



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Analysis of Hand Strength for Pinching Activity

Thesis submitted in accordance with the partial requirements of the
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By

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ANALYSIS OF HAND STRENGTH FOR PINCHING
ACTIVITY

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This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management). The members of the supervisory committee are as follow:

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ABSTRACT

This research is about the study of the human thumb structures and its bones. This research is to gather information on key pinch strength/force and the stress exerted throughout the thumb among Malaysians and analyze it using finite element analysis (FEA) so that it can be used for future references.

Data for this research are gathered and collected from data of previous study similar to this topic being researched. Previous data contains 120 samples but only 60 will be used to analyze in this research. If the outcomes/results of the analysis are not satisfying enough, more data will be selected or gathered manually so that proper analysis can be done correctly. The initial 60 samples from the group of 120 samples are in the age group of 22-40 years old, consist of 3 races which are the Malays, Chinese, and Indians, data are from both the left and right hand, and out of the 60, 30 are males and remaining 30 are females.

Till this point in research, one of the main findings is that many has said that improper use of pinching activities whereas its limitations has been reached can cause diseases such as carpal tunnel syndrome (CTS) and thumb arthritis. This is why a proper research is needed so that diseases like these can be avoided when performing daily tasks. Other findings include data for the pinching exercise is mostly collected from the western population but very minimal in Malaysia.

Data derived from western populations cannot be applied to a comparable Malaysian general public. Gender, hand dominance, age, and weight must be considered when establishing normal values for pinch strength and the stress exerted on the bones.

ABSTRAK

Kajian ini adalah berkenaan dengan struktur tulang ibu jari manusia. Tujuan kajian ini adalah untuk mengumpul maklumat berkenaan daya cubitan ibu jari dan daya-daya yang menekan pada tulang-tulang ibu jari tersebut dikalangan rakyat Malaysia dan dianalisis menggunakan kaedah *finite element analysis (FEA)* supaya keputusan dari kajian ini dapat digunakan untuk kajian-kajian pada masa akan datang.

Maklumat yang digunakan untuk kajian ini diambil daripada data kajian yang telah dilakukan sebelum ini iaitu hampir menyerupai kajian ini. Data dari kajian tersebut mengandungi 120 sampel, tetapi, hanya 60 sampel sahaja akan diambil dan digunakan dalam kajian ini. Jikalau keputusan dari analysis tidak begitu memuaskan, lebih banyak data lagi akan diambil dari data asal atau mengumpul data sendiri supaya analysis dapat berjalan dengan lancar. 60 data asal yang telah dikumpul mengandungi sampel dalam lingkungan umur 22-40 tahun, mengandungi 3 jenis bangsa, Melayu, Cina, dan India, data itu adalah untuk kedua-dua belah tangan, dan 30 adalah lelaki manakala 30 selebihnya adalah perempuan.

Sehingga tahap ini dalam kajian, didapati penggunaan cubitan yang melebihi batasan akan mengakibatkan beberapa penyakit pada ibu jari seperti *carpal tunnel syndrome (CTS)* dan *thumb arthritis*. Oleh kerana itulah kajian yang lebih teliti mengenai daya cubitan dan had-hadnya adalah perlu. Penemuan selanjutnya didapati bahawa data bagi rakyat Malaysia adalah terhad.

Data yang telah dikumpul dan dianalisa di negara-negara barat tidak boleh digunakan sebagai perbandingan normal bagi rayat di negara ini. Jantina, umur, dan berat badan perlu diambil kira apabila menetapkan nilai normal bagi kekuatan cubitan dan daya-daya yang menekan pada tulang ibu jari.

DEDICATIONS

To my late father,
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and my mother,
Hjh. Ramlah Abdul Rahman,
for your love and demonstrating the values of education since I was born.

To my brothers and sisters:
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Mohd Izuan Hj. Abdul Wahab and wife,
Nurbani Hj. Abdul Wahab and husband,
Monisa Hj. Abdul Wahab and husband,
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LIST OF ABBREVIATIONS

Avg.	-	Average
CAD	-	Computer Aided Design
CMC	-	Carpometacarpal
CTS	-	Carpal Tunnel Syndrome
F	-	Force
FEA	-	Finite Element Analysis
FEM	-	Finite Element Method
g	-	Acceleration of Gravity
kg	-	Kilogram
lbs	-	Pound
M	-	Mass
m	-	Meter
mm	-	Millimeter
MPa	-	Megapascals
MSC	-	MacNeal-Schwendler Corporation
N	-	Newton
NASA	-	National Aeronautics and Space Administration
NASTRAN	-	Finite Element Analysis Software
PATRAN	-	Finite Element Analysis Pre-processing Software
r	-	Radius
UTeM	-	Universiti Teknikal Malaysia Melaka
W	-	Weight
π	-	Pi (3.142)

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Hand strengths activities have been studied by researcher in the recent years. Their intentions mainly are to understand the functions and ability of the hand in daily tasks. Until recently, studies which focus on the pinching activity of the hand became more popular. In a journal titled Grip and Pinch Strength: Normative Data for Adults (Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985), studies of the grip and pinch strength were conducted in order to determine the normative strength for adults to be used clinically. However, none of the research done involved the general public from Malaysia.

