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Elderly Anthropometrics for Ergonomic Purposes

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Abstract

Researchers have been more interested in the working population hoping to make the work more effective, more comfortable and more productive. Populations outside the work age such as children and the elderly have not been extensively studied especially in developing countries. In this study, anthropometric measurements were taken from a sample of the elderly in Bahrain to assess their body physique, and to provide anthropometric data that can be used in the design of products for them. In this regard, 39 body measurements were taken (age, weight, 08 standing heights, 3 lengths, 3 sitting heights, 11 circumferences, 2 skin-fold measurements, 2 hand measurements, 2 foot measurements, 2 anthropometric Indices, and 2 strength measurements). Results showed that Bahraini elderly were both overweight (males) and obese (females). In addition, there were statistical differences between gender groups and between age groups. Also there was a clear difference between the Bahraini elderly and elderly from international countries. Finally, some light was shed on the design of products for the elderly.

Keywords: anthropometric measurements, elderly, developing countries, Bahrain.

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أنثروبومتريا المسنين للأغراض الأرغونومية

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الملخص

كان الباحثون ولا يزالون مهتمين بدراسة من هو قادر على العمل أملا في الحصول على المزيد من الإنتاج. أما من يفتقدون إلى القدرة على العمل كالأطفال والمسنين، فلم يحظوا بالدراسة بالقدر الكافي وخاصة في البلدان النامية. لهذا، فقد تم في هذه الدراسة، أخذ القياسات الأنثروبومترية من عينة من المسنين البحرينين لتسليط الضوء على بنيتهم الفيزيقية ولتقديم بيانات أنثروبومترية يمكن استخدامها في تصميم ما يستخدمه هؤلاء الأفراد من أدوات. في هذا الصدد، تم قياس ٣٩ بعدا جسميا تمثلت في السن والوزن وثمانية ارتفاعات في الجلوس وثلاثة أطوال أثناء الوقوف وثلاثة أطوال أثناء الجلوس وأحد عشر محيطا وقياسان لسمك الجلد وقياسان لليد وقياسان للقدم، ومؤشران أنثروبومتريان وقياسان لقوة قبضة اليد. بينت النتائج أن المسنين البحرينيين الذكور يعانون فرط الوزن، بينما تعاني الإناث السمنة. ولم يكن ثمة فروق جوهرية بين الذكور والإناث وبين فئات العمر، لكن كانت ثمة فروق جوهرية بين المسنين البحرينين وغيرهم من مسني الجنسيات الأخرى.

الكلمات المفتاحية: القياسات الأنثروبومترية، المسنون، البلدان النامية، البحرين.

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1. Introduction

The demographics of the world population have considerably changed. People are getting healthier, and living longer. The elderly people have also become a large group in society. According to the United Nations Department of Economic and Social Affairs, it is estimated that the number of elderly in the world surpasses 700 million. In 1950, the population aged 60 years or over reached about 200 million. While, in 2000, the elderly population was about 600 million. In 2006, the number had surpassed 700 million. And by 2050, 2 billion older persons are projected to be alive, implying that their number would have tripled over a period of 50 years (United Nations, 2006).

This increase may be attributed to various factors, such as developed health care programmes, balanced food supplies, persistently low fertility and continuously increasing number of survivors to higher ages. Winn and Ilmarinen predict the working population over 50 years of age will explode during the next 25 years, and argue that the work force will soon comprise approximately 35% of bridge employment workers (50 – 64 years) and only 17% of younger workers (15 – 24 years), (Winn and Ilmarinen, 2000).

Having known that older ages continue to increase, we see a clear change in the area of work, and the development of bridge employment. Bridge employment refers to the work an individual takes up after retirement from career work. It is called bridge employment because it bridges between first retirement and final retirement (stopping completely the work). Quinn defined bridge employment as a part-time or short-duration job that occurs between full-time career employment and complete labor force withdrawal (Quinn, 2002). It acts as a transition between long-term career positions

and total retirement. It is well documented that with aging many physical and physiological changes take place in elderly bodies, hence using data from other populations (e.g adults) for design purposes is not applicable (Rosnah, Mohd Rizal, and Sharifah Norazizan, 2009). The most obvious changes are:

Physical changes: Hettinger mentioned that, by the age of 65, about 70% of the strength that a person had at his/ her youthful peak from 25 to 30 (Hettinger, 1960). Also, all sight aspects deteriorate. The ability of eyes to focus on objects (accommodation) declines. This is due to the loss of elasticity in the lens of the eye. Furthermore, approximately one-third of 65-74 year old people have hearing problems mainly hearing loss. Besides, at old age, motor skills (manual dexterity and tactile feedback) deteriorate, and reaction time decreases. Balance is also reduced by the same age. Other body composition features associated with aging are the distribution of fat, a decreased elasticity of the skin, the atrophy of subcutaneous adiposities resulting in increasing tissue compression (Lipski, et al. 1993).

Physiological changes: By the age of 65 years old, 40 percent decrease in oxygen exchange, 25 percent decrease in respiratory system function, a decrease of 15-20 percent in the function of cardiovascular system, and on the other hand, systemic blood pressure increases (Ogawa, et al. 1992 and Buskirk & Hodgson, 1987). One of the major results of these changes is that fatigue occurs more rapidly.

Psychological changes: At old age, cognitive changes occur among aging adults. It may take older adults more time to encode, store, and retrieve information. The rate, at which new information is learned by them, can be slower. Long-term memory shows substantial changes with age, while short-term memory shows less age-related decline. In addition, most aspects of language ability remain strong. However, wisdom and creativity often continue to the very end of life. Overall prevalence of mental disorders in older adults is less than in any other age group (Anstey & Low, 2004 and Christensen, 2001).

Individuals and/ or institutions who work with the elderly need to be aware of their physical and cognitive abilities, and how they influence their interactions with the environment.

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Anthropometric surveys of the elderly are vital due to the fact that design solutions for the elderly, made in accordance with anthropometric guidelines, are often also easier to use for others who do not have the physical capabilities of young and healthy people. Besides, the elderly anthropometric studies lies in the relatively high number of home accidents among elderly people (Molenbroek, 1987). Products or environments that are difficult to use provide a frequent cause of accidents when the physical and psychological capacities of users are ignored. It is important to consider the fact that with increasing older people size, the planning and design of their products should be made upon their physical, cognitive and anthropometric characteristics (Rosnah, et al. 2009).

In Bahrain, a lot of attention is given to the elderly by both the government and private institutions. On the government side, two ministries participate in caring for the elderly: the Ministry of Social Development and the Ministry of Health.

First, the services of the Ministry of Social Development are given through two care institutions:

- The National Bank of Bahrain House for the Elderly that started in 1985, and gives care to about 50 elderly.
- The Muharraq Centre for Social Care that started in 1995 and gives service to about 60 elderly.

