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Measurement of Anthropometric Parameters for the Honduran Population Database Using Photogrammetry

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Abstract - Honduras lacks its own anthropometric data, making workspaces dysergonomic and increasing the risk of musculoskeletal injury. Therefore, this research has created an anthropometric database for three departments in Honduras: Comayagua, Intibucá and La Paz. Taking a quantitative approach with a correlational scope integrating twenty-nine variables representing the body dimensions of people. The study population consisted of 60 people with a non-probabilistic convenience sample. For a better understanding of the distribution of anthropometric data, the 5th, 50th and 95th percentiles were calculated, providing a guide to design products adapted to Honduran characteristics. The results reveal that men are on average 7.1% taller than women, which is equivalent to a difference of 12.3 cm. However, when considering aspects beyond gender, significant variations are observed within cities due to ethnic diversity. The piloting allowed to reduce the time and margin of error in the measurements, allowing to optimize the time in a 60% faster and efficient way. This study was validated by triangulation, Repeatability and Reproducibility and Technical Measurement Error. The results were found to be within the allowed percentage of variation, which is less than 10% and within the maximum allowable error of 2%.

Keywords**:** anthropometry, photogrammetry, Methods Engineering, Honduran profile, database

1. Introduction

Studies in Honduras show an increase in musculoskeletal disorders due to risks associated with dysergonomic designs in the workplace. This is due to the lack of Honduran anthropometric data, forcing the use of external anthropometric tables and compromising the proper design of workspaces. This situation threatens the efficiency and safety of the operators. The purpose of this research was to contribute to the Honduran anthropometric database by measuring in the departments of Comayagua, Intibucá and La Paz.

Similar to the problem addressed in this study, ten years ago, that is, in 2014, the existence of musculoskeletal disorders in Honduran workers in the maquilas in the department of Cortes, Honduras was also documented [1]. Two years ago, in 2012 in a manufacturing company in Honduras in the department of Yoro, it was also documented that workers also suffered from musculoskeletal disorders mainly in the shoulder [2], this highlights the poor ergonomic condition that exists in the workplaces of different areas in Honduras.

Unfortunately, this is not a national problem; it is a regional problem. In Nicaragua, in 2007, musculoskeletal diseases ranked first in occupational illnesses in different occupations, highlighting workers in maquilas, offices, among others [3].

That is why the creation of anthropometric tables specific to each country is extremely important, in Costa Rica two universities worked together to develop a manual for taking anthropometric measurements in order to create a guide in the measurement process and at the same time facilitate the understanding of the same to encourage the implementation of these projects for the creation of anthropometric bases in the country [4].

In Honduras, information on anthropometric measurements is scarce due to the low importance of occupational health of workers; related to anthropometry there are several investigations that evaluate the nutritional status of people, in the department of Intibucá in Honduras people of both sexes between 19 and 65 years were evaluated [5] and in the department of Santa Barbara people aged between 28 and 40 years were evaluated.[6].

Interest in anthropometric variables has also been seen in studies related to performance in sport, in a study of Honduran soccer players 15 anthropometric variables were evaluated to conclude in correlational tests how these affect the performance of the players.[7].

Next, 6 chapters that make up the scientific article will be presented, each one clearly detailing the research. It begins with the introduction, followed by the methodology in chapter two, which includes the following subsections: Approach and scope, variables, instruments and techniques, and population and sample.

Subsequently, as the third section the reader will be able to observe the results, in chapter four the conclusions are presented, later in chapter five the recommendations will be illustrated, then in chapter six the applicability/implementation will be presented and to culminate the references.

2. Methodology

2.1. Approach and Scope

This research was based on a quantitative approach. In this approach, measurements are made of the established variables, and then the data obtained are analyzed using statistical methods, which allow general statements to be made and future decisions to be made based on the results obtained [8].

The scope of this research is correlational. The purpose of correlational studies is to know the relationship between two or more variables, it also emphasizes that most of the time the data to be studied belong to the same place or case [9]. Twenty-nine variables representing the body dimensions of people in three departments of Honduras: Comayagua, Intibucá and La Paz, were selected in order to describe trends of important characteristics and the expansion of the ongoing anthropometric database of Hondurans.

2.2. Variables

In this study, the anthropometric variables listed in Table I were included. Furthermore, additional factors like age and clothing type were considered.

