UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

CHARACTERISTIC OF ELDERLY PEOPLE HAND AND ITS EFFECT TO WALKING STICK HANDLE: A CASE STUDY IN MALACCA

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CHARACTERISTIC OF ELDERLY PEOPLE HAND AND ITS EFFECT TO WALKING STICK HANDLE: A CASE STUDY IN MALACCA

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A thesis submitted
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DECLARATION

I declare that this thesis entitled "Characteristic of Elderly People Hand and its Effect to Walking Stick Handle: A Case Study in Malacca" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	....
Name	:	....
Date	:	....

DEDICATION

To my other half, Mohd Aminudin and my little girl, Ameena

ABSTRACT

Hand is best known as an ultimate operative instrument, the hand helps in assisting human to grip, pinch, hold and others. According to the statistic in year 2015, the population of elderly people in Malaysia aged 60 years old and above was 2.8 million and by year 2035, the population projection of elderly people will up to 5.6 million. The projection figures give a preliminary picture on the demand for the usage of walking aids among elderly people.This study is to investigate the hand characteristics and biomechanics of elderly people and its effect to different design of handle of walking stick and propose handle of walking stick considering ergonomics aspects of elderly Malaysian. The sample of elderly people was taken from Rumah Seri Kenangan, Cheng, Malacca. They comprises of female and male of Malay, Chinese and Indian races, their age were sixty and above. Physical characteristics of hand such as: contact area, hand length, hand width, hand size, inside grip diameter and grip strength, grip force, was taken. Other than measuring physical dimension of hand, survey was also captures their opinion regarding the comfortability of using three types of handles walking stick design which were mostly used. Three types of walking stick handle were chosen based on market demand. There were positive correlations on hand length and hand size, hand size and inside grip diameter, hand size and grip strength. It has negative correlation for both genders for grip strength and age. Among the three handle of walking stick, the one that contribute to distributed force was handle Swan neck type followed by T-type handle and Crook type handle. On distribution of force among 5 location identified, the location on ulnar nerve area was the highest force. This was also confirmed by results of questionnaires and interview. For recommendation, the design of handle stick that give better comfort those that provide equally distributed force to hand. The size of handle should follow the hand size of elderly people. According to the result, the handle should have three different sizes. Padded handle stick would provide not only better grip but also comfort ability.

ABSTRAK

Tangan dikenal sebagai instrumen pengendalian muktamad, tangan membantu dalam membantu manusia untuk cengkaman, mencubit, memegang dan lain-lain. Menurut statistik pada tahun 2015, penduduk warga tua di Malaysia yang berumur 60 tahun ke atas ialah 2.8 juta dan pada tahun 2035, unjuran penduduk orang tua akan sehingga 5.6 juta. Angka unjuran memberi gambaran awal mengenai permintaan penggunaan alat bantu berjalan di kalangan orang tua. Kajian ini adalah untuk mengkaji ciri tangan dan biomekanik warga emas dan kesannya kepada reka bentuk pemegang tongkat yang berbeza dan mencadangkan tongkat yang ergonomik dengan mengambil kira aspek warga emas dari Malaysia.Sampel orang tua diambil dari Rumah Seri Kenangan, Cheng, Melaka. Mereka terdiri daripada kaum wanita dan lelaki Melayu, Cina dan India, berumur enam puluh tahun ke atas. Ciri-ciri fizikal tangan seperti: kawasan sentuhan, panjang tangan, lebar tangan, saiz tangan, diameter cengkaman dalam dan kekuatan cengkaman, daya cengkaman, telah diambil. Selain daripada mengukur dimensi fizikal tangan, kajian juga mengambil pendapat mereka mengenai keupayaan keselesaan ketika menggunakan tiga jenis desain pemegang tongkat yang kebanyakannya digunakan. Tiga jenis pemegang tongkat dipilih berdasarkan permintaan pasaran. Terdapat hubungan yang positif kepada panjang tangan dan saiz tangan, saiz tangan dan diameter cengkaman dalam, saiz tangan dan kekuatan cengkaman. Ia mempunyai korelasi negatif bagi kedua-dua jantina untuk kekuatan cengkaman dan umur. Di antara tiga pemegang tongkat, salah satu yang menyumbang kepada keseragaman kuasa adalah jenis pemegang Swan neck diikuti oleh pemegang T dan jenis pemegang cangkuk. Dalam taburan tenaga di kalangan 5 lokasi yang dikenal pasti, lokasi ulnar nerve merupakan kuasa tertinggi. Ini turut disahkan daripada hasil soal selidik dan kaedah temu bual. Untuk cadangan, desain pemegang tongkat yang memberi keselesaan ialah yang dapat memberi keseragaman kuasa pada tangan. Saiz pemegang perlu mengikut saiz tangan orang tua. Menurut keputusan, pemegang harus mempunyai tiga saiz yang berbeza. Pemegang tongkat yang berpelapik akan memberikan cengkaman bukan sahaja lebih baik bahkan juga memberi keupayaan keselesaan.

