Review

DEVELOPMENT OF AN ANTHROPOMETRY DATABASE FOR THE MALAYSIAN POPULATION: PROBLEMS AND CHALLENGES

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ABSTRACT

Ergonomics is generally to design for human use and optimizing the working and living conditions. The comfort, safety and ease of use of systems, products and machines require the principles of ergonomics to be incorporated into the design. Anthropometry is a part of ergonomics which deals with the measurement of body dimensions, its capability and limitations of the human ability. Studies have indicated that body dimensions differ for various populations, depending on ethnic group, sex and age. The measurement of physical characteristics and abilities of people provides information that is essential for the appropriate design of occupational and non- occupational environments, as well as for the design of consumer products, clothing, tools and equipment. It has been considered as the very basic core of ergonomics in an attempt to resolve the dilemma of 'fitting people to machines'. It has also been regarded as a branch of anthropology which deals with physical characteristics of the man in time and space, particularly with individual variation, ontogenesis and generic development. Knowledge about man from the point of view of physical anthropometry is very useful for the purpose of ergonomics and design. Thus it is important that an anthropometric database for each nation is developed to ensure design of products and systems are compatible with the user population. In Malaysia, many researchers have conducted anthropometric studies on various groups of people, focused on a small sample size and used for specific designs. Unfortunately, the measurements are not representatives of the population. The work has been individually based, confined to certain group of researchers in various universities and there is no concerted effort towards developing a national anthropometric database.This paper discusses some of the anthropometry work conducted in Malaysia, the problems and challenges in developing the national database, the importance of anthropometry and the roles that the government has to play in developing the database.

***Keywords:** Anthropometry, database, Malaysian, design.*

INTRODUCTION

Anthropometry is a part of ergonomics which deals with the measurement of body dimensions, its capability and limitations of the human ability. Studies have indicated that body dimensions differ for various populations, depending on ethnic group, sex and age. Rosnah and Wong[1]in their study of anthropometry found the differences between various nations. The measurement of physical characteristics and abilities of people provides information that is essential for the appropriate design of occupational and non- occupational environments, as well as for the design of consumer products, clothing, tools and equipment[2]. Anthropometry has been considered as the very basic core of ergonomics in an attempt to resolve the dilemma of 'fitting people to machines'[3]. Novak regards anthropometry as a branch of anthropology which deals with physical characteristics of the man in time and space, particularly with individual variation, ontogenesis and generic development[4]. Knowledge about man from the point of view of physical anthropometry is very useful for the purpose of ergonomics and design.

Anthropometric data is important not only for product design but also for various other applications. Studies have indicated that body dimensions differ for various populations, depending on countries[5], communities[6,] ethnic group[7], gender[8,9] and age[8,9,10].

Anthropometry, Ergonomic and Design

The word “anthropometry” is derived from the Greek words “anthropos” (man) and “metron” (measure) and means measurement of the human body[11]. Anthropometry is the science of measurement and the art of application that establishes the physical geometry, mass properties and strength capabilities of human body[12]. Anthropometrics is an important branch of ergonomics which deals with the measurement of body dimensions, its capacity and limits of human ability. Anthropometric side of ergonomics aim to match the physical form and dimensions of living or working environments or products to those of its user. Anthropometry has been considered as the very basic core of ergonomics in an attempt to resolve the dilemma of ‘fitting people to machines’[3]. Designers often fail to take into account of the variation in the physical qualities of the potential users – generalizing the population, their needs and requirements. Thus, there is the need for an ergonomic approach to designing product and equipment aimed at the well being and satisfaction of the potential users.

There are two main types of anthropometry: structural and functional[13]. Structural anthropometry (often called "static anthropometry") is the measurement of the body at rest including overall measurements like total stature and weight, measurements of links or circumferences like wrist to elbow, knee to hip, circumference of head and measurement of specific landmarks in reference to some other point, like the floor, e.g. eye height. Static anthropometry includes the measurement of assistive devices like canes and wheelchairs either alone or in relationship to the body. While Functional anthropometry (often called "dynamic anthropometry") is the measurement of the body in motion like the reach envelope of seated work, the movement of body parts in relationship to one another or the space required to turn a wheelchair. Functional anthropometry includes the measurement of assistive devices or other objects used by people as they move. It also includes measures of strength (e.g. grip or pull strength) that depend on the characteristics of a task (e.g. direction in which something is pulled or length of time that force must be held).

