Pertanika J. Sci. & Technol. 21 (1): 15 - 28 (2013)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Application of Anthropometric Dimensions for Estimating Stove Height, Stove Depth and Cooking Task Envelope for Malaysian Elderly Population

Ruhaizin Sulaiman[1]*, Zahari Taha[2] and Siti Zawiah Md. Dawal[3]

[1]*Department of Industrial Design, Faculty of Design & Architecture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*

[2]*Department of Manufacturing Engineering, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang, Malaysia*

[3]*Centre for Product Design and Manufacturing (CPDM), Department of Engineering Design and Manufacturing, Faculty of Engineering, University of Malaya, Lembah Pantai, 50603 Kuala Lumpur, Malaysia*

ABSTRACT

Elderly are exposed to physical impairment. This has a strong impact on their daily activities including frying, which is one of the most popular cuisine preparations. The stove height and work envelope are two major ergonomic issues in performing cooking task. There has been little research focusing on Malaysian elderly task performing in addressing these issues. The objectives of this study were to identify the acceptable stove height and depth and to determine the working envelope among Malaysian elderly using anthropometric data. A total of 55 Malaysian elderly (25 male and 30 female) aged between 60 to 85 years participated in this study. Five body measurements were taken from each subject using an anthropometer. The measurements are stature height, shoulder height, arm span, arm reach forward and waist height. Apart from these anthropometric measurements, their present stove height was also measured. The acquisition of stove height dimensions was performed through a series of door to door visit of the elderly homes in Kg. Sg. Merab. These variables were used to estimate the elderly working envelope and determine the stove height, width and depth. Data were analysed using SPSS software. The waist height dimension was to estimate the stove height, the arm reach forward for the depth and the arm span for the length of the table-top where the stove was placed. Meanwhile the stature and shoulder height were used for estimating the position of the overhead compartment or placement of cooking utensils. The 5th percentile was chosen since it is appropriate to accommodate 90% of the studied population. The 5th percentile was also applied for the setting of the working envelope so as to provide better reaching tolerances. Meanwhile, standard was used to compare the present state of the studied kitchen setting. The results show that 56.4% of the elderly waist height is lower than the standard table-top height which is 36 inches (91.4cm) and 36.4% of

Article history:
Received: 4 November 2010
Accepted: 4 April 2011

E-mail addresses:
ruhaizin@putra.upm.edu.my (Ruhaizin Sulaiman),
ztr.motion@googlemail.com (Zahari Taha),
sitizawiahmd@um.edu.my (Siti Zawiah Md. Dawal)
*Corresponding Author

ISSN: 0128-7680

the stove height was found higher than that of the standard. This could apparently cause fatigue and discomfort to shoulders, the neck, the arm and the back of the user. Anthropometrics measurements can be used for estimating the stove height, length and depth. These could also calculate a space taken for certain physical activities, such as frying task envelope. Providing a good combination of stove height, length, depth and ergonomic working envelope could hopefully improve the elderly cooking task and increase their quality of life.

Keywords: Elderly, fatigue, discomfort, ergonomic working envelope, quality of life

---

INTRODUCTION

Physical dimensions and human movement are significant to a space they occupy in any performance of task. This human anthropometrics is also very useful as a guideline in designing products, equipment, furniture, transport or even buildings.

Anthropometry means the study of human body measurement for use in anthropological classification and comparison (Answer.com, 2010). Work envelope, on the other hand, means a space which can cater part or the whole human body movement when performing certain tasks. In this paper, the investigation was carried out based on standing work posture and the work envelope derived from the anthropometrics measurements of the elderly. There are other methods of assessing working posture, such as Rapid Entire Body Assessment (REBA) by Hignett (1998), McAtamney and Hignett (1995), or Rapid Upper Limb Assessment (RULA) by McAtamney and Corlett (1993); nonetheless, these will not be discussed further in this paper.