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LIST OF ABBREVIATIONS

ABBREVIATION	MEANING
ANOVA	Analysis of variance
CBTS	Cubital tunnel syndrome
CQH	Comfort questionnaire for hand tools
CTD	Cumulative trauma disorder
CTS	Carpal tunnel syndrome
EMG	Electromyography
EVA	Ethylene vinyl acetate
MVC	Maximum voluntary contraction
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PSE	Point of subjective equality
RSI	Repetitive strain injuries
SEMG	Surface electromyography
WMSD	Work-related musculoskeletal disorders

LIST OF SYMBOLS

%	-	Percentage
mm	-	Millimeter
kg	-	Kilogram
F_g	-	Grip force
F_p	-	Push force
F_c	-	Contact force
F_N	-	Normal force
cm	-	Centimeter
cm^2	-	Area unit
L	-	Length
D	-	Diameter
D1	-	Diameter major axes
D2	-	Diameter minor axes
°	-	Degree
±	-	Plus minus
N	-	Newton
s	-	Sample standard deviation
a	-	Desired accuracy percentage
z	-	Confidence level
n	-	Sample size
∑	-	Summation
α	-	Alpha value
t	-	t-test value
$\bar{x}$	-	Sample mean
df	-	Degree of freedom

SS	-	Sum of squares
MS	-	Mean of squares
μ	-	Means
y	-	Dependent variable
x_p	-	Independent variable
β_p	-	Regrssion coefficient

LIST OF PUBLICATIONS

Journal

1. Afifah *et al.,* 2011. Investigation on the relationship of hand size, ratio of handle diameter/hand length, inside grip diameter, and contact area to grip strength. *Malaysia Journal of Ergonomics,* Special Issue 2011, pp.72-82.

Book

1. Ng, P. K., Saptari, A., and Fauzi, A. M., 2013. Chapter 8: Hand anthropometry: A descriptive analysis on elderly Malaysians. **In** *Anthropometric Research in Malaysia* (1st ed.), pp.148-169. Bandar Baru Bangi: National Institute of Occupational Safety and Health (NIOSH).

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

People work in industry, at home, or in the offices are using tools or equipment to help them perform their jobs. These tools were developed to assist people work easier, faster and more productive. Despite of numerous finding in technology for tool advancement, hands and fingers are still primary tools in manufacturing industry as well as household jobs and human activities around the world. The hand is a part of human body used in nearly all physical work activities. Hand is best known as an ultimate operative instrument, the hand helps in assisting human to grip, pinch, hold and others. Due to its versatile applications, many equipment and tools were designed to accommodate hand characteristics and limitations. However, hand activities without knowledge in safety and prevention may end up this primary human tool becomes injured or disable. For example high force grip exertion, awkward positioned can lead to injuries and musculoskeletal disorder (Ellis *et al.*, 2004).