Generally, the use of anthropometry data in designing is based on three principles: designing for extreme individuals, designing for adjustable range and designing for the average[14]. Designing for extreme individuals is an attempt to accommodate almost all of the population. When a specific dimension or feature is a limiting factor, that limiting factor can dictate either the maximum (95^{th} percentile) or minimum (5^{th} percentile) value of the population variable is used. Certain features of equipment or facilities can be designed to be adjustable to the individuals who use them. Usually, the adjustable range covering from the 5^{th} to the 95^{th} percentile is used. Designing for the average or the 50^{th} percentile means that half of the population is excluded and thus, should be avoided unless for legitimate reasons.

Anthropometry Studies in Malaysia

Malaysian anthropometry database is very much behind in comparison to other Asian countries such as Japan and Korea. For example, the Japanese have their own national database and it is being referred to in many international applications[15]. Local product designers do not even realize that data actually exist for the local population and resolve with international anthropometry data. This is of course understandable because data exist in academic literatures and journals and not as standard or guidelines that they can get off the shelves.

Daruis et al.[16]identified many recent studies that are close to Malaysian demographics which were published recently, such as the comparison between contemporary Singaporean dataand data of 20 years ago as well as Indonesian data[17], Southern Thais industrial workers[18] and Filipino university students[19].

Nonetheless, Malaysian individual's efforts in establishing anthropometric databases are ample however they are scattered in academic literatures and remain mostly in journals. Studies are usually according to specific needs, for example, anthropometric studies for clothing design[20], health and nutrition application[21], anthropometric design for elderly[22,23,24]and anthropometric analyses and design for school children[25,26]. In engineering application, among others on driving comfort[27], whose focus was on drivers preferred postures and the development of a Malaysian anthropometric database[28,29], on seat fit parameters[16,30] and on anthropometrics data for male and female industrial workers[31]. A summary of some of the work conducted in Malaysia is shown in Table 1.

Problems in Developing a Comprehensive Malaysian Anthropometry Database

As discussed, there are studies conducted and efforts made in collecting the Malaysian anthropometric data. However, the work is fragmented, based on specific requirements of the researchers, done in a particular location with varying data being collected. Among the problems and challenges in developing the Malaysian Anthropometric database are discussed.

Lack of Research Funding

A lack of commitment and understanding from the higher authorities on the importance of anthropometric data towards designing of living spaces and products posed a major problem for Malaysian researchers to get funding. Establishing anthropometry data is not a priority in research funding allocation, even in organizations like NIOSH, Malaysia, DOSH and even SIRIM. The bulk of the research funding goes to research that has explicit products, intellectual property rights, patents and commercialism. However, when researchers acquire the funding, it has been slashed down and limited that no comprehensive work was able to be carried out.

Basically, with the limited funding, researchers were forced to limit the population sampled and often use the population in their respective universities, using university students as their subjects. More often than not, the funding comes from the University itself. The lack of funding may also limit the incentives given to the subjects and does not encourage their participation in the data collection process.

Methods of Data Collection

There is no uniformity between researchers on the method of data collection. Some work did not adequately explain how they determine the landmarks, and which guideline they use among

others. There is also a question of standardization between the methods used. The different types of clothing worn may also present variability in the measurement as subjects are measured fully-clothed. The number and kind of measurements also differs based on the specific requirements, different age group, ethnicity and even locality. Thus, the different methods used in the various studies need to be considered, validated and verified.

Representative Samples

Malaysia's population is composed of 3 major ethnic groups, the Malays being the majority, followed by the Chinese and Indians. In most studies, representative sample of each ethnic group is difficult to obtain. There are problems in communication as numerators are usually from one particular race and the unwillingness to participate. Studies have shown that there are differences in anthropometric data between races and ethnic groups. Thus, a Malaysian anthropometric database must include the representatives of each group.