Working in a kitchen could be an issue for some elderly, especially when preparing their meal. This is due to shrunk cartilage throughout the spine that begs their standing strength ability and endurance. The posture among the aged also has a slumped character that could limit the movement (Tilley, 2008). According to Opila *et al*. (1988), line of gravity is forward of the spine (L4-5), i.e. the body has a forward bending moment which is counterbalanced by ligament forces and back muscle forces. If the body centre gravity is moved forward, it causes a variety of biomechanical stresses while standing or walking (Lee *et al*., 2001). Another factor is the 50% reduction of leg strength (Tilley, 2008) which decreases the elderly standing endurance and this may require them to use supportive instrument, such as canes, tripod aids, walkers, or even chair when performing cooking task.

Ecologically, elderly are exposed to breakdown of functional impairments. These include changes in anthropometry, musculoskeletal attributes, respiration and circulation, nervous functions, capacity for physical work, brain and memory, visual functions, hearing, taste and smell, as well as sensitivity and also sensory and psychomotor performance (Taha & Ruhaizin, 2010). These factors have negative impacts on their performance in instrumental activities of daily living (IADL) or even the basic activities of daily living (BADL). In a household setting, a task such as opening a can of red beans is considered far more complex than cellular or molecular mechanisms of aging due to complex body and environmental systems involved. Some surveys conducted show that older populations (65+) have greater difficulty in performing one or more common self-care activities, such as eating, using the toilet, dress, bathing, or

preparing meals in the kitchen (Dawson *et al*., 1987; AARP, 2000; Taha & Ruhaizin, 2008).

Cooking task is normally performed in a standing posture. This is because ordinary meal preparation requires high physical mobility between a work-triangle. The performers in this case, who are the elderly, will have to stand and use both their hands while performing the task regardless of whether they are right-, or left-handed. The dominant hand normally performs the main task and is supported by the other hand. For example, a right-handed user holds the ladle with his right hand while the left hand will hold and stabilise the frying pan caused by forces of stirring.

Besides physical frailty, the other factors effecting cooking performance are the height of the stove and work-top. For example, the incorrect height of the table-top could contribute to shoulder fatigue, neck pain, back pain and elbow pain after completing the task. The actual frying task normally requires higher hand rising due to additional stove height and the height of the frying pan. Furthermore, the ladle set used for mixing the cuisine could also add-up the height of hand rising and make the situation worst. Although providing stepping stool for

Fig.1: The height of the stove is higher than the subject's waist height.

Fig.2: Subject's arm could easily rise-up close to his shoulder height while stirring.

Fig.3: The stove is too low than the subject's waist height. Bending the neck exceeding 20 degree could cause neck fatigue.

Fig.4: The arm is lifted above the shoulder height. This contributes to shoulder pain and arm fatigue.

shorter persons may overcome this problem, this is merely a short-term solution and can still contribute to accident in the kitchen.

Fig.1, Fig.2, Fig.3 and Fig.4 illustrate the subjects performing frying task in their kitchen settings. Each figure shows a different ratio between the subject's waist height and the height of the stove. In particular, both Fig.1 and Fig.4 show that the table-top is too high. It is clear that the pan is higher than the subject's elbow height. This position may cause shoulder discomfort or fatigue. Meanwhile, Fig.3 illustrates that the tabletop level is far below the waist height, and this position forces the subject to tilt her neck down. As shown in Fig.5, the neck flexion angle should not exceed the range between 0-20 degrees to prevent neck fatigue.

Some of the examples above show that incorrect stove height could contribute to musculoskeletal disorder, primarily on the shoulder and the neck. Pain on the elbow is also reported at times. Konz and Johnson (2004) stated that musculoskeletal disorder is also known as occupational cerviobrachial disorder (OCD) and upper limb disorder (ULD). If an elderly is diagnosed of having this disorder, the chances to come back to a normal healthy state are very slim or there is no chance for it at all. He or she will definitely depend on others for the rest of his or her life.