Statistics shows that human injuries particularly on hand related in Malaysia as reported by Department of Occupational Safety and Health in 2012 were 1187 cases (Amin *et al.,* 2015). The injuries include upper arm, elbow, forearm, wrist, hand and fingers are caused by the faulty or improperly used of the hand tools or powered hand tools. Report from the Emergency Department of Hospital Serdang in 2010 also revealed that out of 428 registered industrial accidents, 106 (24.7%) was work-related hand injuries and 46.2% of the cases had severe of work-related hand injuries (Al-Husuny, 2011). In developed country like in United States, this type of hand injuries: hand, wrist and fingers accounted for 10.3 percent or 4.7 million injuries of all United States emergency-room visits in 2009 (Centers for Disease Control and Prevention, 2009). In the workplace, only the back injuries contribute to more days-away-from-work injuries than the hands. According to the latest data from the United States Bureau of Labor Statistics (2011), employers reported 140,460 hand injuries that led to lost workdays in 2011, at an incidence rate of 13.9.

Domestic activities such as sport and household activities also contribute to a number of hand related injuries. For instance, data from a general health study in 2010 reported that 22% of adolescent aged between 12 to 19 and 14% of senior citizen aged 65 and above in Canada encountered with the hand injuries while participating in sports (Billette and Janz, 2011). Based on the data, wrist and hand are listed among the part of body affected by the most serious injury after ankle and foot with 714,000 cases at an incidence rate of 17.3 (Billette and Janz, 2011). A survey from Prince of Wales Hospital in Hong Kong revealed that from June 1992 to May 1993, 7.6% of the hand injuries were contributed during sports or recreational activities (Hung *et al.,* 1997).

Among the group age in Malaysia the highest proportion is elderly people. According to the statistic in year 2015, the population of elderly people in Malaysia aged 60 years old and above was 2.8 million and by year 2035, the population projection of elderly people will up to 5.6 million (Department of Statistic Malaysia, 2015). The projection figures give a preliminary picture on the demand for the usage of walking aids among elderly people. This figure should have been anticipated by the government to prepare contingency basic need such as nursing house for elderly, aide equipment for walking such as walking stick, wheel chair and so on.

Due to aging process, among the elderly problem mostly found is capability to walk decline because of loss of some the muscle fibers that make up the muscles which then affects the muscular movements and body balance (Imrhan, 2006b). It makes the elderly people requires greater muscular strength compared to other age group so that they can easily move and perform daily routine without difficulties. Thus, the demand of walking aids such as walking stick will increase in the near future. Various designs of walking stick available in the market, however there are limited information to be accessed on which design is comfort and safe for users.

This issue raised the important of knowledge of characteristic of hand and its limitation and the design of handle as the interface between hand and walking stick. The design of tools usually follows the shape or curvature of the human body. To have this kind of design of equipment that may afford these features, ergonomics considerations should be employed. Ergonomics is a branch of science that study human characteristics for the appropriate design of the living and work environment (Kroemer *et al.,* 2001). Ergonomics applies the scientific principles, methods, and data drawn from a variety of discipline to the development of engineering systems in which people play a significant role.

Principles of ergonomics design in tool and environment needs to be applied. Poor design tools and working environment will damage the primary tools of human such as hand. Understanding ergonomics risks factors such as force, frequency, awkward position, static position, lack of recovery, and contact stress when users performing the jobs are necessary to reduce the damage of human body. The damages may affect the musculoskeletal systems.

Walking stick can be categorized as one of the hand tool to help people walking. Hand tools design need to fit the curvature of the hand, as well as need to be held securely with straight wrist and suitable arm postures, and must utilize strength and energy capabilities without overloading the body (Kroemer, 2001).

Other than contours of hand, parameters such as, contact area, hand size, handle tool dimension and other related attributes such as grip force and normal force need to be considered in hand tool design. Due to the effect of these forces, handles requires specific ergonomics consideration in order to avoid any risks or hand injuries when users using it.