As we know, different populations have also different backgrounds. The Asians are smaller in body size, the Americans have bigger palms, and so on. Data for the Malaysians are also different from others. Information regarding the hand strength of pinching activity will have more practical applications for the Malaysians in the future, such as when designing products that requires pinching activities by the users or normative data that can be used clinically. The findings of this research will eventually lead to some useful change in best practice in the population daily activities, but first, the most important question to be answered is what are the key pinch strength/force of the thumb and the stress exerted on the bones for the Malaysian general public?

1.2 Goals

The aims of this research are mainly to:

1. Determine the strength/force of pinch and the stress exerted on the bones for pinching activities done by Malaysians.
2. Analyze data using NASTRAN with pre-processing software called PATRAN.
3. Provide recommendations, suggestions, and solutions for future research or for future product design determination.

1.3 Scope

The scope of this research is limited to:

- Study the strengths/force and the stress exerted on the bones for pinching activity in daily tasks.
- The type of pinch called the key pinch type or also known as the lateral pinch.
- Randomly test any Malaysians that are willing to participate. However, the subjects are to be free from any disabilities or disease especially disease that are related with the hand.
- Use some of the pinch force data taken from previous study done by a UTeM student.
- Analyze using finite element with the use of software called PATRAN and NASTRAN.

1.4 Purpose of research

Purposes from previous studies related to this topic have been written like; the primary purpose of this study was to establish clinical norms for adults aged 20 to 75+ years on four test of hand strength, Mathiowetz *et al.* (1985), and, data that define the magnitude of force necessary to complete functional key pinch tasks are limited. Other research aims are, the study aims to establish target pinch force for completing selected tasks that require a range of useful functional activities, Smaby *et al.* (2004). As we can see, none of these researchers have researched on the Malaysian population's hand strength for the key pinch activities and data that surrounds this specific topic are still limited. The purpose of this study is to gather information on key pinch strength/force among Malaysians and analyze it using finite element analysis (FEA) to determine the stress exerted on the bones so that it can be used for future reference.

This research are more focused on only the pinching activity, namely the key pinch (also known as lateral pinch), to determine the stress exerted on the bones be used as a normative data for the Malaysian population. Upon completing this study, it is hope that the information can be used for future studies regarding this specific topic. This study is also chosen because there is very limited information regarding the lateral pinch strength especially for the Malaysian residents.

1.5 Overview

The human hand is a very important component to us as humans. Sanders and McCormick (1987) states that the human hand is a complex structure composed of bones, arteries, nerves, ligaments, and tendons, as shown in Figure 1.1 and 1.2 respectively. It is useful to accomplish many tasks. Such tasks include gripping and pinching movement in daily activities. This study as mentioned earlier only emphasizes on pinching activities namely the lateral or key pinch.



Figure 1.1: The anatomy of the hand

(http://www.eorthopod.com/images/ContentImages/hand/hand_anatomy/hand_anatomy_intro01.jpg)