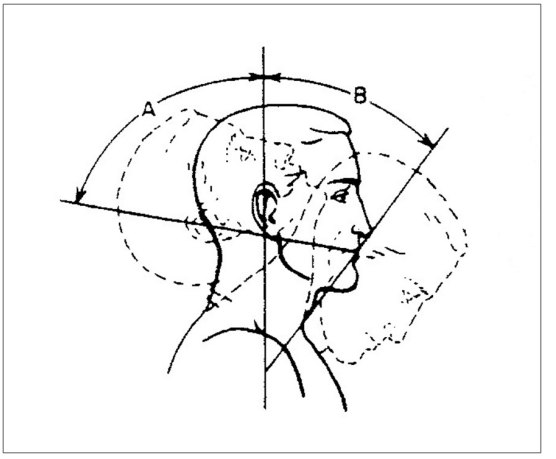

Fig.5: The Neck Extension (A) and Flexion (B) (Source: FAA William J. Hughes Technical Centre) (Exhibit 14.3.3.2.1 Joint movement ranges)

Therefore, greater focus on elderly anthropometrics measurement, their working envelopes, and the kitchens stove height should be investigated. This paper presents the result of a study on the elderly stoves height and their nature of working envelopes in everyday cooking task.

The most common height for a kitchen counter top is 36 inches (or 91.4cm). Premade based cabinets are designed for this finished height. Thus, the height of 36 inches (91.4cm) is typically the optimal and most ergonomic height for a kitchen counter. It may not be the best for a specific task, but it is apparently the best overall compromise for the majority of tasks done in the kitchen. For most people, a kitchen counter top height of 36 inches (91.4cm) provides a comfortable work station. Extremely short or tall people, or those with special needs, may want to modify that height to better suit their needs (About.com, 2008).

According to the National Kitchen and Bath Association (NKBA), the minimum height of the first level, which is 28 inches (71cm), shows that it is fully complied for the elderly requirement. On the other hand, the maximum height of the second level, which is 45 inches (114cm), is too high for Malaysian elderly.

According to Peterson (1998) and Tilley (2002), the standard kitchen cabinet height is 36 inches (91.4cm) and 24 inches (61cm) deep. NKBA has proposed two level ranges of work-counter heights. One is 28 inches (71cm) to 36 inches (91.4cm) above the finished floor and the second is 36 inches (91cm) to 45 inches (114cm), (Krengel, 1997).

METHOD AND INSTRUMENT

Anthropometrics measurement

A total of 55 Malaysian elderly (25 males and 30 females) aged between 60 to 85 years, with the mean age of 66.98 years, participated in the anthropometrics measurement of this study. The subjects were pooled in a community hall for a briefing on the objectives of the research and the procedures of the data acquisition. Basic subjects' background information, such as name, age, health status, gender and address, was also recorded for demographic purposes.

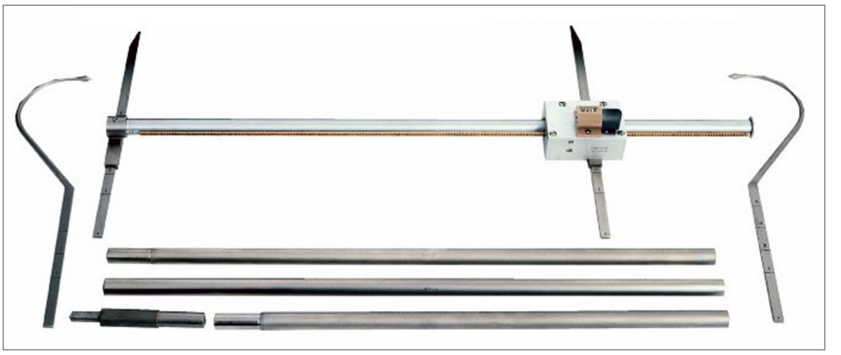

Fig.6: Instrument used to acquire anthropometric data

Five body dimensions were measured on each individual elderly during the session. These include stature (standing height), shoulder height, arm span, arm reach forward and waist height. The *"anthropometer"* is the main instrumental set used in the data acquisition (see Fig.6). Each measurement was taken 3 times and the average was recorded for statistical analysis.

Measuring the Table-top, Stove and Frying Pan Height

The acquisition of these measurements was performed through a series of door-to-door visit of 55 elderly homes in Kg. Sg. Merab. These data are important to evaluate the existing kitchen settings and to compare those with the present guidelines or standard, as well as the relation with the elderly anthropometrics. Each of the table-top, stove and pan heights, as well as the depth of their kitchen worktops, was measured using an ordinary measuring tape. The data were analysed using SPSS software.