This thesis focuses on hand of parameters to be considered in designing walking stick handle used by elderly people. Any design of the devices or tools for these groups of people can have an effect on user comfort. Thus, ergonomics consideration must be put at the first place while designing products for these groups of people. A good practice in ergonomics improves and serves for a comfort and safe condition, thus endorse for a better daily life activity.

1.2 Problem Statement

Walking aid such as walking stick is a common apparatus for elderly people. The problem happened due to age related changes in their neural, sensory and musculoskeletal systems which can lead to balance impairments that have a tremendous impact on the ability to move safely. This requires the usage of walking aids to assist them during walking.

Walking stick handle design for elderly people can have an effect on user comfort and safety. User comfort can be greatly affected by the design of walking stick handles as users have to support part of their body on the walking stick, thus placing a lot of pressure from the palm onto the walking stick handle. Improperly designed walking stick handles can have undesirable consequences such as fatigue at the triceps part because of the muscles worked to hold the user's weight up (Diez, 1997).

Researches had done on discomfort in the hand, it caused by improperly designed handled tools not only could lessen the precision, efficiency, concentration and motivation of the user in doing the activity (Johansson *et al.,* 1999; Kuijt-Evers *et al*., 2004) but on a longer term it may lead to several undesirable consequences including injuries to user hand (Wu and Hsieh, 2002; Afifah *et al.,* 2011).

Facts obtained from the United States Department of Health and Human Services (2009) informed that from 2001 to 2006, an average of 129 Americans ages 65 and older were treated in emergency departments each day for injuries from falls that involved from the usage of walking stick. However, there is no fact regarding number of accidents or injuries due to walking stick for elderly Malaysian.

Common problem reported that chronic musculoskeletal injuries may lead to cumulative trauma disorders (CTDs). Babski and Crumpton (1997) explained the common CTDs are carpal tunnel syndrome (CTS) and cubital tunnel syndrome (CBTS) where the nerve disorder causes pain, numbness and tingling in the first and second fingers and the palm of the hand for CTS and ring and small fingers of the hand for CBTS. Other identified musculoskeletal injuries in the upper extremity are such tendonitis, vibration-induced white finger (Aldien *et al*., 2005), ischemia (Wickens *et al.,* 2004), osteoarthritis, synovitis (Nag *et al*., 2003), tenosynovitis (Eksioglu and Kizilaslan, 2008), ulnar nerve entrapment, trigger finger (Garcia-Caceres *et al*., 2012) and strained muscles (Imrhan, 2006a; Wimer *et al*., 2010).

It has been hypothesized that the factor contribute to the development of CTS, CBTS and other musculoskeletal injuries including forceful exertions accompanied by high frequency and awkward posture (Taha and Nazaruddin, 2005; Eksioglu and Kizilaslan, 2008), duration (Wu and Hsieh, 2002), wrist posture due to excessive ulnar deviation

(Kumar *et al.,* 2008), forceful grip exerted by the hand (Seo *et al*., 2007), pressure at the base of the palm (Wickens *et al.,* 2004), age, sex, previous fractures (Babski and Crumpton, 1997), hands held in fixed position over long periods, persistent strain (Garcia-Caceres *et al*., 2012), push or hand-handle contact force and large grip effort (Aldien *et al*., 2005; Wimer *et al*., 2010). In addition, slippage between the hand and work object can also result in hand injuries (Seo *et al*., 2007).

There appears to be no studies that investigate the effects of the parameters such as force grip pressure at base palm, handle contact area, age, and sex to user comfort for walking stick user's particularly elderly people in Malaysia.

1.3 Research Questions

There are five research questions in this study to answer as follows;

1. What are the effects of hand size and handle shape to contact area?
2. What are the relationship of parameters hand size and contact area to grip strength and force?
3. What are the effects of inside grip diameter to grip strength?
4. What are the effects of handle design to grip force?
5. What are the effects of different handle size and shape to user comfort?