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Anthropometric Characterization of Campeche's Population

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ABSTRACT

Anthropometry is an important branch of ergonomics that deals with body measurements, particularly measurements of body size, shape, strength, mobility, flexibility, and work capacity. Reliable anthropometric data and technical procedures of ergonomics can be powerful tools to optimize the design of products to fit human dimensions. However, in Mexico, there is a scarcity of this type of data, particularly in the state of Campeche. This study aims to characterize the anthropometry of the economically active population in the northern part of the state of Campeche by creating an anthropometric chart for the design of adequate workstations and workspaces. The study was conducted with a sample of 382 subjects aged between 15 and 65 years, and 46 structural anthropometric dimensions and weights were taken and collected following the protocols most commonly used among experts in anthropometric and ergonomics. Data were analyzed to determine mean and standard deviation for all anthropometric dimensions. In conclusion, an anthropometric chart was developed to describe the characteristics of the economically active population as a priority for the manufacturing and service industries.

Keywords: Anthropometric charts, Anthropometric characterization, Economically active population of campeche, Standing postures, Seated postures

INTRODUCTION

Several studies have reported an increase in the prevalence of musculoskeletal problems in the general and working population in both developed and developing countries (Buckle and Devereux, 2002; Colombini and Occhipinti, 2006; Ahacic and Kåreholt, 2010; Hagen *et al.*, 2011; Öztürk and Esin, 2011; Nazari *et al.*, 2012; Widanarko *et al.*, 2014; Dianat *et al.*, 2015; Organización Mundial de la Salud, 2021). Other researchers have also reported a high rate of occupational injuries due to inadequate equipment design and have proposed the analysis of anthropometric characteristics to improve safety and prevent workplace injury (Brkić, Klarin and Brkić, 2015; Sutalaksana and Widyanti, 2016). The prevention of MSDs is, therefore, one of the most important factors that can have a major impact on improving productivity and promoting occupational health and safety (Kogi *et al.*, 2003).

Ergonomics has as its main objective the adaptation of tasks, spaces, and tools to the workers, and likewise, of products to the users. (Pheasant and

Haslegrave, 2016). Designers of many products, environments, and systems must take into account the size and physical shape of the intended user often referred to as designing for physical adaptation (Garneau and Parkinson, 2016), as the workplace must adapt to the body size and mobility of operators (Grandjean and Kroemer, 1997).

Anthropometric measurements are considered the starting point for the design and redesign of workstations, where ergonomic guidelines are to be applied and support research and applied for work with quantitative arguments. This implies a greater facility for the adaptation and modification of the working conditions where the worker works, thus improving productive performance and decreasing the possibility of generating a musculoskeletal disorder in the workers that work in the workstations. (López Acosta *et al.*, 2019). This study's anthropometric measurements can serve as a foundation for the ergonomic design of equipment, tools, and workstations that can make the workplace safer and more user-friendly. Small and medium-sized enterprises offer significant employment opportunities in industrially developing countries. Regarding the productive development generated in the northern part of the state of Campeche, 77% of the working-age population is engaged in retail trade activities, the manufacturing industry, mainly textiles, and providing temporary accommodation services. (INEGI, 2020). This involves manufacturing processes with in-line flows, activities that demand handling loads, and arranging goods. This requires the design of workstations and workspaces, which are established empirically or with the available spaces and resources without performing an analysis of the needs of the population that uses them, so the adoption of a system of anthropometric measurements of these sectors, to use in the design of workstations, would generate many benefits and would be a factor of optimization in the methods and work processes, in addition to adjusting the workstations to the physical characteristics of the operators working in these sectors.

Therefore, anthropometric investigations can provide essential data for the design of ergonomic equipment, tools, products, or environments, and thus may have significant potential for improving work efficiency, productivity, ease of use, fit, comfort, and safety (Hanson *et al.*, 2009; Kushwaha and Kane, 2016). The objective of this research is to develop an anthropometric chart that characterizes the economically active population of Campeche, making it the first anthropometric measurement in the State of Campeche, which is considered a significant contribution to the workforce in the area.