Fig.7, Fig.8, Fig.9, Fig.10 and Fig.11 show the acquired anthropometrics measurements in this study.

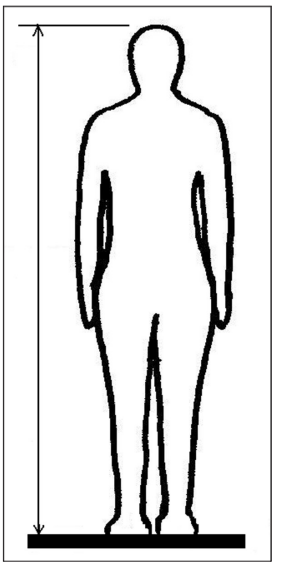

Fig.7: Stature height

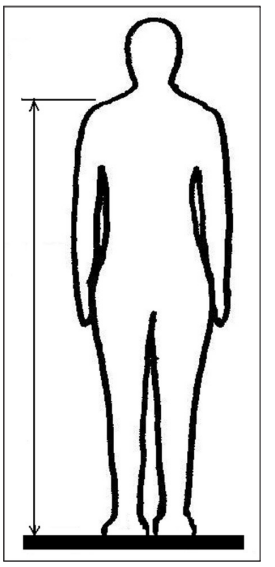

Fig.8: Shoulder height

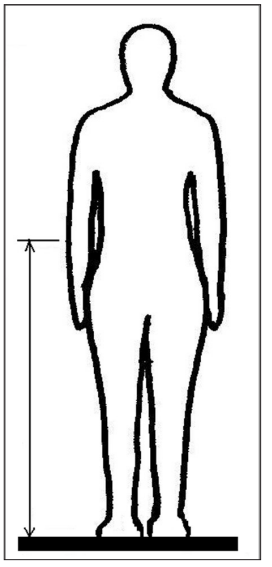

Fig.9: Waist height

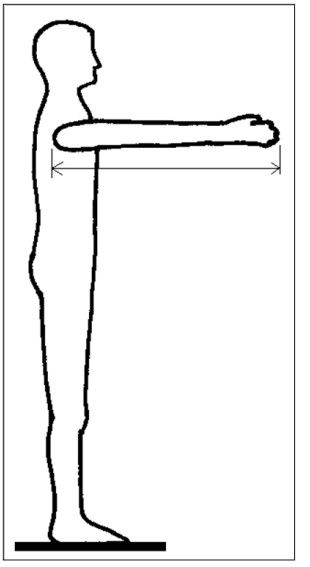

Fig .10: Arm reach forward

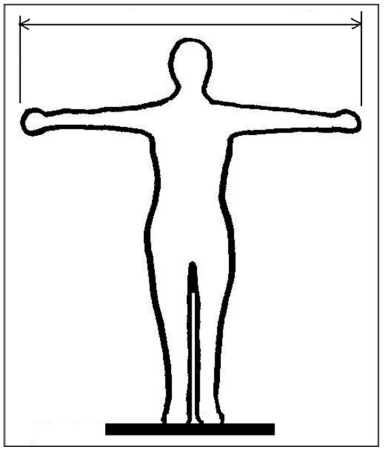

Fig.11: Arm span

RESULTS AND DISCUSSION

The anthropometrics data acquisition involved 5 measurements, and these included stature height, shoulder height, arm span, arm reach forward and waist height. The other variable is stove height. The statistical results are shown in Table 1 to Table 8 as well as Fig.7 to Fig.12. Table 9, on the other hand, shows the comparison with the previous findings.

The Stove Height

The 'stove height' is a dimension measured from the floor to the top of the stove. This includes table or cabinet where the stove is placed on. The results are in Tables 1, and 2, as well as in Fig.12. Table 2 shows that 36.4% of the stove height is higher than 36 inches (91.4cm) which is as suggested by NKBA.