Procedure of Data Measurement

Another issue when setting up Malaysian anthropometry database is the procedure of having subjects to be without their clothes or in very minimal clothing. It is just not the culture and nature of the majority and local society. Measurement over clothing is generally not recommended due to a potential increase in systematic error[32], and most large-scale anthropometry studies have strict guidelines regarding clothing[33]. Investigators who have evaluated the effects of clothing on measurements found that measurements taken with clothing were systematically larger than measurements made with no clothing[34]. Information about the size and abilities of clothed people are more realistic in the setting to which the measurements would be applied. However, contrary to prior studies, Feathers et al.[2], found that clothing did not systematically increase the measurements but reduced measurement consistency for all of the methods that they tested. Measurement made over clothing may also obstruct the landmarks from being identified clearly. This will lead to intra- and inter- observer error. Kouchi and Mochimau[35] suggested that explicit definition of landmarks in more detail might reduce the 'landmarking errors'. The differences in measurements taken based on the landmarks identified may contribute to the way anthropometric data were taken and affect their values.

Instrumentation

Most of the data were measured manually using anthropometers and other instruments. Since different numerators were used, inter and intra-data variability should be checked. Thus, it is not simply compiling the various datasets together. Also, it is time consuming and the number of body dimensions measured may also be limited. The ability of the measurers especially novices, to identify the correct landmarks with or without the clothing may also affect the readings.It is thought that the emerging of 3D body scanner helps the data collection process and gives the most accurate data[36]. However, scientists are still sceptical of the practicality of the technology[37] and there is no widely accepted protocol for 3D anthropometry[35]. It is indeed a very expensive procedure and most Malaysian researchers don't have access to such extravagance.

According Hanson et al.[38]measurement with computerised mechanism such as the body scanner would certainly produce a highly accurate data; however the downside would be inflexibility, immobility and very costly which is very true in Malaysian research set-up.

CHALLENGES

Representative Sampling

Since Malaysia is made up of various ethnic groups, the database composition must be representative of the population. Research is often done in certain areas, mostly in towns and cities and may not be adequately represented as each ethnic group is focused in certain areas.

Funding

Funding is a big issue as it requires convincing the relevant stakeholders of its importance. The national importance of an anthropometric database to the development of the nation has to be emphasised. Anthropometric database can influence the design of the workspace, house design space requirements, problems of accessibility and many more applications which are of interest to the public. This in turn can be turned into policies that are mandatory as minimum requirements.

Cooperation among the researchers

A way of coping with the limited funding is for researchers to work together. Funding may be applied individually, but work in a cooperative manner. Researchers may work independently but with coordination. Forming strategic alliances will be more synergistic.

Standardization of Measurement

Efforts must be made to develop a set of standards for measurements by developing guidelines which will be accessible to all. If all the researchers follow the same guidelines, inter and intra variability maybe reduced and compilation of all the work will be more reliable since the measurements are made under the same conditions.