Table I Measurement Variables

Antropometric Measurements (cm, kg)	
Weight	Knee height seated
Height	Popliteal height seated
Eye height	Distance from buttocks to knees seated
Shoulder height	Thoracic depth
Elbow height	Elbow-to-elbow width
Knuckle height	Shoulder width seated
Foregrip	Hip width seated
Elbow grip	Foot length
Waist circumference	Foot width
Hip width	Hand length
Sitting height	Hand width
Eye height seated	Head length
Shoulder height seated	Head width
Elbow height seated	Head circumference
Thigh clearance seated	

2.3. Instruments and Techniques

The instruments used in the study included a digital scale, which measured the weight of participants, and an anthropometric tape, which measured body circumferences. Microsoft Excel was utilized to record the data and generate percentile tables, while the “Measure” application (photogrammetry) was employed for all measurements except body circumferences. The techniques applied included the Standard ISO 7250-1, used as a reference for selecting the measurements, and Minitab software, which was used to perform the Student's t-test and analysis of variance (ANOVA). Descriptive statistics were employed to calculate the percentiles of the anthropometric dimensions, and a non-probabilistic distribution by convenience was chosen for sample selection. Finally, Power BI was used to create a dashboard for graphically visualizing key information from the collected data.

2.4. Population, Sampling and Sample

2.4.1 Population

This study selected as a population an equivalent number of individuals that were selected in previous research conducted in 2023 and 2024 on anthropometric parameters in the departments of Francisco Morazán, San Pedro Sula, Yoro, Olancho, El Paraíso and Choluteca, with the objective of maintaining consistency with those studies:

Population 1: A group of 60 individuals between the ages of 20 and 65 from the department of Comayagua.

Population 2: A group of 60 individuals between the ages of 20 and 65 from the department of La Paz.

Population 3: A group of 60 individuals between the ages of 20 and 65 from the department of Intibucá.

2.4.2 Sampling

For the sampling, given the longitudinal nature of this macro research in progress, the same population was selected as in previous studies, so a non-probabilistic convenience sample was chosen in order to maintain standardization. The population consisted of 60 people between 20 and 65 years of age [11][12].

2.4.3 Sample

For this study, a census was conducted, which implies that all individuals in the population were investigated. Therefore, the sample and the population are identical, thus guaranteeing a complete and accurate representation of all the elements under analysis:

Sample 1: A group of 60 individuals between the ages of 20 and 65 from the department of Comayagua.

Sample 2: A group of 60 individuals between the ages of 20 and 65 from the department of La Paz.

Sample 3: A group of 60 individuals between the ages of 20 and 65 from the department of Intibucá.

3. Results and Analysis

3.1 Anthropometric measurements by traditional and photogrammetric methods

Given the importance of the measurement of anthropometric parameters in this research, we first investigated the instruments used for each measurement in both methods such as traditional and photogrammetry. Also, the ISO 7250-1 Standard was used to define the postures that the individuals should have throughout the measurement process of the 29 variables to standardize the data collection.

3.1.1 Pilot test of both methods for validation of the photogrammetry tool

For the pilot test, five representative parameters were selected from the twenty-nine established. We had the collaboration of 6 subjects, with each one 20 repetitions of each parameter were performed with both methods. They are presented in Table II.

Table II Anthropometric measurements of the pilot test

Sujeto 1 (30)										
	Height		**Knuckle height**		**Sitting height**		**Shoulder width, seated**		**Hand length**	
	Trad.	**Photo**	**Trad.**	**Photo**	**Trad.**	**Photo**	**Trad.**	**Photo**	**Trad.**	**Photo**
1	153.4	153	68.5	69	81.8	82	36	36	15	15
2	153.4	153	68.5	69	81.8	82	36	36	15	15
3	152.9	153	68.5	69	81.9	82	36	36	14.8	15
4	153.4	153	68.5	69	81.9	82	35.8	36	15	15
5	153.6	153	68.5	69	81.9	82	35.8	35	15	15
6	153.4	153	68.5	69	82	82	35.8	36	14.5	14
7	153.6	153	69.5	69	81.9	82	35.8	36	15	14
8	153.4	153	69.4	69	81.9	82	35.8	36	15	15