TABLE 1: Statistics of the stove height

Stove Height

N	Valid	55
	Missing	0
Mean		87.5709
Std. Deviation		7.10870
Minimum		73.60
Maximum		99.00
Percentiles	5	74.6400
	50	86.3000
	95	99.0000

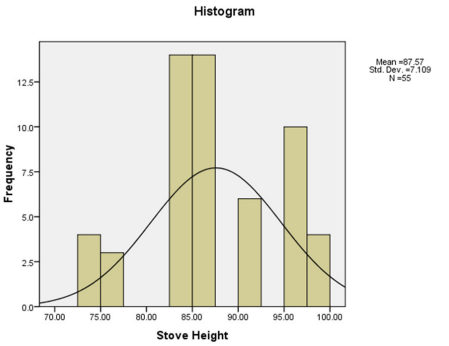

Fig.12: Frequency of the height of stoves

TABLE 2: Frequency of the height of stoves

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	73.6	2	3.6	3.6	3.6
	74.9	2	3.6	3.6	7.3
	76.2	3	5.5	5.5	12.7
	83.8	14	25.5	25.5	38.2
	86.3	14	25.5	25.5	63.6
	91.4	6	10.9	10.9	74.5
	96.5	10	18.2	18.2	92.7
	99	4	7.3	7.3	100.0
	Total	55	100.0	100.0	

TABLE 3: Statistics of waist height

Waist Height

N	Valid	55.0000
	Missing	.0000
Mean		90.0491
Std. Deviation		4.3723
Minimum		81.0000
Maximum		101.0000
Percentiles	5	82.6000
	50	90.0000
	95	96.6000

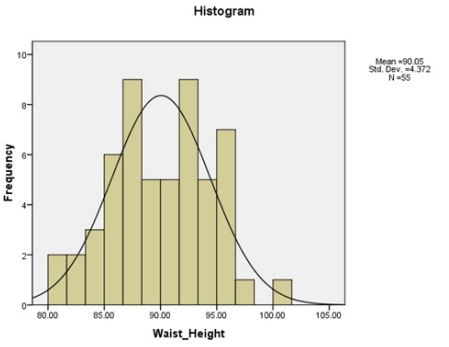

Fig.13: Frequency of waist height

TABLE 4: Frequency of waist height

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	81	2	3.6	3.6	3.6
	83	1	1.8	1.8	5.5
	83.2	1	1.8	1.8	7.3
	84	1	1.8	1.8	9.1
	84.2	1	1.8	1.8	10.9
	84.5	1	1.8	1.8	12.7
	85	1	1.8	1.8	14.5
	85.1	1	1.8	1.8	16.4
	85.8	1	1.8	1.8	18.2
	86.4	1	1.8	1.8	20.0
	86.5	2	3.6	3.6	23.6
	87	1	1.8	1.8	25.5
	87.2	1	1.8	1.8	27.3
	87.5	2	3.6	3.6	30.9
	87.8	1	1.8	1.8	32.7
	88	4	7.3	7.3	40.0
	88.8	1	1.8	1.8	41.8
	89	2	3.6	3.6	45.5
	89.5	1	1.8	1.8	47.3
	89.6	1	1.8	1.8	49.1
	90	1	1.8	1.8	50.9
	91	3	5.5	5.5	56.4
	91.4	1	1.8	1.8	58.2
	92	3	5.5	5.5	63.6
	92.1	1	1.8	1.8	65.5
	92.2	1	1.8	1.8	67.3
	92.5	2	3.6	3.6	70.9
	92.7	1	1.8	1.8	72.7
	93	1	1.8	1.8	74.5
	93.5	1	1.8	1.8	76.4
	93.8	2	3.6	3.6	80.0
	93.9	1	1.8	1.8	81.8
	94.5	1	1.8	1.8	83.6
	95	1	1.8	1.8	85.5
	95.1	1	1.8	1.8	87.3
	95.2	1	1.8	1.8	89.1
	95.5	2	3.6	3.6	92.7
	95.9	1	1.8	1.8	94.5
	96.5	1	1.8	1.8	96.4
	97	1	1.8	1.8	98.2
	101	1	1.8	1.8	100.0
	Total	55	100.0	100.0	

Tables 3 and 4, as well as Fig.13, show the results of the waist height of the elderly. It was found that 56.4% of the waist height of the elderly is lower than 36 inches (91.4cm).