Table 1 - Summary of various anthropometric studies in Malaysia

No	Title of paper	Subjects	Age	Location	Dimension	Equipment	Method
1	A study on the suitability of science laboratoryfurniture in Malaysian secondary school. *AhmadNazif* et al.[25],*Asia Pacific Symposium on Advancements in Ergonomics and Safety* (2011).	57 males and 63 females	16 – 19 years old	Government secondary school that located in Selangor	6 sitting anthropometric dimension	- Standard anthropometer set - Measurement tape	- Static anthropometry measurement. - All the measurements were taken by permanent assistants.
2	Malaysian Sitting Anthropometry for Seat Fit Parameters *Daruis et al.[16]Human Factors and Ergonomics in Manufacturing & Service Industries* (2011).	216 people	18 – 40 years old	11 states in the Malaysian Peninsula.	Stature 14 sitting anthropometric	- Local automobile seats - Anthropometer - Meter ruler - Callipers - Measuring tape	- Direct measuring methods
3	Integration of Comfort into a Driver's Car Seat Design Using Image Analysis. *Mohamad et al.[28]American Journal of Applied Science* (2010a).	- 26 males - 19 females - Driving experienc e (years)	20-30 years old		- Stature - 9 Sitting anthropometric dimensions	Different cars: - Compact A - Medium Sedan B - Premium Sedan C	- Pearson correlation using the SPSS software - Statistical analysis
4	Development of Malaysian anthropometric database. *Mohamad et al.[29]World Engineering Congress* (2010b).	- 516 males - 491 females	15-80 years old		- 40 standing and sitting - Anthropometric dimensions	- Human body measuring kit - Anthropometer for body dimension measurements	- The dimensions measured were recorded in a form - The data collection was for both standing and sitting postures
5	Neck, upper back and lower back pain and associated risk factors among primary school children. *MohdAzuan et al.[26], Journal of Applied Sciences* (2010).	- 100 children	8-11 years old	Pengkalan Hulu, Perak, Malaysia	Only standing height	- TANITA electronic weighing - Harpenden anthropometer was used to measure their standing height	- Questionnaire
6	Predictors of handgrip strength among the free living elderly in rural Pahang, Malaysia. *Moy et al.[22]Iranian Journal of Public Health* (2011).	- 434 elderly		Pahang, Malaysia	Hand	- Jamar Dynamometer	- Study location and sampling method - Data collection - Dutch Musculoskeletal Questionnaire (DMQ) - Statistical analysis
7	Anthropometry Dimensions of Older Malaysians:Comparison of Age, Gender and Ethnicity. *Rosnah, et al.[23]Asian Social Science* (2009).	- 129 males - 101 females	60 years old and above		Use anthropometric data previously collected for comparisons.		- Statistical - Package for the Social Sciences (SPSS) - T-test analysis - Chi-square analysis

8	Ageing in place: Towards an ergonomically designed home environment for older Malaysians. Sharifah Norazizan *et al.*[24]*Gerontechnology* (2006).	- 386 people		In five urban locations	40 anthropometric measurements		-	Interview
10	Anthropometric, biochemical and clinicalassessment of malnutrition in Malaysian patientswith advanced cirrhosis. *Tai et al.*[21], *Nutrition Journal*(2010).	- 36 patients	18 years and above		- 3 anthropometric data calculate - Body mass index	- Measuring tape at the right arm. - Harpenden skin fold caliper. - Hand dynamometer (JAMAR) in kilogram force (Kg/F)	- Nutritional assessment - Subjective global assessment - Statistical analysis	
11	Using Data Mining Technique to Explore Anthropometric Data towards theDevelopment of Sizing System. *Zakaria et al.*[39],*International Symposium on Information Technology ITSim* (2008).	- 629 females	7-12 years old	Selangor, Malaysia	- Body mass index - 12 anthropometric data		- Descriptive analysis of average, mean and standard deviation - Factor analysis method - Principal component analysis technique (PCA)	

CONCLUSIONS

Anthropometric data can define a country's population. Different characteristics of a population can indicate a person's origin. Though this may not be as importantas its contributionin designing work systems, products and home environment that are safer, more comfortable and healthier.

As ergonomics is gaining importance in the Malaysian society and the realisation that the lack of ergonomics is associated with musculoskeletal disorders, having an anthropometric database can provide some guidelines in designing. Using anthropometric data, design of systems, products and environment can 'fit' the population better. Designers are able to design better by taking into consideration the limitations and capabilities of the human body.

REFERENCES

1. Rosnah, MY. & Wong, OO. Development of an Anthropometric dimensions database for the Malaysian population.*ASEAN J.Sci. Technol. Develop*.1995; 12: 67-77.

2. Feathers, DJ. Paquet, VC. & Drury, CG. Measurement consistency and three-dimensional electromechanical anthropometry. *International Journal of Industrial Ergonomics* 2004; 33(3): 181–190.

3. Wang, EM. Wang, MJ. Yeh, WY. Shih, YC. Development of anthropometric work environment for Taiwanese workers, *Int. J. of Industrial Ergonomics* 1999; 23:3-8.