Second, Services of the Ministry of Health are given through two institutions:

- The Unit for the Elderly care that was established in 1973 and gives service to more than 130 elderly.
- The Psychological Therapy Unit that was established in 1979 at Salmaniya medical Complex to care for al the elderly in Bahrain.

On the private side, a great effort is given to the elderly through many societies and centres, of which:

- UCO House for Parents Care that was established in 1994 at Al-Hidd area.
- Wisdom Society for the Retired that was established in 1989 to reinsert those who retired from work and who are willing to continue working as far as they are physically and mentally able to go on working.

• Al-Manar House for the Elderly that was established in 2001.

If the elderly is to live independently and self-efficiently, whether at home or in social care institutions, equipment, tools, environment, daily-use items, and personal-use items should be designed for them, so that their needs are entirely satisfied, and abilities and limitations are carefully considered.

Consequently, this study was carried out aiming at assessing the anthropometric profile of the elderly in Bahrain, making a comparison between males and females, and between Bahrainis and elderly from other nationalities and providing anthropometric data which could be used for the ergonomic design of working and living environment and products such as working tools, home appliances and clothing which can significantly influence the quality of life for this group of people. It is to note that, in Bahrain, anthropometric research of the elderly for designer use has not been conducted up to the present.

2. Materials and Methods:

2.1) Research Design: The largest part of this research is an anthropometric survey necessitating the use of a survey method. According to Groves et al, the survey is ‘‘a systematic method for gathering information from a sample of entities for the purposes of constructing quantitative descriptors of the population of which the entities are members’’ (Groves, Fowler, Couper, Lepkowski, Singer, and Tourangeau, 2004). In addition, a comparative method is used. Almost all anthropometric studies need some kind of comparisons to see whether the differences between the individuals, subgroups and samples are significant.

2.2) Population and sample:

a. Population: According to Bahraini Ministry of Health, the number of the elderly in Bahrain is about 07 % of the whole population (about 87000) in 2011. However, the number is increasing. It is expected that the elderly will form about 20.4 % in 2022, and 24.9 % in 2050. This increase is attributed to age longevity, health care and balanced nutrition (Habib, 2009).

b. Sample: Taking into account the nature of the Bahraini society, a conservative society, and the facilities available to researchers (financial resources, time, documents, etc) it was decided to carry out the anthropometric survey in care houses: UCO House for Parents Care (Al-Hidd area) with 50 elderly (30 females and 20 males), and Al-Manar House for the Elderly with 34 elderly (20 females and 14 males). Subsequently, the sample consisted of 84 elderly (34 males and 50 females). Table (1) depicts sample subjects' age.

Table (1)
Age of sample subjects according to age groups.

Age group	males	Mean	SD	Females	Mean	SD
60-69	12	63.75	2.27	23	64.04	1.83
70-79	8	73.37	2.11	12	73.41	2.28
80-89	10	85.00	2.04	9	84.00	2.16
90 >	4	93.25	1.63	6	92.66	2.13

2.3 Equipment: Authors used the easy-to-use equipments mainly the Harpenden anthropometer, skinfold calipers, sliding calipers and Seca weighing scales.

2.4 Anthropometric measurement: To satisfy the aims of this study, the following anthropometric dimensions and indices were measured:

a) Demographic characteristics: Age, sex, and employment status.

b) Body weight.

c) 08 standing heights: Body height, shoulder height, elbow height, knee height, thigh height, leg height, shoulder height, and elbow height.

d) 3 lengths: head length, abdomen length and arm length.

e) 3 sitting heights: Body height, shoulder height, and elbow height.

f) 11 circumferences: Shoulder circumference, abdomen circumference, hip circumference, head circumference, neck circumference, chest circumference, waist circumference, thigh circumference, fore-arm circumference, ankle circumference, and upper-arm circumference.

g) 2 Skin-fold Measurements: Triceps skin-fold, and sub-scapular skin-folds.

h) 2 Hand Measurements: Hand length, and hand width.
i) 2 Foot Measurements: Foot length, and foot width.
j) 2 Anthropometric Indices: Waist Hip Ratio (WHR), and Body Mass Index (BMI).
k) 2 Strength Measurements: Right hand grip and left hand grip.

2.5 Procedures: The procedures of this research consisted of the following:
1. Administrative procedures: The researchers were faced with a challenge of locating their subjects. In Bahrain, the elderly can be met in the following locations; at home, in care houses, in hospitals and at work for those doing bridge employment. The first experimental week of the study showed that it is easier and more practical to take the anthropometric measurements from the elderly who reside in care houses where assistants, aids, and appropriate places for measurement are available. Therefore, it was decided that the study location will be at two day private care houses: UCO House for Parents Care and Al-Manar House for the Elderly. Before measurements were taken, subjects' consents to participate in the study were taken. All participants were informed of the procedures and the measurements that will be performed, they were asked to sign informed consent forms approved by the administration of the care house they belong to.
2. Technical procedures: All measurements were taken with the following points in mind:
- The measurements were made according to the definitions of the selected body dimensions as given in Pheasant (Pheasant, 1986).
- Elderly subjects postures were maintained as natural as possible according to Hertzberg (Hertzberg,1968).
- All measurements were taken in the morning (from 08.00 am to noon) during summer (in June and July 2011) where subjects were wearing light clothes.
- While measurements were taken, subjects were sitting or standing with body weight evenly distributed on both legs.
- All Anthropometric measurements measured in this study are based on protocols as outlined primarily in Wright, Govindaraju, and Mital. (1997), and also in Pheasant (1996), Roebuck, (1995) and Smith, Norris,

and Peebles, (2000). All participants were provided adequate rest (self-determined as and when needed) between measurements to minimize effect of static fatigue.

2.6 Quality of anthropometric data: If designers, health offices and all those concerned with the elderly are to use anthropometric data; and if data are to describe the population, anthropometric surveys should be quality checked. Authors used the following measures to achieve this aim:

a. Recorded measurements: All measurements were taken twice, and the mean was recorded.

b. Prior to taking measurements, assistants were given two training sessions: The theoretical session shed lights on how to carry out an anthropometric survey, to measure the dimensions, to define the landmarks, and to record the readings. Whereas the practical session focused on practical issues of measurements. It was done as follows: first, one of the researchers took the measurement and recorded the reading. The assistant who was observing then took the measurement and recorded it. A comparison between the two values was made. If the difference between the two measurements was greater than ± 02 mm, the assistant was asked to re-measure again the dimension he/ she was measuring.

c. For measurements validation, the formula of Panchon et al's was used. Se= 100 x ((shoulder height - elbow height) – (arm length) / (arm length) (Panchon, et al. 2004). According to this formula, measurements are valid if the index (Se) is less than 7%. Results indicated that (Se) value was (6.39%) in the range described by the authors.

2.7 Statistical analysis: The most widely statistical measures in anthropometric studies including the actual one are: mean, standard deviation (SD), coefficient of variation (CV) and standard error of mean (SEM). In addition to these measures, t- test and ANOVA were computed. Data were analyzed using Statistical Package for Social Science (SPSS) version 17.0. In addition, a 5% level of probability was used to indicate statistical significance.