Referring to the heights of both the stoves and the waist, it was found that Malaysian elderly are working on a higher work-top, and therefore, they are exposed to discomfort and fatigue.

The recommended stove height for Malaysian elderly is 82.6cm (32.5 inches). This is a little bit higher than the height of countertop for seated user which is between 28 – 32 inches (71cm – 81.3cm), as suggested by Peterson (1998). In order to fulfil the majority of the elderly stove height requirement, a range of stove height is more significant and it should be established. The 5th percentile of both the stove height (74.6cm) and waist height (82.6cm) could accommodate 90% of the studied population. Therefore, the recommended range of stove height should be from 74.6 - 82.6cm (or 29.4 - 32.5 inches).

The Working Envelope

All the variables (namely, stature height, shoulder height, arm span, arm reach forward and waist height) were measured and analysed to identify the elderly working envelopes. The *stature* and *shoulder height* were meant for setting the overhead compartment height. Meanwhile, the *arm span* dimension is to set the width of kitchen cabinet and considering the left and right reaching. The *arm reach forward* is to set the work-top depth and the frontal reaching. Meanwhile, the *waist height* is to set the height of the work-top. In this study, the working envelope was calculated based on the 5th percentile of the above variables so as to ensure that the space fit most subjects. Table 5 shows that the arm reach forward is 67.28cm (26.7 inches), while Fig.14 reveals the frequency of arm reach forward. Table 6 shows that the height envelope is 138.14cm (or 54.4 inches). Meanwhile, the arm span (see Table 7) is 142.6cm (or 56.1 inches). Table 8 shows the results of the shoulder height at 114.2cm (or 45.0 inches).

The results of the arm span presented in Table 7 and Fig.16 are to identify the minimum length of the work-top. All the visited kitchens have a longer table top and this comply with the anthropometric of the studied population.

TABLE 5: Statistics of arm reach forward

ArmReach_Forward

N	Valid	55.0000
	Missing	.0000
Mean		76.1964
Std. Deviation		4.8223
Minimum		66.8000
Maximum		89.5000
Percentiles	5	67.2800
	50	76.0000
	95	85.5200

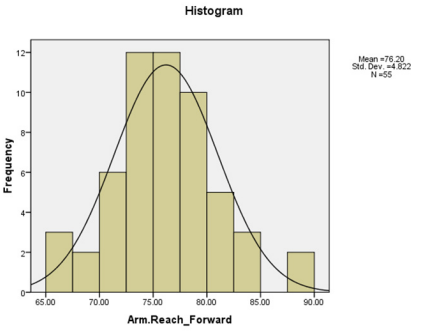

Fig.14: Frequency of arm reach forward

TABLE 6: Statistics of stature height

Height

N	Valid	55.0000
	Missing	.0000
Mean		149.8055
Std. Deviation		7.4186
Minimum		135.0000
Maximum		167.4000
Percentiles	5	138.1400
	50	150.0000
	95	163.7600

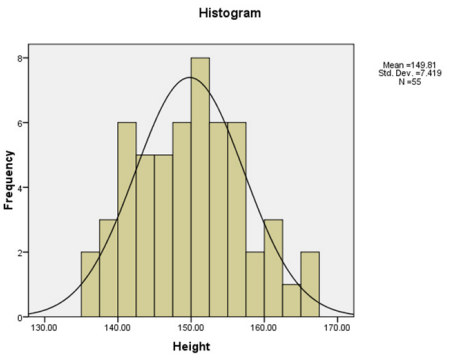

Fig.15: Frequency of the stature height

TABLE 7: Statistics of arm span

Arm Span

N	Valid	55.0000
	Missing	.0000
Mean		155.8782
Std. Deviation		8.1482
Minimum		134.8000
Maximum		172.8000
Percentiles	5	142.6000
	50	155.6000
	95	170.2600