4. Novak, E., The role of anthropometry in design of work and life environments of the disabled population, *Int. J. of Industrial Ergonomics* 1996; 17:113-121.

5. Kotiyal, K. andTettey, S. Anthropometry for Design for the Elderly, *Int. J. Occupational Safety and Ergonomics*2001; 7(1): 15-34.

6. Ghosh, JR. Khatoon, Z.Bhattacharjee, A. &Bandyopadhyay, AR. Comparative Study on Anthropometric Variables in Two Communities of West Bengal, India. *Anthropologist* 2005; 7(3):217-219.

7. Yap, WS. Chan, CC. Chan, SP. Wang YT., Ethnic differences in anthropometry among adult Singaporean Chinese, Malays and Indians, and their effects on lung volumes, *Respir. Med.* 2001; 95(4): 297-304.

8. Perissinotto, E. Pisent, C. Sergi, G.&Grigoletto, F., Anthropometric measurements in the elderly, age and gender differences, *British Journal of Nutrition* 2002; 87(2): 177-186.

9. Rosnah, MY. Sharifah Norazizan, SAR. Nurazrul, SH.TengkuAizan, H. Ahmad, HH. Aini, MS. Lina, GSC. Lo, WC. &Mohd Rizal, H. Comparison of Elderly Anthropometry Dimensions amongst Various Population, *Asia-Pacific Journal of Public Health*2006; 18: 20-25.

10. Suriah, AR.Zalifah, MK.Zainorni, MJ.Shafawi, S.Mimie Suraya, S. Zarina, N. Wan Zainuddin, WA. Anthropometric Dimensions of the Elderly, Mal J. Nutr. 1998; 4(1/2): 55-64.

11. Bridger, RS., Introduction to ergonomics, 3rd edition, Taylor & Francis Group New York, 2009.

12. Leilanie, J. and Prado, DL. Anthropometric measurement of Filipinomanufacturing workers, *Int. J. Ind. Ergonomics* 2007; 37: 497-503.

13. Tayyari, F. and Smith, JL., Occupational ergonomics: Principles and applications. 2nd ed., Kluwer Academic Publishers, London, 2000.

14. Sanders, MS. and McCormick, EJ., Human factors inengineering and design (7th edition), McGraw-Hill, Singapore, 1992.

15. Tilley, AR., The measure of man and woman, human factors in design, John Wiley and Sons, New York, 2002.

16. Daruis, DDI. Deros, B. and Nor, M., Malaysian sitting anthropometry for seat fit parameters, *Human Factors and Ergonomics in Manufacturing & Service Industries*2011; 21(5):443-455.

17. Chuan, TC. Hartono, M. and Kumar, N. Anthropometry of the Singaporean and Indonesian populations, *International Journal of Industrial Ergonomics* 2010; 40(6): 757-766.

18. Klamklay, J. Sungkhapong, A. Yodpijit, N. and Patterson, PE. Anthropometry of the southern Thai population, *International Journal of Industrial Ergonomics*, 2008;38:111-118.

19. Del Pradu-Lu, JL. Anthropometric measurement of Filipino manufacturing

workers, *International Journal of Industrial Ergonomics* 2007; 37:497-503.

20. Zakaria, N. & Ng, LK. Replacement of the manual anthropometric survey management into Web based environment: the case of children sizing system development. Manuscript send to IEEE Colloquium on Humanities, Science and Engineering (CHUSER) conference. 5-6 December, Penang, Malaysia, 2011.

21. Tai, Mei-Ling, S. Goh, KL. MohdTaib, SH. Rampal, S. and Mahadeva, S., Anthropometric, biochemical and clinical assessment of malnutrition in Malaysian patients with advanced cirrhosis, *Nutrition Journal*2010; 9(27): 2-7.

22. Moy, FM. Chang, EWH. andKee, KW. Predictors of handgrip strength among the free living elderly in rural Pahang, Malaysia, *Iranian Journal of Public Health* 2011;40(4): 44-53.