3. Results and discussion

First, The anthropometric profile of the elderly in Bahrain: Table (2), presents the anthropometric profile results.

Table 2
Anthropometrics of Bahraini elderly

Measurements	Sex	N	Mean	Std Dev.	CV	Std Error Mean	Percentiles		
							5th	50th	95th
Right Hand Grip (kg)	Male	34	22.2500	7.59822	34.1	1.30308	08.15	21.15	35.92
	Female	50	16.7600	4.71822	28.1	0.66726	07.20	17.20	24.33
Left Hand Grip (kg)	Male	34	20.8529	6.78587	32.5	1.16377	08.40	20.75	32.97
	Female	50	16.3460	4.61715	28.2	0.65296	07.10	17.05	25.07
Weight (kg)	Male	34	73.5647	14.6949	19.9	2.52016	47.45	72.30	106.37
	Female	50	80.0340	18.0091	22.5	2.54688	50.90	74.90	120.27
Body Height (cm)	Male	34	165.0088	9.21903	5.59	1.58105	149.37	165.25	181.50
	Female	50	152.6300	5.41899	3.55	0.76636	141.55	153.00	161.90
Torso (cm)	Male	34	80.5912	5.24262	6.51	0.89910	70.37	80.85	89.75
	Female	50	73.6000	3.87693	5.27	0.54828	66.10	74.00	78.72
Knee Height (cm)	Male	34	40.8529	1.97150	4.83	0.33811	37.75	41.00	44.25
	Female	50	37.2900	2.27248	6.09	0.32138	33.00	37.00	40.22
Thigh Height (cm)	Male	34	43.9588	2.93899	6.69	0.50403	38.75	44.00	49.80
	Female	50	42.5600	2.78597	6.55	0.39400	38.00	42.50	48.00
Leg Height (cm)	Male	34	84.5706	4.37767	5.18	0.75076	77.25	84.75	91.75
	Female	50	79.6900	3.90955	4.91	0.55289	73.239	79.69	86.1407
Shoulder-grip length (cm)	Male	34	73.3215	8.66521	11.8	1.48607	59.023	73.321	87.6190
	Female	50	68.1254	7.55662	11.1	1.06866	55.656	68.12	80.5938
Arm length (cm)	Male	34	43.2181	6.2231	14.4	1.06725	32.949	43.21	53.4862
	Female	50	40.3574	7.0520	17.4	0.99730	28.721	40.35	51.9932
Hand length (cm)	Male	34	18.7643	3.5241	18.8	0.60437	12.949	18.764	24.5790
	Female	50	15.9898	3.2310	20.2	0.45693	10.658	15.98	21.3209
Hand breadth at metacarpal (cm)	Male	34	10.1223	9.3725	92.6	1.60737	5.3423	10.122	25.5869
	Female	50	08.3345	8.3562	100	1.18174	5.4532	8.334	22.1222
Foot length (cm)	Male	34	24.6512	2.3541	9.54	0.40372	20.766	24.65	28.5354
	Female	50	23.1423	3.1212	13.5	0.44140	17.992	23.14	28.2922
Foot breadth (ball of foot) (cm)	Male	34	7.3121	1.2386	16.9	0.21241	5.2684	7.312	9.35579
	Female	50	5.3424	1.9924	37.3	0.28176	2.0549	5.342	8.62986

Table 2 Continued

Measurements	Sex	N	Mean	Std Dev.	CV	Std Error Mean	Percentiles		
							5th	50th	95th
Shoulder Height (cm)	Male	34	140.6788	8.28534	6.0	1.42092	124.00	140.6	151.349
	Female	50	128.21 64	7.03270	5.6	0.99457	112.61	128.2	135.820
Elbow Height (cm)	Male	34	97.65 00	10.1015	10.3	1.73239	80.982	97.65	114.317
	Female	50	93.8222	5.4329	5.8	0.76832	84.857	93.82	102.786
Forearm Height (cm)	Male	34	27.5735	1.95065	7.07	0.33453	24.62	27.75	31.25
	Female	50	41.2600	2.73160	6.62	0.38631	37.55	41.00	47.00
Head Width (cm)	Male	34	14.7882	0.88789	6.00	0.15227	12.87	14.90	16.15
	Female	50	12.3100	1.08275	8.80	0.15312	11.00	12.00	14.00
Shoulder Circumference (cm)	Male	34	42.8588	6.47424	15.1	1.11032	34.90	41.70	55.22
	Female	50	36.8500	3.63409	9.86	0.51394	33.00	36.00	43.80
Abdomen Width (cm)	Male	34	30.3882	2.95991	9.74	0.50762	25.15	30.40	34.77
	Female	50	30.9400	3.58944	11.6	0.50762	25.00	30.00	37.90
Hips Width (cm)	Male	34	32.4882	2.72405	8.38	0.46717	27.65	32.40	36.75
	Female	50	34.2600	3.65089	10.6	0.51631	29.10	33.00	40.00
Head Circumfe rence (cm)	Male	34	55.8441	1.96456	3.52	0.33692	52.15	56.25	59.12
	Female	50	55.2700	2.39943	4.34	0.33933	51.55	55.00	59.00
Neck Circumfe rence (cm)	Male	34	38.7353	4.15100	10.7	0.71189	32.25	38.25	46.62
	Female	50	39.2000	3.81725	9.74	0.53984	32.55	39.00	45.80
Chest Circumfe rence (cm)	Male	34	99.2500	9.08399	9.15	1.55789	85.00	98.50	118.62
	Female	50	109.2400	13.89400	12.7	1.96491	90.00	110.00	134.60
Waist Circumfe rence (cm)	Male	34	100.2353	11.42249	11.4	1.95894	77.00	99.00	117.12
	Female	50	105.1600	14.29051	13.5	2.02098	84.55	105.00	130.90
Abdomen Circu mference (cm)	Male	34	101.4176	10.08270	9.94	1.72917	84.00	99.75	116.62
	Female	50	113.4800	14.80105	13.0	2.09318	92.10	114.00	141.35
Hip Circumfe rence (cm)	Male	34	97.5294	15.70704	16.1	2.69374	67.62	98.50	18.50
	Female	50	116.5100	15.99314	13.7	2.26177	87.95	114.50	147.00
Thigh Circumfe rence (cm)	Male	34	46.2794	6.39729	13.2	1.09713	35.75	46.25	58.12
	Female	50	51.7000	8.24683	15.9	1.16628	36.30	52.00	66.00
Fore-arm Circu mference (cm)	Male	34	24.8235	2.20111	8.87	0.37749	20.75	25.00	29.00
	Female	50	26.4200	2.80189	10.6	0.39625	22.00	27.00	31.00
Ankle Circum ference (cm)	Male	34	24.3088	1.87089	7.70	0.32085	21.37	24.00	27.87
	Female	50	23.5900	3.28213	13.9	0.46416	91.10	23.00	29.45
Upper Arm Circ umference (cm)	Male	34	28.3529	2.91685	10.2	0.50024	23.00	28.00	33.62
	Female	50	33.2900	4.56483	13.7	0.64556	25.65	32.50	42.35