9	153.4	154	69.5	69	81.9	82	35.8	35	15	15
10	153.4	153	69.5	68	82	81	35.8	36	14.5	15
11	153.4	155	69.5	69	81.8	82	35.8	36	14.5	15
12	153.4	154	69.5	70	81.9	81	36	36	15	14
13	153.4	154	68.5	69	81.9	82	36	35	14.5	15
14	153.3	154	68.5	69	81.9	82	36	36	15	14
15	153.3	153	68.5	69	81.8	81	36	36	15	14
16	153.3	153	68.5	69	82	82	36	35	15	15
17	153.3	153	68.5	70	81.9	82	36	36	14.5	15
18	153.4	154	68.5	68	81.9	82	36	35	15	15
19	153.4	153	69.5	69	81.9	82	35.8	36	15	15
20	153.4	153	69.5	69	81.9	82	36	36	15	15

Student's t-test was performed with the objective of comparing whether there was a significant difference between the measurements obtained using the photogrammetry method and the traditional method [13]. For this purpose, a t-test was carried out for each parameter, on each of the 6 tables, having a total result of 30 t-tests. The results are shown in Table III.

Table III Student's T-test results

		Student´s T-test for two independent samples with equal variances					
		95% confidence, significance value p> 0.05					
Parameter		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6
P value	Height	0.372	0.063	0.673	0.854	0.226	0.333
	Knuckle height	0.208	0.206	0.174	0.492	0.121	0.407
	Sitting height	0.057	0.073	0.467	0.591	0.160	0.109
	Shoulder width, seated	0.248	0.253	0.084	0.125	0.159	0.253
	Hand length	0.474	0.577	0.063	0.306	0.074	0.577

The null hypothesis was defined as Ho= There is no significant difference between the means of the samples and the alternate hypothesis H1= There is a significant difference between the means of the samples. The results showed that there are no statistically significant differences between the means of both groups, the p-values are greater than 0.05, therefore, the null hypothesis (Ho) is accepted in the 30 t-tests performed.

3.1.2 Final anthropometric measurements for each city

Following the piloting and validation of the tool for the photogrammetry method, twenty-nine anthropometric measurements were taken, previously contemplated for the design of the workstations, for the 60 people in each selected population sample. The sequence began in the departmental capital of Comayagua, then traveled to the capital of La Paz and ended in La Esperanza, Intibucá. People with willingness to collaborate and time availability were measured. The measurement process was carried out in different selected places that met the criteria found in the pilot test in order to have greater control of the measurement environment, for example, institutes, military academy and residential areas. Men and women participated, specifically people in active employment, from different professions or trades. An example of the collected measurements is shown in Table IV and V.

Table IV Average Anthropometric measurements of men, Comayagua

Anthropometric measurements of men in Comayagua				
	Average	S.Deviation	Max.Measurement	Min.Measurement
Age	30.6	12.0	65.0	20.0
Weight	70.2	13.8	118.2	46.1
Height	173.1	5.6	186.0	163.0

Eye height	160.4	5.9	175.0	151.0
Shoulder height	142.2	6.0	156.0	131.0
Elbow height	106.0	4.8	119.0	97.0
Knuckle height	34.0	3.9	40.0	27.0
Foregrip	85.3	4.2	92.0	75.0
Elbow grip	73.3	6.2	81.0	54.0
Waist circumference	53.8	8.3	64.0	18.0
Hip width	24.0	6.4	55.0	17.0
Sitting height	41.1	4.2	52.0	36.0
Eye height seated	48.4	7.1	68.0	34.0
Shoulder height seated	35.7	4.5	48.0	26.0
Elbow height seated	39.7	4.9	54.0	32.0
Thigh clearance seated	52.9	3.4	60.0	39.0
Knee height seated	16.7	2.0	21.0	13.0
Popliteal height seated	56.0	4.4	62.0	37.0
Distance from buttocks to knees seated	22.4	3.1	31.0	18.0
Thoracic depth	86.1	13.1	120.5	68.4
Elbow-to-elbow width	18.5	1.0	21.0	16.0
Shoulder width seated	7.7	0.8	9.0	6.0
Hip width seated	27.6	1.9	31.0	24.0
Foot length	8.5	1.0	10.0	7.0
Foot width	19.5	2.7	26.0	14.0
Hand length	16.4	1.3	19.0	14.0
Hand width	56.0	1.8	60.0	53.2
Head length	72.5	3.4	82.0	67.0
Head width	36.8	2.2	43.0	34.0
Head circumference	76.0	4.2	85.0	67.0