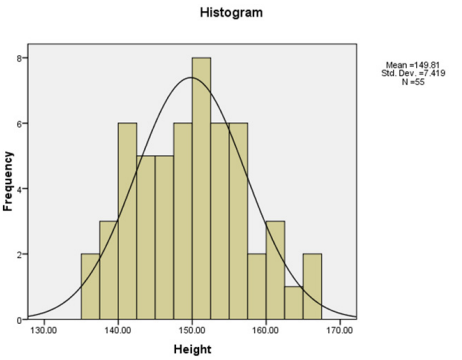

Fig.16: Frequency of arm span

TABLE 8: Statistics of Shoulder Height

Shoulder Height

N	Valid	55.0000
	Missing	.0000
Mean		125.0109
Std. Deviation		6.5600
Minimum		111.5000
Maximum		141.6000
Percentiles	5	114.2000
	50	124.5000
	95	136.3200

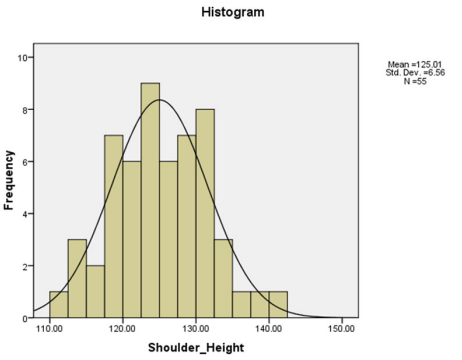

Fig.17: Frequency of shoulder height

According to Hignett and McAtamney (2000), the good work envelope should consider the limitations of body movements and measurements. Trunk flexion is within 0-20 degree and extension may reach 60 degree. Meanwhile, the neck movement is within 0-20 degree in flexion and extension. The knees flexion is within 30-60 degrees. The upper arm extension is within 20 degree, while the flexion may be up to 90 degree and over. The lower arms flex is between 60-100 degrees and over. As for the wrist movement, it is 0-15 degree, either in flexion or extension. Following these setting could avoid illness or syndrome from bad working envelope.

According to Grey (1997), there are two worktop heights. One is for the use of small appliances which is 17-25cm (7-10inches) lower than the elbow height. The other is 5-10cm (3-4inches) below the users' flexed elbow height while work on food preparation.

On the other hand, Sharifah Norazizan *et al*. (2006) also measured the elderly elbow height and found that the mean of Malaysian elderly elbow height is 89.20cm for the females and this is 97.10 cm for the males. The average for both the means is 93.15cm. Therefore, the stove height for both genders is 68.15-76.15cm and the worktop height is 83.15-88.15cm based on Grey's tolerances.

Table 9 shows the estimating dimension of stove deep. In contrast with the high reach and easy reach dimensions, the 5th percentile was used. This was done to ensure the optimum reach for majority of the studied population. Meanwhile, Woodson *et al*. (1992) stated that the counter width or deep dimensions should be between 16-24 inches (or 40.64 - 60.96cm). It was found that the proposed width or depth dimension (60.00-70.00cm) was above that of Woodson's findings.

Both the variables in this study are important in the sense of user friendly task performing and the recommended values should met requirement for most of the user populations, i.e. the 'design for the tall accommodates the small (Konz & Johnson, 2004).

CONCLUSION

Anthropometric measurements can be used to estimate the work envelope as well as to suggest the stove height, depth and length dimensions. It is also crucial for Malaysian elderly to have the right working envelope setting to avoid fatigue which could further contribute to musculoskeletal disorder (MSD) problem in the long-term. Besides, this could also improve safety, especially to avoid kitchen accident during meal preparations. It is suggested to further investigate other ADL or IADL tasks envelope and compare it with the anthropometrics of Malaysian elderly in order to improve their task performance and quality of life.

Moreover, the future kitchen furniture design should incorporate ergonomics consideration, specifically the height and reaching distance of the users. The recommendations are stated in the last column of Table 9. In more specific, providing an ideal or custom stove length, width and height will hopefully reduce ergonomics issues of cooking and ensure user's comfort. In order to accommodate 90% of the elderly population, the 5th percentile of their waist height, arm span and arm reach forward data were used as the reference point for designing the stove height, length and depth. On the other hand, the elderly should also be exposed to a good meal preparation practice and basic understanding on ergonomics. According to Saxon and Etten (2002), the gerogogy approach of teaching should be adapted to the elderly so as to increase their

ergonomics awareness towards performing any BADL, ADL and IADL. A good understanding and realization of self physical and physiological limitations may also help the elderly reduces exhaustion, muscle pain, eliminate fatigue and so forth upon completing certain tasks. It is hoped this doing this will further increase their independency and improve their well being.