23. Rosnah, MY. Mohd Rizal H. and Sharifah Norazizan, SAR. Anthropometry dimensions of older Malaysians: comparison of age, gender and ethnicity, *Asian Social Science* 2009; 5(6): 133-140.

24. Sharifah Norazizan, SAR. Rosnah, MY. TengkuAizan, H. Lina, GSC.andMohd Rizal, H., Ageing in place: towards an ergonomically designed home environment for older Malaysians, *Gerontechnology* 2006; 5(2): 92-98.

25. Ahmad Nazif, NK. Ezrin Hani, S. Lee, CK. and Ahmad Rasdan, I., A study on the suitability of science laboratory furniture in Malaysian secondary school, Asia Pacific Symposium on Advancements in Ergonomics and Safety (Ergosym2011), 5-6 December, Perlis, Malaysia, (2011).

26. MohdAzuan, K. Zailina, H. Shamsul, BMT. NurulAsyiqin, MA. MohdAzhar, MN. and SyazwanAizat, I. Neck, upper back and lower back pain and associated risk factors among primary school children, *Journal of Applied Sciences*2010; 10(5): 431-435.

27. Mohamad SyafiqAizat, H. Raja Ariffin, RG.andMirtaWidia, Pilot Investigation on the Driving Posture Comfort among Malaysian Drivers, *Advanced Materials Research*2012; 605-607:466-471.

28. Mohamad, D. Deros, BM. Wahab, DA. Daruis, DDI. and Ismail, AR., Integration of comfort into a driver's car seat design using image analysis, *American Journal of Applied Science* 2010a; 7(7): 924-929.

29. Mohamad, D.,Deros, BM. Ismail, AR. and Daruis, DDI., Development of Malaysian anthropometric database, World Engineering Congress, 2-5 August, Kuching, Sarawak, Malaysia. (2010b).

30. Daruis, DDI. Deros, BM. and Nor, MJM. Understanding the effect of noise, vibration and seat discomfort towards a passenger's vehicle driver through self-reported survey, *JurnalTeknologi* 2008;49(A):39-53.

31. Taha, Z. Nazaruddin, I. Ghazilla, RA. And Syed Salim Agha, SS. Anthropometrics Data of Malaysian Industrial Workers, 6th Pan Pacific Conference on Occupational Ergonomics Beijing China, 2001.

32. Roebuck, JA. Kroemer, KHE. Thomson, WG. Engineering Anthropometry Methods, Wiley, New York, 1975.

33. Gordon, C. Bradtmiller, B. Clauser, C. Churchill, T. McConville, J.Tebbetts, I. Walker, R., Anthropometric Survey of US Army Personnel: Methods and Summary Statistics, Technical Report (TR-89/027) (ADA209600), US Army Natick Research, Development and Engineering Center, Natick, MA. (1989).

34. Paquette, S. Case, HW.Annis, JF. Mayfield, TL. Kristensen, S. Mountjoy, DN. The Effects of Multi Layered Military Clothing Ensembles on Body Size: A Pilot Study. US Soldier and Biological Chemical Command Soldier Systems Center, Natick, MA. (1999).

35. Kouchi, M. and Mochimaru, M. Errors in landmarking and the evaluation of the accuracy of traditional and 3D anthropometry, *Applied Ergonomics* 2011;42(3): 518-527.

36. Robinette, KM. and Hudson, JA. Anthropometry, In the Handbook of human factors and Ergonomics,Salvendy, G. (Ed.) Hoboken: John Wiley & Sons, 2006.

37. Hsiao, H. Anthropometric procedures for protective equipment sizing and design, Human Factors 2012; 55(1): 6-35.

38. Hanson, L. Sperling, L. Gard, G. Ipsen, S. and Vergara, CO., Swedish anthropometrics for product and

workplace design, *Applied Ergonomics* 2009; 40(4): 797-806.

39. Zakaria, N., Mohd, J. S., Taib, N., Tan, Y. Y., &Wah, Y. B. Using data mining technique to explore anthropometric data towards the development of sizing system. In *Information Technology, 2008. ITSim 2008. International Symposium on* (Vol. 2, pp. 1-7). IEEE.