pelvis and spine, ability to move and exercise without losing balance to the lower back. Next, the powerful musculature is utilized in abrupt sprinting and jumping, specifically in athletes. Also, one of the most frequent causes of musculoskeletal concerns and preventing injuries is hip flexor strain. Weaker hip flexor strength was seen in people whose function was declining compared to those who performed similarly or better. According to the researchers, focusing on maintaining hip flexor strength could offer significant benefits once you become older (Millard, 2021). Therefore, several postures can strengthen the hip flexor to maintain strength and prevent injuries, as shown in Figure 1.3.

Figure 1.3: Hip flexor Exercises

As a result, there is a lack of research on ergonomics studies, especially when designing and evaluating the equipment. Therefore, according to the topic of the study, it is important to be aware and ensure the flexor muscles work efficiently.

1.2 Problem Statement

Implementing ergonomics solutions can make employees more comfortable and increase productivity for the industry. Ergonomics is an important part of research in the product development process. Its purpose is to increase the safety, comfort and performance of a product or an environment. According to the annual report by the Society Organization Society (SOCSO), accident involving scaffolding has been reported in as many as 368 for five years. The engineer can reduce the number of these accidents by helping the engineer study and design the ergonomic structure. The accident might happen because of slipping, tripping, or falling from height when workers are on scaffolding, as shown in Figure 1.4. An engineer lacks data on hip flexor strength to determine the optimum size, shape, and form of a product to create and design an ergonomic product.

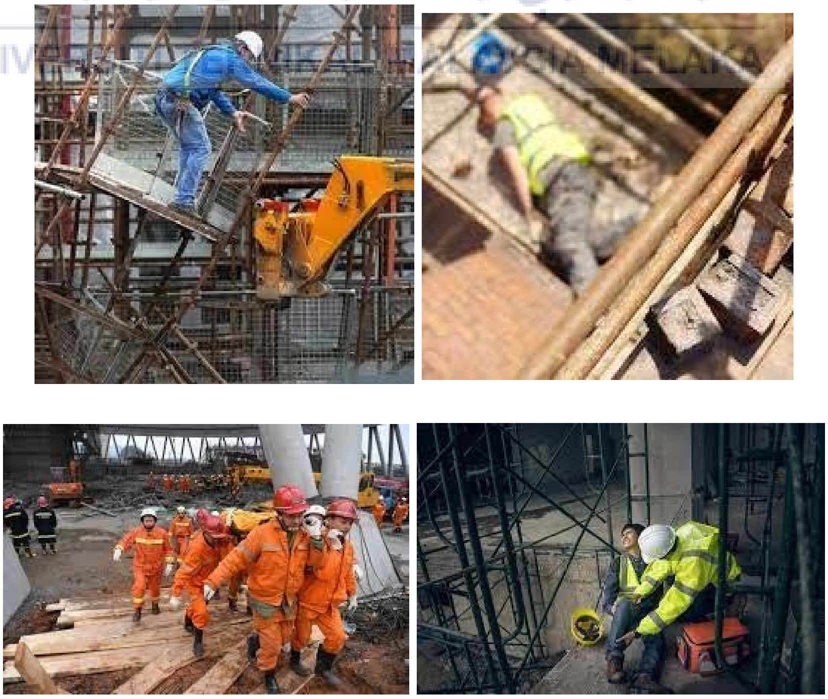

Figure 1.4: Hazard at construction area

Next, Figures 1.5 and 1.6 show that force gauges and torque gauges are available on the market and in the FKP lab. The functionality gauges are to measure force and torque. However, gauges are made for simple mechanics experiments that involve pushing and pulling force and measuring torque strength. These gauges can be used to measure hip flexor strength, but the test rig is not suitable for use. Since the existing test rig did not meet the requirements, there is no method to gather data. As illustrated in Figure 1.7, a former student attempted to conduct an experiment to determine hip flexor strength using a method that was clearly ineffective.

Figure 1.5: Force Gauge Mark 10

Figure 1.6 Torque Gauge Mark 10