Table 2 Continued

Measurements	Sex	N	Mean	Std Dev.	CV	Std Error Mean	Percentiles		
							5th	50th	95th
Triceps Skin fold (mm)	Male	34	18.5588	6.30147	33.9	1.08069	06.75	19.00	32.00
	Female	50	35.9000	9.25434	25.7	1.30876	22.00	35.00	56.35
Sub Scapular Skin fold (mm)	Male	34	23.0588	6.40521	27.7	1.09848	12.25	22.00	33.00
	Female	50	37.9800	9.23058	24.3	1.30540	19.85	37.50	52.45
Waist hip Ratio	Male	34	1.0699	0.35655	33.3	0.60115	00.86	01.01	01.61
	Female	50	0.9074	0.08993	9.91	0.01272	00.77	00.89	01.06
Body Mass Index (kg/m^2)	Male	34	26.9056	4.211211	15.6	0.72237	20.57	26.84	35.72
	Female	50	34.2264	6.77394	19.7	0.95798	22.45	33.12	47.13
Arm Circumfe rence (mm)	Male	34	283..529	29.1685	10.3	5.00236	230.00	280.00	336.25
	Female	50	332.900	45.6482	13.7	6.45564	256.50	325.00	423.00
Mid- arm circu mference (mm)	Male	34	225.2547	22.85623	10.1	3.91981	192.37	222.26	268.79
	Female	50	220.1740	38.18640	17.3	5.40037	145.66	215.97	282.03
Mid-arm Muscle Area (MAMA) (cm^2)	Male	34	40.8015	8.5622	20.9	1.4684	29.468	39.335	57.705
	Female	50	39.7338	13.5495	34.0	1.1962	16.916	37.142	63..334
Mid-arm Fat Area (MAFA) ($Cm^{2)}$	Male	34	23.8599	9.2717	38.8	1.5900	07.403	39.335	57.705
	Female	50	50.1265	16.3496	32.6	2.3121	28.705	47.433	63.334

a) Anthropometric measurements: Table (2), shows the results of both men and women, namely: Mean, SD, CV, SEM, and percentiles (5^{th}, 50^{th}, and 95^{th}).

As to the CV % results, the following criteria were taken up in the Table (2) criteria were taken up in the interpretations of coefficient of variation values. ($CV \leq 5$) designates small dispersion, ($6 \leq CV \leq 15$) designates that the dispersion is of average strength, and ($CV \geq 16$) designates great dispersion. It has been found that the highest values were the triceps skin fold for males (33.9), the waist hip ratio for males (33.3), sub scapular skin fold for males (27.7), the triceps skin fold for females (25.7), sub scapular skin fold for females (24.3), weight for females (22.5) and for males (19.9). These values exceeded highly the values of all other dimensions which are generally small, meaning that the greatest dispersions are in these body dimensions. The greater the CV values, the more difficult the design decisions will be. However, the smallest CV values were head circumference values for males (3.52), height for females (3.55), and

head circumference values for females (4.34), indicating that the smallest dispersions are in these dimensions. In order to reduce CV% values, one has to increase the mean values and/ or to reduce standard deviation values which could be done by adding new observations to the sample. Increasing the sample mean will in-turn cause CV to decrease.

However, as regards to the SEM, it has been found that the highest SEM values were arm circumference values for both females (6.45) and males (5.00). These results indicate that spread among the above mentioned anthropometric body dimension (arm circumference) is greater than spread among the means of other set of indices and dimensions. Therefore, design or redesign decisions where body dimensions and indices with large SEM values are used, should be carefully made as generalizations from the sample to the population could be difficult.

b) Anthropometric Indices:

- Waist to hip ratio (WHR): WHR is a simple anthropometric index for assessing the amount and distribution of body fat. It was found that WHR for male subjects was 1.06, and .90 for female subjects. These values showed that the male subjects were at risk of being obese at the abdominal region which indicates risk factor of being prone to heart related diseases (Alam, Larbi, Pawelec, & Paracha, 2011). While female subjects of this study are considered to be within normal ranges in regard to WHR (Alam, Larbi, Pawelec, and Paracha, 2011). Obesity in older age can be referring to sedentary lifestyle, as people in the Gulf area in general, and especially in Bahrain are more prone to inactive lifestyle. This can be due to many factors including weather conditions (hot and humid climate in most of the year time), traditions, and other factors related to the health status of the elderly. (Patil, Parale, Kulkarni, Pati, 2011) show that waist–to–height ratio in addition to waist-to-hip ratio, BMI, and waist circumference showed to be good predictors to coronary artery disease risk factors in the elderly.
- Body mass index (BMI): BMI was used in this study as it is convenient for this age group. In addition, it is used in many anthropometric studies (Perissinotto, et al, 2002; Delarue, et al. 1994), despite the fact that

some authors consider it as a poor index in the identification of obesity (Allison, et al. 1997; Seidell & Visscher, 2000). High BMI was found to be associated with coronary heart disease in elderly men (Huang, et al. 1997). Results show that males and females BMI means were 26.90 (SD 4.21) and 34.22 (SD 6.77) respectively. According to the World Health Organization (WHO) BMI classification of underweight (Below 18.5), normal (18.5-24.9), overweight (25.0-29.9), obesity (30.0 and over), it is clearly seen that male subjects are regarded overweight, whereas female subjects are obese. Bahraini women used to be active income performing their own house works. They also had a share in their family income in the earlier years before the invention of oil in the country. Later, the living life had changed where women cut down their movement pattern and become prone to sedentary life style as part of a wealth in life style. This kind of life style continued, where nowadays, most of the Bahraini families depend on house-maids to perform their house works. Furthermore, other factors like dieting, health status are also considered to reflect obesity. These results do not conform with what (Corish and Kennedy, 2003) have suggested that height, weight, BMI and muscle reserves decrease with increasing age.