METHODOLOGY

Determination of the Sample

According to the latest National Survey of Population and Housing, the economically active population reported in the Northern Zone of the State of Campeche, comprising the municipalities of Calkiní, Hecelchakán, and Tenabo is 66,571 people, of which 33,880 are women and 31,802 are men (INEGI, 2020).

Based on this information, it was determined that the sample size with a confidence level of 95% and an expected error of 5% for a population of 66,571 is 382.

Determination of the Anthropometric Measurements to be Included in the Study

The following structural anthropometric dimensions were determined to have a database that allows the design of workstations, tools, and machinery according to the main economic activities carried out in the region.

Standing dimensions: Height, maximum vertical reach, eye height, shoulder height, elbow height, hip height, knuckle height, toe height, knee height, upper limb length, shoulder-grip length, maximum lateral reach with the elbow at 90° with grip, maximum lateral reach with the elbow at 90° without grip, wingspan, elbow span, chest depth, abdominal depth.

Seated dimensions: Height in a seated position, height to eyes seated position, the height of shoulder in a seated position, height for elbow rest, height subscapularis height, the height of iliac crest, thigh thickness, gluteal-knee length, gluteal-popliteal length, popliteal height, knee height, shoulder width (bideltoid), shoulder width (biacromial), hip width, head length, head width, elbow length to fingertips, shoulder-elbow length, functional grip reach, hand length, palmar length, palm width, hand width, wrist circumference, wrist thickness, wrist width, grip circumference/hand grip diameter, foot length, foot width.

Measuring Instruments

For the measurement of body weight and the descriptive dimensions of body composition consisting of body fat percentage, muscle mass percentage, and bone density, bioimpedance was selected as the measurement method because it is considered a safe, cheap, accurate, and non-invasive method that provides data on a person's body composition (García-Soidan et al., 2014; Gutiérrez and Beneit, 2011; Ortega González et al., 2018; Quintero Alarcón et al., 2022). A specialized digital scale H.U.T. model HBBSVD-2559 was used, which has a Strain-Gauge system with 4 high-precision sensors to measure body fat and water, muscle mass, bone density, the minimum required kilocalories, and body mass index. The maximum capacity of the scale is 180 kg with a 100 g measurement division.

The other structural anthropometric dimensions were measured with a complete ErgoMeasure anthropometer kit, consisting of a 2010 mm portable stadiometer, a 700 mm large vertical straight-branch anthropometer, a 500 mm medium straight-branch anthropometer, a 250 mm small straight-branch anthropometer for hand measurements, a cone for measuring grip diameters, all with an accuracy of ±1 mm. In addition, a 150 mm flexible tape measure, a 300 mm digital tape measure, and a height-adjustable bench.

Data Collection

The sample was selected randomly using the Catalog of Localities of the Support System for the Planning of the Program for the Development of Priority Zones Planning Support System was used to identify the total number of localities in each of the municipalities to be studied. With this information, a basic ballot box model was used to select the localities where the measurements were taken for each of the municipalities. Once the localities were selected, the participants determined in the sample were selected through the quota sampling principle. Therefore, by knowing and having established the criteria of the municipality, gender, and age ranges, it was feasible to select individuals at the discretion of the researcher, following the quota sampling method.

Once the dimensions and measurements for the research were determined, a formal request was made to the Ethics and Research Committee of the Autonomous University of Ciudad Juarez for the evaluation of the scientific, medical, ethical and legal aspects of the research project, obtaining its authorization.

During the measurement session, the purpose of the research was briefly explained to each participant and he/she was asked if he/she wished to participate in the research. The participants' signatures were obtained on the informed consent form and an interview was conducted to collect basic sociodemographic information, including gender, place of origin, date of birth, age, current employment status (employed or unemployed), sector of employment (primary, secondary, tertiary), work activity, family relationship (in the case of relatives).