TABLE 9: A Comparison of the Standing Work Envelope

	SAE (1977)	Grey (1997) tolerance	NKBA & Krengel (1997)	Peterson (1998) & Tilley (2002)	Sharifah Norazizan et. al. (2006)	Finding 5th tile (2010)	Proposed dimensions
Elbow Height (cm)	104.00	-	-	-	93.15	-	-
Table -top Height (cm)	91.50	5-10cm Below Elbow height	91.00 – 114.00	91.00	83.15 – 88.15*	-	-
Stove Height (cm)	-	17-25cm Below Elbow height	71.00 – 91.00	-	68.15 – 76.15*	74.64	74.60 - 82.60
Stove Depth (cm)	76.00	60.00cm (based on shelf depth)	-	61.00	-	67.28	60.00 – 70.00
Stove Length (cm)	-	-	-	-	-	-	Minimum 142.60

* Estimating using Grey's tolerances.

REFERENCES

Dawson, D., Hendershot, G., & Fulton, J. (1987). *Functional Limitations of Individuals Age 65 Years and Over*, Advanced Data, Vital and Health Statistics No. 133. US Public Health Service, Hyattsville, MD, June 10.

Grey, J. (1997). *Home Design Workbooks: Kitchen*. London: Dorling Kindersley Limited.

Hignett, S., & McAtamney, L. (2000). Rapid Entire Body Assessment (REBA). *Applied Ergonomics, 31*, 201-205.

Konz, S., & Johnson, S. (2004). *Work Design: Occupational Ergonomics* (6th ed). Arizona: Holcomb Hathaway Publishers.

Krengel, J. W., & Baczynski, B. (1997). *Kitchens, Lifestyle and design.* Glen Cove, N.Y.: PBC International Inc.

Lee, C-M, Jeong, E-H, & Freivalds, A. (2001). Biomechanical effects of wearing high-heeled shoes. *Int. J. Of Ind. Ergonomics*, *28*, 321-326.

McAtamney, L., & Corlett, N. (1993). RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*, *24*(2), 91-99.

Opila, K., Wagner, S., Schiowitz, S., & Chen, J. (1988). Postural alignment in barefoot and high-heeled stance. *Spine*, *13*(5), 542-547.

Peterson, M. J. (1998). *Universal kitchen and bathroom planning*. New York: McGraw-Hill.

Saxon, S. V., & Etten, M. J. (2002). *Physical Change and Aging: A Guide for the Helping Professions* (4th ed). New York: Springer Publishing Company, Inc.

Sharifah Norazizan, S. A. R., Rosnah, M. Y., Tengku Aizan, H., Ahmad Hariza, H., Aini, M. S., Mohd Rizal, H., Hirfarizan Mardianah, M. T., & Lina, G. S. C. (2006). Anthropometric data of older Malaysians. *Asia Pacific Journal of Public Health*. *18*.

Taha, Z., & Ruhaizin, S. (2008). *Ergonomics Consideration in the Design of Products for the Elderly Population.* Proceedings of the 9th Asia Pacific Industrial Engineering & Management Systems Conference (APIEMS2008) (p. 309), Bali, Indonesia, December 3rd – 5th.

Taha, Z., & Ruhaizin, S. (2010). Perceived Kitchen Environment among Malaysian Elderly. *American Journal of Engineering and Applied Sciences 3*(2), 270-276.

Tilley, A. R. (2002). *The Measure of Man and Woman: Human Factors in Design*. New York: John Wiley & Sons, Inc.

Wagner, D., Birt, J. A., Snyder, M., & Duncanson, J. P. (1996). *Human Factors Design Guide: for acquisition of Commercial-Off-The-Shelf Subsystems, Non-developmental Items, and Developmental Systems*. *Final Report and Guide*. FAA William J. Hughes Technical Center, USA. DOT/FAA/CT-96/1

Woodson, W. E., Tillman, B., & Tillman, P. (19920. Human Factors Design Handbook (2nd ed.) New York: McGraw-Hill, Inc.