- Mid-arm Muscle Area (MAMA) (cm2): The anthropometry of the upper arm includes what is called the principal anthropometry measures such as the upper arm length, the triceps skin fold, and the mid- arm circumference. The derived measures that derive from the principal measures using specific formulae such as the mid- arm muscle area (MAMA), and the mid- arm fat area (MAFA). MAMA is an estimation of the area of the bone and muscle portions of the upper arm. It is seen in Table (2) that males and females mean values equal (40.8015) and (39.7338) respectively indicating that they are around the 50th percentile. According to Frisancho (1990), these values point out that the muscles of the male and female Bahraini elderly are of average values.
- Mid-arm fat Area (MAFA) (cm2): The mid- arm fat area (MAFA) is an estimation of the area of the far portions of the upper arm. It has been used as a representation of body composition specifically fat in both

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clinical and field research settings for decades (Frisancho, 1981; Wolfe, et al. 1994; Çiçek, et al 2010). Results indicate that the elderly males values were (9.0), whereas the female values were (16.3) indicating that the Bahraini elderly are generally fat but not to the extent of having what is called Bingo wings. In comparison with other elderly from other nationalities, the Bahrainis are fatter than the Indians (Bisai, et al. 2009), but not as fat as the Brazilians (Martins dos Santosa and Sichieri, 2005).

c) Anthropometric differences between males and females: Table (3), Shows some significant differences between men and women subjects. Significant differences are seen between the two groups where men were found to have bigger values in the following dimensions: right hand grip, left hand grip, body height, shoulder height, knee height, thigh height, leg height, head circumference, shoulder circumference, hip circumference, waist hip ratio, and body mass index. Whereas, women were found to have bigger values in the following dimensions: forearm circumference, chest circumference, abdomen circumference, hip circumference, thigh circumference, for-arm circumference, arm circumference, triceps skinfold, sub-scapular skin fold, and arm circumference.

On the other hand, Table (3) also, shows that differences in body weight, thigh height, shoulder height, abdomen circumference, hip circumference, head circumference, neck circumference, chest circumference, waist circumference, ankle circumference, mid-arm circumference values, are not statistically significant. Elderly men showed to have lower triceps values and a higher lean mass than elderly women (Portero –Mclellan, et al. 2010)

Table 3
Anthropometric differences between males and females

Measurements	Sex	N	Mean	Std Dev.	T-test	Significance
Right Hand Grip	Male	34	22.2500	7.59822	4.625	0.000
	Female	50	16.7600	4.71822		

Table 3 Continued

Measurements	Sex	N	Mean	Std Dev.	T-test	Significance
Left Hand Grip	Male	34	20.8529	6.78587	3.473	0.000
	Female	50	16.3460	4.61715		
Weight	Male	34	73.5647	14.69494	-1.737	0.086
	Female	50	80.0340	18.00918		
Height	Male	34	165.0088	9.21903	7.741	0.000
	Female	50	152.6300	5.41899		
Torso	Male	34	80.5912	5.24262	7.025	0.000
	Female	50	73.6000	3.87693		
Knee Height	Male	34	40.8529	1.97150	7.433	0.000
	Female	50	37.2900	2.27248		
Thigh Height	Male	34	43.9588	2.93899	2.209	0.030
	Female	50	42.5600	2.78597		
Leg Height	Male	34	84.5706	4.37767	5.349	0.000
	Female	50	79.6900	3.90955		
Shoulder-grip length (cm)	Male	34	73.3215	8.66521	4.752	0.031
	Female	50	68.1254	7.55662		
Arm length (cm)	Male	34	43.2181	6.2231	3.475	0.037
	Female	50	40.3574	7.0520		
Hand length (cm)	Male	34	18.7643	3.5241	2.841	0.001
	Female	50	15.9898	3.2310		
Hand breadth at metacarpal (cm)	Male	34	10.1223	9.3725	2.632	0.021
	Female	50	08.3345	8.3562		
Foot length (cm)	Male	34	24.6512	2.3541	1.867	0.041
	Female	50	23.1423	3.1212		
Foot breadth (ball of foot) (cm)	Male	34	7.3121	1.2386	2.102	0.007
	Female	50	5.3424	1.9924		
Shoulder Height	Male	34	32.2794	1.85534	0.260	0.795
	Female	50	32.1300	2.97405		
Elbow Height (cm)	Male	34	97.65 00	10.1015	5.102	0.008
	Female	50	93.8222	5.4329		
Forearm Height	Male	34	27.5735	1.95065	-25.15	0.000
	Female	50	41.2600	2.73160		

Table 3 Continued

Measurements	Sex	N	Mean	Std Dev.	T-test	Significance
Head Width	Male	34	14.7882	0.88789	11.05	0.000
	Female	50	12.3100	1.08275		
Shoulder Circumference	Male	34	42.8588	6.47424	5.43	0.000
	Female	50	36.8500	3.63409		
Abdomen Width	Male	34	30.3882	2.95991	-0.741	0.461
	Female	50	30.9400	3.58944		
Hips Width	Male	34	32.4882	2.72405	-2.409	0.081
	Female	50	34.2600	3.65089		
Head Circumference	Male	34	55.8441	1.96456	1.156	0.251
	Female	50	55.2700	2.39943		
Neck Circumference	Male	34	38.7353	4.15100	-0.529	0.599
	Female	50	39.2000	3.81725		
Chest Circumference	Male	34	99.2500	9.08399	-3.687	0.000
	Female	50	109.2400	13.89400		
Waist Circumference	Male	34	100.2353	11.42249	-1.677	0.097
	Female	50	105.1600	14.29051		
Abdomen Circumference	Male	34	101.4176	10.08270	-4.140	0.000
	Female	50	113.4800	14.80105		
Hip	Male	34	97.5294	15.70704	-5.378	0.000
	Female	50	116.5100	15.99314		
Thigh Circumference	Male	34	46.2794	6.39729	-3.227	0.002
	Female	50	51.7000	8.24683		
Fore-arm Circumference	Male	34	24.8235	2.20111	-2.787	0.007
	Female	50	26.4200	2.80189		
Ankle Circumference	Male	34	24.3088	1.87089	1.154	0.252
	Female	50	23.5900	3.28213		
Upper Arm Circumference	Male	34	28.3529	2.91685	-5.574	0.000
	Female	50	33.2900	4.56483		
Triceps Skinfold	Male	34	18.5588	6.30147	-9.520	0.000
	Female	50	35.9000	9.25434		
Sub Scapular Skinfold	Male	34	23.0588	6.40521	-8.175	0.000
	Female	50	37.9800	9.23058		
Waist hip Ratio	Male	34	1.0699	0.35655	3.090	0.003
	Female	50	0.9074	0.08993		

Table 3 Continued

Measurements	Sex	N	Mean	Std Dev.	T-test	Significance
Body Mass Index	Male	34	26.9056	4.211211	-5.602	0.000
	Female	50	34.2264	6.77394		
Arm Circumfe rence (mm)	Male	34	283..529	29.1685	- 8.86	0.000
	Female	50	332.900	45.6482		
Mid- arm circu mference (mm)	Male	34	225.2547	22.85623	6.023	0.008
	Female	50	220.1740	38.18640		

d) Anthropometric differences between age groups:

Table (4)
Anthropometric differences between age groups

Gender	Age group	60- 69		70- 79		80- 89		90 and >		F- Test	Significance
		Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Men	Height	169.3	5.9	168.1	5.9	162.8	6.4	157.6	2.5	9.12	.000
	Weight	77.4	4.27	75.3	3.29	70.9	3.47	68.0	6.27	7.84	.001
	N	12		8		10		4			
Women	Height	163.4	2.9	158.4	4.1	157.5	5.6	156.8	3.5	7.84	.000
	Weight	82.0	5.9	77.5	6.0	72.3	4.1	69.9	3.1	19.7	.000
	N	23		12		9		6			

Table (4), demonstrates that in both men and women, height decreased at a constant rate with increasing age. Yet, Scheffe's test, indicated that height vary significantly with age groups. For men, first age group (60- 69) is significantly taller than both the third (80- 89) (p< .005) and the fourth (90 and Over) (p< .000) groups. In addition, it is also taller than the second group (70- 79), but the difference isn't significant (p< .0810). Alternatively, for women, the difference between the first and other three groups (p< .019, p< .011, and p< .005 respectively) were significant.