Once the sociodemographic information was collected, height was measured with an ErgoTech México ErgoMeasure portable stadiometer. Following the protocol applied by Hernandez-Arellano *et al.*, (2016). The digital scale was configured according to height, gender, and age, asking the subject to step on the scale without shoes, jewelry, or watches that could interfere with the reading, with arms resting on the sides of the body and the head placed in the Frankfort plane and proceeded to measure weight, muscle mass percentage, body fat percentage, dehydration percentage, and bone density.

Subsequently, the remaining anthropometric measurements were taken according to accepted anthropometric protocols, taking two independent measurements for each dimension for each subject. If the difference between the two measurements exceeded the acceptable level, a third measurement was taken to ensure the accuracy of the records. (Hernandez and Gómez Bull, 2016; López Acosta *et al.*, 2019).

Information Processing

For the statistical processing of the data, mean and standard deviation were calculated following the methods used by Avila-Chaurand, Prado-León and González-Muñoz (2007); Hernández Flores (2015); and Vázquez Salinas, Ibarra Mejía and Guerra Jaime (2016).

The information was collected in a Microsoft Excel spreadsheet and subsequently processed generating the mean and standard deviation for each dimension.

RESULTS

The following tables show the data of body weight and the descriptive dimensions of body composition consisting of body fat percentage, muscle mass percentage and bone density, as well as the 46 structural dimensions of the sample of 382 subjects (275 men and 107 women) from the northern part of the state of Campeche, Mexico.

Table 1. Anthropometric data of men from 15 to 65 years of age (prepared by the authors).

	Men 15-29		Men 30-49		Men 50-65	
Dimension (cm)	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Body weight (kg)	74.63	15.07	78.70	14.70	74.54	14.47
Body fat percentage	23.60	5.75	28.99	5.25	29.39	5.02
Muscle mass percentage	36.98	3.52	33.56	3.09	33.24	2.91
Bone density (kg)	3.01	0.19	3.09	0.18	3.08	0.18
Height	165.64	6.53	160.39	6.73	158.13	6.03
Max vertical reach	211.07	8.14	204.69	9.24	202.77	8.88
Eye height	155.92	6.93	150.20	6.47	147.97	5.70
Shoulder height	139.12	6.41	135.65	7.87	132.53	6.00
Elbow height	104.27	5.80	101.31	4.54	99.66	4.99
Hip height	96.00	4.77	90.77	4.76	91.74	3.93
Knuckle height	72.06	3.41	70.77	4.38	69.84	3.58
Toe height	62.27	3.23	61.91	3.80	59.95	3.35
Knee height	51.62	4.71	49.37	2.57	49.90	3.85
Upper limb length	83.16	4.29	81.14	4.28	80.79	4.21
Shoulder-grip length	71.97	3.76	70.46	4.47	70.35	3.89
Max lateral reach elbow 90° with grip	36.55	1.85	35.43	1.70	35.65	1.73
Max. lateral reach elbow 90° without grip	46.66	2.07	45.44	1.93	45.50	1.92
Wing span	173.50	7.45	168.87	7.69	166.46	8.64
Elbow span	89.99	5.02	88.19	4.25	85.93	4.81
Chest depth	22.84	2.42	23.98	2.42	23.91	2.22
Abdominal depth	23.68	3.84	27.09	3.78	28.33	3.70
Height Seated Position	85.13	4.68	83.35	5.65	81.11	3.39
Height to Eyes Seated Position	74.44	4.10	71.67	4.30	69.42	6.31
Height of Shoulder in Seated Position	57.49	7.88	56.49	6.85	54.23	2.36
Height for Elbow Rest	20.70	3.07	21.23	2.96	20.22	2.65
Subscapularis Height	45.23	3.50	44.48	2.96	42.88	3.46

Continued

Table 1. Continued.