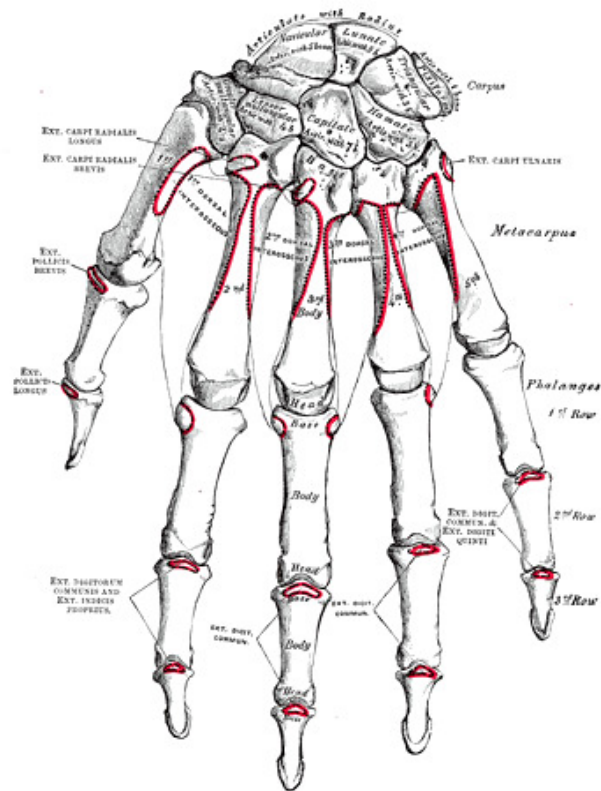


Figure 1.2: The bone structure of the hand

(<http://upload.wikimedia.org/wikipedia/commons/archive/e/e5/20070123185310!Gray220.png>)

According to Klien and Fernandez (1996), there are three types of pinch which are the lateral or key pinch, chuck pinch, and tip or pulp pinch. Key pinch mainly uses the thumb. Sanders and McCormick (1987) mentioned that the thumb is the only finger that is flexed, abducted, and opposed by strong, short muscles located entirely within the palm of the hand.

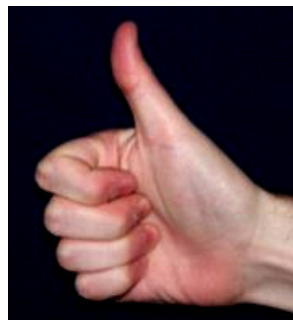


Figure 1.3: The thumb
(Wikipedia, 2006)

1.5.1 Bones

The thumb consists of 3 bones:

1. distal phalanx (of the first digit)
2. proximal phalanx (of the first digit)
3. first metacarpal

1.5.2 Muscles

Its movements are controlled by eight muscles (each with "pollicis" in the name):

Name	Location	Nerve
extensor pollicis longus	forearm	posterior interosseous nerve
abductor pollicis longus	forearm	posterior interosseous nerve
flexor pollicis longus	forearm	anterior interosseous nerve
extensor pollicis brevis	forearm	posterior interosseous nerve
abductor pollicis brevis	hand	median nerve
flexor pollicis brevis	hand	median nerve
opponens pollicis	hand	median nerve
adductor pollicis	hand	ulnar nerve (deep branch)

Table 1.1: List of muscles in the thumb

(Thumb, 2007)

Description from the Wiki online encyclopedia mentioned that the thumb, unlike other fingers, is opposable, in that it is the only digit on the human hand which is able to oppose or turn back against the other four fingers, and thus enables the hand to refine its grip to hold objects which it would be unable to do otherwise.

Key pinch as shown in Figure 1.4 is the thumb pad to lateral aspects of middle phalanx of index finger.

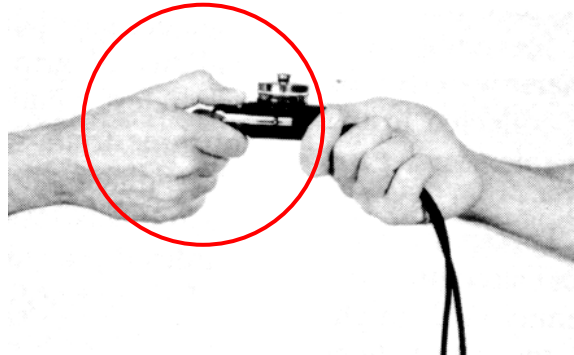


Figure 1.4: Key pinch

(Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985)

Previous study has determined the acting forces when doing key pinching activities. Figure 1.5 is a computer visualization of the directions of the joint reaction for the key pinch posture for an applied load of 10N. Forces vector represented with single headed arrows, and moment vectors are represented with double headed arrows, Giurintano *et al.* (1994).

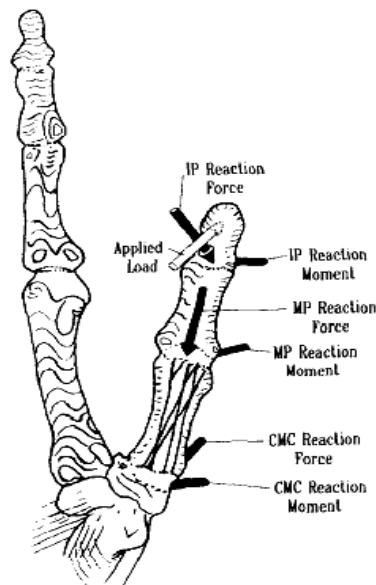


Figure 1.5: Forces in key pinch activity

(Guarintano, Hollister, Buford, Thompson, & Myers, 1995)