Table (4), furthermore demonstrates that weight in both men and women, decreased constantly with age. The calculation of Scheffe's test shows the following: For men, first age group (60- 69) is significantly heavier than the third group (p< .009) and the fourth group (p< .005). In addition, it is also heavier than the second group, but the difference isn't significant (p<

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.0756). On the other hand, for women, differences between the first and other groups were significant. The first group is heavier than the second group (p< .058), the third group (p< .000) and the fourth group (p< .000). These results are consistent with Rosnah, et al. (2009) who reported that body weight and height declined with aging among elderly from different backgrounds (Malays, Italians, Canadians). Launer and Harris (1996) have also found almost similar results. They showed that BMI and height to decline with aging. On the other hand, they demonstrated that BMI values of women are higher than that of men from similar ages. Coqueiro, et al. (2009) reported a decline in anthropometric measurements with the advancement of age among Cuban elderly men and women. The age of 70 years showed to be the decisive moment for the main anthropometric differences reported. Similarly, anthropometric values showed a decline in both elderly men and women of Santiago, Chile, where women tend to have a higher BMI values. However, men showed to be taller and heavier (Santos, et al. 2004).

e) Anthropometric differences between Bahraini elderly and other nationalities

Table 5
Elderly values from different nationalities (males and females)

	Reference	Nationality	Gender	Age	Body Height			Body Weight		
					N	Mean	SD	N	Mean	SD
1	Kothiyal & Tettey, (2000)	Australia	Male	65-92	33	165.8	7.9	33	72	11
			Female	65-92	138	152.1	N/A	138	61	N/A
2	Kirvesoja, et al. (2000)	Finland	Male	70-80	24	170.3	8.5	N/A	N/A	N/A
			Female	70-80	31	156.5	5.5	N/A	N/A	N/A
3	Molenbroek, (1987)	Netherlands	Male	65-74	152	165.6	8.2	194	67.3	1.3
			Female	65-74	457	154.3	7.2	621	62.6	1.4
13	Perissinotto et al. (2002)	Italy	Male	65–84	5462	171.7	N/A	5462	72.6	N/A
			Female	65–84	5462	1522	N/A	5462	63.8	N/A
14	Kuczmarski et al. (2000)	US	Male	50 and above	7561	N/A	N/A	7561	86	N/A
			Female	50 and above	7561	N/A	N/A	7561	70.9	N/A
	Delarue, et al. (1994)	France	Male	65-97	289	167.5	0.07	289	71.85	10
			Female	65-97	337	155.25	0.05	337	61.6	11.53

Table 5 Continued

	Reference	Nationality	Gender	Age	Body Height			Body Weight		
					N	Mean	SD	N	Mean	SD
4	Jarosz, (1999)	Poland	Male	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Female	60-96	106	152.4	6.92	106	65.4	10.5
5	Hu et al. (2007)	China	Male	65.2–85.1	50	165.5	54.3	50	68	10.6
			Female	65.0–80.7	55	152.6	69.3	57	60	9.7
6	Pennathura & Dowling, (2009)	Mexican Americans	Male	60- 85	40	166.4	7.90	N/A	N/A	N/A
			Female	60-85	106	152.5	9.89	N/A	N/A	N/A
7	Faruque, et al, (2006).	Bangladesh	Male	60-106	718	159.7	6.1	718	47.7	8.6
			Female	60-106	478	147.0	5.7	478	41.1	9.4
8	Rosnah et al, (2009).	Malaysia	Male	60 and above	129	162.3	7.5	129	66.6	11.3
			Female	60 and above	101	149.0	5.8	101	60.0	13.8
9	Barbosa, et al. (2005)	Brazil	Male	60 and above	770	164.4	0.06	770	68.20	12.41
			Female	60 and above	1124	150.0	0.05	1124	62.57	0.06
10	Coqueiro, et al, (2009)	Cuba	Male	60 - 102	708	166.0	0.07	708	63.36	12.32
			Female	60 - 102	1197	152.8	1.92	1197	59.40	12.51
11	Suriah, et al. (1998)	Malaysia	Male	60-89	140	159.4	7.3	140	55.42	11.82
			Female	60-89	204	146.0	5.1	204	47.78	10.77
12	Santos, et al, (2004).	Chile	Male	60–99	411	164.6	7.1	411	73.2	13.0
			Female	60–99	807	149.8	6.3	809	63.6	13.4
	This study	Bahrain	Male	60-92	34			34		
			Female	60-92	50			50		

It can be seen from Table (5) that anthropometric dimensions (body height and weight) of individuals from developed countries (Australia, Finland, Netherlands, Italy, USA, France, and Poland) are higher than anthropometric dimensions of individuals from developing countries (China, Bangladesh, Malaysia, Brazil, Cuba, Chile, and Bahrain). Anthropometric dimensions of developed countries are 168.18 cm, and 73.95 kg for height and weight respectively for males, and 153.79 cm and 64.22 kg for height and weight respectively for women. However, developing countries anthropometric dimensions are 163.54 cm and 63.21 kg for height and weight respectively for males, and 149.96 cm and 56.35 kg for height and weight respectively for women. Mediterranean elderly (Italy, Greece, and Greeks living in Australia) showed to have higher

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values of BMI than their counterparts from Europe, Asia, Africa, and the United States. Furthermore, it is to note that anthropometric differences are also seen among populations from developed countries. Women had higher values in BMI and triceps skin fold, whereas men had higher values in muscle mass (indicated by muscle circumference measurements and indices) (Launer & Harris, 1996).