Table V Average Anthropometric measurements of men, Comayagua

Anthropometric measurements of women in Comayagua				
	Average	S.Deviation	Max. Measurement	Min.Measurement
Age	28.0	10.1	59.0	20.0
Weight	60.3	9.7	104.8	49.1
Height	162.4	5.4	172.0	154.0
Eye height	151.9	7.3	170.0	133.0
Shoulder height	136.2	8.7	164.0	124.0
Elbow height	100.9	4.1	107.0	93.0
Knuckle height	33.2	4.7	48.0	25.0
Foregrip	81.0	3.7	89.0	71.0
Elbow grip	70.2	5.5	76.0	53.0
Waist circumference	54.1	2.0	59.0	50.0
Hip width	21.6	2.6	30.0	17.0
Sitting height	38.2	2.0	42.0	35.0
Eye height seated	42.3	4.9	55.0	31.0
Shoulder height seated	35.8	4.2	50.0	29.0
Elbow height seated	37.5	3.6	49.0	32.0

Thigh clearance seated	49.3	4.8	55.0	33.0
Knee height seated	15.4	1.7	21.0	12.0
Popliteal height seated	54.0	4.3	66.0	40.0
Distance from buttocks to knees seated	20.9	1.8	26.0	18.0
Thoracic depth	75.1	8.2	102.5	61.0
Elbow-to-elbow width	16.8	1.0	18.0	15.0
Shoulder width seated	7.4	0.4	8.0	6.0
Hip width seated	24.4	2.1	29.0	16.0
Foot length	8.1	0.7	10.0	7.0
Foot width	18.7	1.9	22.0	16.0
Hand length	15.9	1.6	20.0	13.0
Hand width	54.2	2.4	58.0	46.0
Head length	67.9	4.9	77.0	60.0
Head width	34.9	2.3	43.0	30.0
Head circumference	70.5	3.1	76.0	64.0

3.1.3 Comparison of male and female samples

After completing the data collection in the three cities, the data were grouped by gender in each city and percentiles were calculated. With this information, it was possible to make comparisons and identify patterns and trends in the study variables, such as height, weight and the rest of the 29 anthropometric measurements selected for this research. To compare the three cities by gender, percentiles were calculated by selecting the percentiles commonly used in descriptive statistics, such as the 5%, 50% and 95% percentiles. In addition, to carry out the calculation it was necessary to obtain the mean and standard deviation of each set of data corresponding to the groups of each department. A k value equal to 4.14 was also used for the percentiles along with a confidence level of 95% confidence for the calculated means. These calculations were based on the book "Methods, Standards and Working Design" [14].

Table VI Differences and Similarities of Samples (MEN)

	Men					
	P50 (Mean Percentile)					
	Comayagua		**La Paz**		**Intibucá**	
Measurements	**L.Limit**	**U.Limit**	**L.Limit**	**U.Limit**	**L.Limit**	**U.Limit**
Weight	65.0	75.4	64.0	75.3	70.4	81.7
Height	171.0	175.2	166.7	173.0	171.8	175.2
Eye height	158.1	162.6	153.4	159.2	157.8	161.9
Hip width, seated	34.0	37.4	35.2	38.4	34.5	36.1
Head length	18.4	20.5	18.9	20.1	18.3	19.2

Table VII Differences and Similarities of Samples (WOMEN)

	Women					
	P50 (Mean Percentile)					
	Comayagua		**La Paz**		**Intibucá**	
Measurements	**L.Limit**	**U.Limit**	**L.Limit**	**U.Limit**	**L.Limit**	**U.Limit**
Weight	56.6	64.0	64.5	78.0	57.0	65.5
Height	160.4	164.4	156.0	162.7	156.1	159.5
Eye height	149.1	154.6	145.8	152.2	143.5	148.5
Hip width, seated	34.0	37.6	35.0	39.4	34.8	37.6
Head length	18.0	19.4	18.6	19.8	16.5	17.9

Based on the 50th percentile, a difference was observed in the men from the city of La Esperanza, Intibucá, who were heavier with a difference of 6.14 and 7 kg compared to the men from La Paz and Comayagua, respectively. Observing the lower limit of the 5th percentile, it is found that the height of the men in the department of La Paz has a lower limit (LL)=150.4 cm (9.1 cm and 13 cm below Comayagua and La Esperanza, Intibucá respectively).