Dimension (cm)	Men 15-29		Men 30-49		Men 50-65	
	Mean	SD	Mean	SD	Mean	SD
Height of Iliac Crest	17.13	1.87	15.72	1.51	15.31	1.39
Thigh Thickness	15.09	2.24	15.19	1.98	14.35	2.18
Gluteal-Knee Length	59.26	3.40	58.17	2.68	57.34	3.50
Gluteal-Popliteal Length	47.74	2.83	45.79	2.59	45.58	3.48
Popliteal Height	42.33	3.09	39.97	2.31	40.28	3.16
Knee Height	52.22	3.20	50.39	2.28	49.52	4.55
Width Bideltoid	47.60	3.67	48.79	3.78	48.32	3.65
Width Biacromial	41.24	2.61	40.86	2.10	41.17	2.30
Hip Width	41.39	3.92	42.38	3.13	40.96	3.15
Head Length	19.14	0.79	19.22	0.87	20.42	6.27
Head Width	16.75	0.63	17.39	4.10	16.58	0.89
Elbow Length to Fingertips	46.71	2.44	45.19	2.66	44.70	3.27
Shoulder-Elbow Length	36.23	4.21	35.20	5.66	35.12	4.67
Functional Grip Reach	171.29	7.82	165.58	8.46	165.32	7.14
Hand Length	18.61	0.82	18.00	0.91	18.22	0.97
Palm Width	9.88	0.59	9.93	0.54	9.99	0.56
Hand Width	8.22	0.65	8.26	0.61	8.42	0.36
Palmar Length	10.67	0.51	10.53	0.63	10.47	0.50
Wrist Circumference	18.31	1.27	18.68	1.15	18.87	1.02
Wrist Thickness	6.17	0.41	6.28	0.43	6.33	0.38
Wrist Width	4.55	0.44	5.39	5.70	4.63	0.36
Hand Grip Diameter	42.79	3.30	39.16	3.54	38.85	3.22
Foot Length	25.63	1.05	24.67	1.19	25.03	1.28
Foot Width	10.11	0.60	9.87	0.48	10.06	0.66

Table 2. Anthropometric data of women from 15 to 65 years of age (prepared by the authors).

Dimension (cm)	Women 15-29 Mean	Women 15-29 SD	Women 30-49 Mean	Women 30-49 SD	Women 50-65 Mean	Women 50-65 SD
Body weight (kg)	60.08	12.24	69.42	12.34	77.13	13.33
Body fat percentage	26.53	5.13	34.79	6.41	40.38	6.44
Muscle mass percentage	34.65	2.34	30.63	2.91	28.22	2.78
Bone density (kg)	2.10	0.10	2.12	0.06	2.16	0.07
Height	154.12	6.48	148.86	5.12	147.44	4.60
Max vertical reach	194.22	9.73	187.29	7.52	185.37	6.66
Eye height	143.86	6.54	140.18	6.87	137.66	7.11
Shoulder height	127.22	9.71	124.35	4.44	123.46	4.21
Elbow height	95.98	4.93	94.50	3.50	93.59	3.42
Hip height	92.14	4.86	88.08	4.32	87.80	3.80
Knuckle height	67.89	3.79	67.15	3.28	66.97	2.99
Toe height	59.07	3.67	58.60	4.36	57.94	2.85
Knee height	47.71	3.36	46.07	2.75	46.08	2.51
Upper limb length	76.04	3.70	74.31	3.07	74.83	3.29
Shoulder-grip length	66.17	3.69	64.68	3.11	65.33	2.85
Max lateral reach elbow 90° with grip	33.80	1.96	33.18	1.53	33.70	1.97
Max. lateral reach elbow 90° without grip	42.89	1.92	42.04	1.60	42.50	2.00
Wing span	158.16	7.50	153.47	6.43	153.49	6.16
Elbow span	82.70	4.17	81.89	12.31	80.27	3.20
Chest depth	20.14	1.93	22.36	2.33	23.35	1.97
Abdominal depth	22.15	3.70	27.24	3.69	30.98	4.20
Height Seated Position	80.63	3.57	78.50	3.11	77.68	2.99
Height to Eyes Seated Position	69.79	3.47	67.96	3.01	66.91	4.08
Height of Shoulder in Seated Position	52.56	3.01	52.57	2.30	52.64	2.65

Continued

Table 2. Continued.