Second, providing anthropometric data to use in the future design: It has already been mentioned that human beings experience a lot of changes when they are old. In fact, these changes take place at all personality levels (somatic, cognitive, affective and spiritual levels). These changes should be taken into consideration when designing for them. It is worth mentioning that what has been deigned for use by younger adults does not necessarily fit the elderly. Therefore, designs should be specifically made for the elderly. Karwowski (2005) defined one of the general dimensions of ergonomics discipline as design whether it is in its traditional form or in its new form of the universal design. It can be considered as a new paradigm that can go hand in hand with ergonomics to fit work, equipment and environment to people (Ostroff, 2001). It is defined as "an approach to creating environments and products that are usable by all people to the greatest extent possible" (Mace, et al. 1991). The Center for Universal Design of the School of Design at the State University of North Carolina, USA, has given seven principles that guide designers in their design endeavor. These are:

1. Equitable use- the design is useful and accessible to all people and has the same mode of use.
2. Flexible use- the design suits multiple individual preferences and abilities.
3. Simple and intuitive use - the design is understandable and readable regardless of experience, knowledge, language skills or levels of cognition and concentration
4. Perceptible information- the design has the information needed for use, regardless of environmental conditions and users' sensory capabilities.
5. Tolerance for error - the design minimizes the dangerous consequences arising from accidental or unintended actions.

6. Minimum physical effort –the product can be used efficiently and is convenient with a minimum of fatigue.
7. Dimensions appropriate for use and comfort – they provide space and dimensions to ensure flexibility, reach, manipulation and use regardless of the user's size, posture and mobility; the components are within comfortable reach (Story, et al. 1998).

Nowak (2006) stated: "By adjusting the articles of daily use, appliances, and interior furnishings to the dimensions and physical predispositions of the elderly, ergonomics not only provides this group of people with the facilities for living independently, but also contributes to the increase of their life comfort and often prevents them from dangerous accidents". Elderly ergonomic designs will not achieve their aims unless elderly abilities and limitations are known. In this study, various anthropometric measurements have been taken to be put at the hands of designers to use while designing for the elderly. The various standing heights, the lengths, the sitting heights and the circumferences are used in designing the reach wherever it is needed (at home, at work, at hospital). Strength measurements are to be used in designing work, tasks and operations that need grip, push, and pull. However, hand and foot measurements are used in the design of tools and clothing such as gloves and shoes.

4. Conclusion: The aim of this research was to investigate the anthropometric profile of the elderly in Bahrain, study the anthropometric differences between the males and females subgroups, between the elderly age groups, and between elderly from Bahrain and elderly from other nationalities. First, the profile has been clarified through various anthropometric measurements taken from both the Bahrainis and from international subjects. Second, the anthropometric differences have been calculated. Third, anthropometric data are ready to use in design or redesign purposes. It is known that older people often have problems using everyday products because the design of many commonly used products do not take into account their limitations. Further, despite the fact that the authors were willing to measure as large a sample of the elderly as possible, the dispersion of the elderly among day care houses, their homes,

at work and at hospitals prevented the authors from having a larger sample. Likewise, the most beautiful lesson that has been learned in this research was to try first to understand the needs of the elderly to maintain their self respect and independence, and treat them accordingly. This may be the access to building good relationship with them so that anthropometric measurements are carried out efficiently.

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References:

Alam, I., Larbi, A., Pawelec, G. and Paracha, P. (2011). Relationship between anthropometric variables and nutrient intake in apparently healthy male elderly individuals: A study from Pakistan. *Nutrition Journal*. *10,* 1-9

Allison, D. B., Gallagher, D., Heo, M, Pi-Sunyer, F.X. & Heymsfield, S. B. (1997). Body mass index and all-cause mortality among people age 70 and over: the Longitudinal Study of Aging. *International Journal of Obesity*. *21,* 424–431

Anstey, K. J. & Low, L.F. (2004). Normal cognitive changes in aging. *Australian Family Physician*. *33*(10), 783- 787.

Barbosa, A. R., Souza, J. M. P., Lebrão, M. L., Laurenti, R., and Marucci, M., (2005). Anthropometry of elderly residents in the city of São Paulo, Brazil. Cad. *Saúde Pública, Rio de Janeiro*. *21*(6), 1929-1938.

Bisai, S., Bose, K., Khatun, A. and Bauri, H. (2009). Age-Related Anthropometric changes and Undernutrition among Middle Aged and Older Savar Tribal Females of Keonjhar District, Orissa, India. *Journal of Life Sciences, 1*(1), 21-26

Martins dos Santosa,D. and Sichieri, R. (2005). Body mass index and measures of adiposity among elderly adults. *Revista de Saúde Públicav, 39* (2), 1-6

Buskirk, E.R, and Hodgson, J.L. (1987). Age and aerobic power: The rate of change in men and women. *Federation proceedings*. *46*, 1824-1829.

Christensen, H. (2001). What cognitive changes can be expected with normal aging? *Australian and New Zealand Journal of Psychiatry*. *35*, 768–775.

Çiçek, B. Öztürk, A. Mazicioğlu, M. M., İnanç, N, and Kurtoğlu, S. (2010). A novel cut-off for abdominal obesity derived from various anthropometric indices to predict body composition: arm fat area. *Turkish Journal of Medical Sciences*. *40* (4), 515-523

Coqueiro, R., M.S., Barbosa, A. R., and Borgatto, A. F. (2009). Anthropometric measurements in the elderly of Havana, Cuba: Age and sex differences. *Nutrition*. 25, 33–39.

Corish, C.A., Kennedy, N.P., (2003). Anthropometric measurements from a cross-sectional survey of Irish free-living elderly subjects with smoothed centile curves. *British Journal of Nutrition*. *89* (1), 137–145.

Delarue, J., Constans, T., Malvy, D., Radignac, A., Couet, C., and Lamisse, F., (1994). Anthropometric values in an elderly French population. *British Journal of Nutrition*. *71*, 295-302

Faruque, A., Khan, A. I., Roy, C. N., Malek, M. A., Salam, M. A., and Khaled, M. A., (2006). Anthropometric Characteristics of Elderly People: Observations at a Large Diarrheal Hospital in Dhaka, Bangladesh. *Southeast Asian Journal of Tropical Medicine and Public Health*. *37* (4), 784-792.

Frisancho, A. (1981). New norms of upper limb fat and muscle areas for assessment of nutritional status. *American Journal of Clinical Nutrition, 34,* 2540-2545.

Frisancho, R. (1990). *Anthropometric standards for the assessment of growth and nutritional status*. Ann Arbor: The University of Michigan Press.

Groves, R., Fowler, F., Couper, M., Lepkowski, J., Singer, E., and Tourangeau, R., (2004). *Survey Methodology*. Hoboken: Wiley.

Habib, F. (2009). Incidence of Depression among Elderly Attending Primary Health Care Centers. *Bahrain Medical Bulletin*. *31*(4), 1-7.

Hertzberg, H.T.E. (1968). The conference on standardization of anthropometric techniques and terminology. *American Journal of Physical Anthropology*. *28*(1), 1-16.

Hettinger, T. (1960). Muskelkraft bei Mannern und Fraun. *Zentralblatt Arbeit und Wissenschaft*. *14,* 79-84.

Hu, H., Li, Z., Yan, J., Wang, X., Xiao, H., Duan, J., and Zheng, L., (2007). Anthropometric measurement of the Chinese elderly living in the Beijing area. *International Journal of Industrial Ergonomics*. *37,* 303–311.

Huang, B., Rodreiguez, B.L., Burchfiel, C.M., Chyou, Po-H., Curb, J.D. and Sharp, D.S. (1997). Associations of adiposity with prevalent coronary heart disease among elderly men: the Honolulu Heart Program, *International Journal of Obesity and Related Metabolic Disorder. 21* (5), 340-348.

Jarosz, E., (1999). Anthropometry of elderly women in Poland: dimensions for design. I*nternational Journal of Industrial Ergonomics*. *25,* 203-213.

Karwowski, W. (2005) Ergonomics and human factors: the paradigms for science, engineering, design, technology and management of human-compatible systems, *Ergonomics*. *48,* 436-463.

Kirvesoja, H., VaKyrynen, S., and Hak I. A. (2000). Three evaluations of task-surface heights in elderly people's homes. *Applied Ergonomics*. *31,* 109-119

Kothiyal, K., and Tettey, S., (2000). Anthropometric data of elderly people in Australia. *Applied Ergonomics*. *31,* 329-332.

Kuczmarski, M.F., Kuczmarski, R.J., and Najjar, M., (2000). Descriptive anthropometric reference data for older Americans. *Journal of the American Dietetic Association*. *100* (1), 59–66.

Launer, L. and Harris, T. (1996). Weight, Height and Body Mass Index distributives in geographically and ethnically diverse samples of older persons. *Age and Ageing*. *25,* 300-306.

Lipski, P.S.; Torrance, A.; Kelly, P.J. and James, O.F. (1993). A study of nutritional deficits of long-stay geriatric patients. *Age and Ageing*. *22,* 244-255.

Mace, R.L., Hardie, G.J., and Plaice, J.P. (1991) *Accessible environments: Toward universal design*. In W. Preiser, J. Vischer and E. White, (Eds.) Design Interventions: Toward a More Human Architecture, Van Nostrand Reinhold: New York.

Molenbroek, J.F.M., (1987). Anthropometry of elderly people in the Netherlands; research and applications. *Applied Ergonomics*. *18*(3), 187–99.

Nowak, E. (1996). The role of anthropometry in design of work and life environments of the disabled population. *International Journal of Industrial Ergonomics*. *17* (2), 113-121

Nowak, E. (2006). Anthropometry for the Needs of the Elderly. In W. Karwowski (Editor). *International Encyclopedia of Ergonomics and Human Factors,* Second Edition. CRC Press.

Ogawa, T., Spina, R.J., Martin, W. H. Kohrt, W. M. Schechtman, K. B., Holloszy, J.O, and Ali Ehsani, A.A. (1992). Effects of Aging, Sex, and Physical Training on Cardiovascular Responses to Exercise. *Circulation*. *86* (2), 494-503.

Ostroff, E. (2001). *Universal Design: The New Paradigm*. In W.F.E. Preiser and E. Ostroff, (Eds.) Universal Design Handbook. New York: McGraw-Hill.

Panchon, E. Lobato, R. Sanchez, F. and Panchon, A. (2004). Index for quality control in anthropometric surveys. *International Journal of Industrial Ergonomics*. *34,* 479–482.

Patil, V.C, Parale, G.P, Kulkarni, P. M, Patil, H.V. (2011). Relation of anthropometric variables to coronary artery risk factors. *Indian Journal of Endocrinal Metabolism*. *15* (1), 31-37

Pennathur, A., and Dowling, W., (2009). Effect of age on functional anthropometry of older Mexican American adults: a cross-sectional study. *International Journal of Industrial Ergonomics*. *32,* 39–49.

Perissinotto, E., Pisent, C., Sergi, G., Grigoletto, F., and Enzi, G. (2002). Anthropometric measurements in the aged people: age and gender differences. *British Journal of Nutrition*. *87* (2), 177–186.

Pheasant, S., (1996). *Bodyspace*. 2nd Edition. London: Taylor & Francis.

Portero-MeLellan, K.C. Staudt, C., Silva, F. R. F., Delbue Bernardi, J. L. Baston Frenhani, P. and Leandro Mehri, V. A. (2010). The use of calf circumference measurement as an anthropometric tool to monitor nutritional status in elderly inpatients. *Journal of Nutritional Health Aging*. *14* (4), 266-270.

Quinn, J. (2002). *Changing retirement trends and their impact on elderly entitlement programs*. In S. Altman & D. Schactman (Eds.), Policies of an aging society (p. 295). Baltimore, MD: The John Hopkins University Press.

Roebuck, J., (1995). *Anthropometric Methods: Designing to Fit the Human Body*. Human Factors and Ergonomics Society, Santa Monica, CA.

Rosnah, M.Y., Mohd Rizal, H. and Sharifah Norazizan, S.A.R., (2009). Anthropometry Dimensions of Older Malaysians: Comparison of Age, Gender and Ethnicity. *Asian Social science*. *5* (6), 133- 140.

Santos, J. L., Albala, C., Lera, L., Garcı, C., Arroyo, P., Pe´rez-Bravo, F., Angel, B., and Pela´ez, M., (2004). Anthropometric Measurements in the Elderly Population of Santiago, Chile. *Nutrition*. *20*, 452– 457.

Seidell, J.C., & Visscher, T.L.S. (2000). Body weight and weight change and their health implications for the elderly. *European Journal of Clinical Nutrition*. *54* (suppl. 3), S33-S39.

Smith, S., Norris, B., Peebles, L. (Eds.), (2000). *Older Adult Data: The Handbook of Measurements and Capabilities of the Older Adult*. Institute for Occupational Ergonomics, University of Nottingham, Nottingham, U K.

Story, M. F.; Mueller, J. L. & Mace, R. L. (1998). *The Universal Design File; Designing for people of all ages and abilities*. Raleigh, North Carolina State University School of Design.

Suriah, A., Zalifah, M.K., Zainorni, M.J., Shafawi, S., Mimie Suraya, S., Zarina N. and Wan Zainuddin W.A, (1998). Anthropometric measurements of the elderly. *Malaysian Journal of Nutrition*. *4*, 55-63.

United Nations, (2006). *Population aging 2006,* Department of Economic and Social affairs, population Division. United Nation Publication, Sales NO. E.06.X111.2.

Winn, F.J, and Ilmarinen, J. (2000). An international perspective on the older worker. *International Journal of Industrial Ergonomics*. *25*(5), 461-463.

Wolfe, W., Campbell, C., Frongillo, E., Haas, J., and Melnik, T. (1994). Overweight schoolchildren in New York State: prevalence and characteristics. *American Journal of Public Health, 84,* 807-813.

World Health Organization. (1995). *Physical Status: The Use and Interpretation of Anthropometry*. Geneva, Switzerland: World Health Organization.

Wright, U., Govindaraju, M.,Mital, A., (1997). Reach profiles of men and women 65 to 89 years of age. *Experimental Aging Research*. *23*, 369–395.