Dimension (cm)	Women 15-29		Women 30-49		Women 50-65	
	Mean	SD	Mean	SD	Mean	SD
Height for Elbow Rest	20.23	5.80	21.39	2.35	20.84	2.54
Subscapularis Height	41.68	3.41	41.13	2.32	41.22	2.93
Height of Iliac Crest	17.81	2.22	17.22	1.95	17.73	1.90
Thigh Thickness	14.05	1.84	14.61	1.72	15.56	2.17
Gluteal-Knee Length	56.14	2.98	55.04	2.38	55.89	3.35
Gluteal-Popliteal Length	45.81	2.65	44.66	2.55	44.77	2.72
Popliteal Height	38.52	2.06	37.24	3.58	36.09	2.47
Knee Height	48.45	2.44	46.80	2.64	46.40	2.68
Width Bideltoid	43.57	3.84	46.52	3.79	48.16	3.71
Width Biacromial	36.67	2.46	37.16	2.18	37.98	2.15
Hip Width	40.91	3.92	43.63	4.18	45.24	5.04
Head Length	18.64	0.79	18.34	0.95	18.39	0.74
Head Width	16.28	0.61	16.25	0.64	16.22	0.93
Elbow Length to Fingertips	43.11	1.94	42.00	1.68	42.04	2.63
Shoulder-Elbow Length	33.76	3.55	31.82	1.89	32.08	2.58
Functional Grip Reach	157.62	12.94	154.09	4.80	152.68	5.80
Hand Length	17.07	0.76	16.64	0.70	16.48	0.89
Palm Width	8.74	0.54	8.79	0.49	8.87	0.67
Hand Width	7.28	0.46	7.27	0.40	7.38	0.55
Palmar Length	9.79	0.50	9.65	0.53	9.63	0.43
Wrist Circumference	16.61	1.21	17.55	1.26	18.35	1.55
Wrist Thickness	5.57	0.36	5.91	0.47	6.15	0.51
Wrist Width	4.02	0.38	4.30	0.39	4.53	0.40
Hand Grip Diameter	39.86	2.88	37.19	2.38	37.25	2.23
Foot Length	23.12	1.18	22.77	0.95	23.36	1.13
Foot Width	8.97	0.55	9.21	0.58	9.54	0.74

CONCLUSION

One of the key benefits of reliable anthropometric information is the ability to optimize product design and reduce the risk of injuries and disorders. By considering the physical characteristics of the target population, product designers can create products that are better suited to the intended user, reducing the likelihood of injury or discomfort associated with the use of the product. In the case of this study, the design of an anthropometric chart that describes the characteristics of the economically active population in the northern part of the state of Campeche represents an important step in reducing the risk of workplace injuries and musculoskeletal disorders.

In addition to improving product design, anthropometric information can also be used to evaluate the ergonomics of existing products and workstations. By comparing the physical dimensions of the user to the dimensions of the product or workstation, ergonomists can identify areas where adjustments may be necessary to improve the fit and comfort of the product.

Anthropometric information can also be used to guide the selection of personal protective equipment, such as gloves, safety glasses, and protective clothing. By considering the physical characteristics of the user, ergonomists can choose equipment that provides adequate protection while also ensuring a comfortable fit. This is particularly important in industries where workers are required to use personal protective equipment on a regular basis, such as construction, manufacturing, and healthcare.

It can be concluded that the design of an anthropometric chart describing the characteristics of the economically active population, which considers the main measures used in the design of workstations and workspaces under ergonomic guidelines, continues to be a priority for the manufacturing and service industries, since it is possible to reduce the risk of injuries or musculoskeletal disorders derived from the adoption of inadequate postures.

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