In the analysis of the measurements of the women in the sample of this study, the 5th percentile in La Paz reveals a LL= 133.5 cm of height (12.9 and 17.2 below La Esperanza and Comayagua respectively). However, when considering the mean percentile, there is little variability in the heights with values that 50% of the women measure more than 163.5 cm and the other 50% less than 158.5 cm approximately for Comayagua, La Paz and La Esperanza, Intibucá.

In the sample, it was observed that women from the department of La Paz have a higher value in the weight measurement, 67.72 (9.5 and 9.68 kg above Comayagua and La Esperanza, respectively). At the 95th percentile of height, the upper limit of Comayagua is UL=173 cm and that of La Paz is UL=174.6 cm, exceeding by approximately 5.7 cm, above the upper limit of La Esperanza, Intibucá UL=168.1 cm.

Differences in height were found between both genders in each city. The mean height of males is approximately 11.1 cm greater than that of females in each city. Differences in height between percentiles also reflect this trend.

3.1.4. Table of anthropometric percentiles of previous study in the cities of Choluteca, El Paraíso and Olancho.

The percentile table presents a detailed analysis of the distributions of the 29 anthropometric measurements for the female and male population in the three cities. When comparing genders, it is observed that men have higher height values in all percentiles (5%, 50% and 95%), while women show lower values. With respect to the weight variable, men also have higher values in all percentiles compared to women.

Table VIII Differences and Similarities of Samples (MEN)

	Men					
	P50 (Mean Percentile)					
	Choluteca		**Olancho**		**El Paraíso**	
Measurements	**L.Limit**	**U.Limit**	**L.Limit**	**U.Limit**	**L.Limit**	**U.Limit**
Weigth	62.8	74.0	68.0	77.9	65.5	77.1
Height	167.7	172.2	151.4	173.0	164.5	168.6
Eye Height	156.2	161.0	153.3	161.2	153.5	158.0
Shoulder Height	141.8	146.2	138.9	146.5	137.5	142.0
Elbow Height	96.0	108.8	98.6	108.0	102.4	106.4

Table IX Differences and Similarities of Samples (WOMEN)

	Women					
	P50 (Media					
	Choluteca		**Olancho**		**El Paraíso**	
Measurements	**L.Limit**	**U.Limit**	**L.Limit**	**U.Limit**	**L.Limit**	**U.Limit**
Weigth	57.8	64.0	58.9	66.8	63.6	69.7s
Height	153.5	159.0	157.2	164.2	158.3	163.5
Eye Height	142.4	147.9	145.6	151.9	147.0	152.3
Shoulder Height	129.1	134.6	131.0	136.3	133.8	138.7
Elbow Height	95.8	99.8	97.2	101.5	98.6	102.9

3.2 Validation for this anthropometric study

To ensure the accuracy, precision, and reliability of the anthropometric data collected while minimizing systematic and random errors, three validation methods were employed: a pilot test to validate the tools, validation through Repeatability and Reproducibility (R&R) analysis, and validation using the Technical Measurement Error (TME). [15] [16]

4. Conclusions

In relation to the time of the final anthropometric measurements, it was observed that these were performed 60% faster, this reduction was thanks to the piloting previously performed; this was essential, since it helped in planning and time reduction, it also allowed recognizing the importance of guiding the subject in the correct postures before and during the measurement process, as well as the familiarization with the measurement method before taking the final measurements, crucial steps to reduce the margin of error in the measurements.

Regarding the second objective, through the comparative analysis of the kavo percentiles in the 3 cities analyzed, it was determined that the samples differ from each other, revealing significant variations in a range of 2 to 5 cm among women and 1 to 4 cm among men, especially in measurements such as height, knee height, weight, among other equally relevant measurements. This highlights the importance of having anthropometric measurements for each city due to the diversity, since the native difference can have an impact on the proper ergonomic design and compliance with specific regulations to avoid health risks.

Thanks to the validation tests of the Technical Measurement Error and the Reproducibility and Repeatability analysis in objective number four, it was possible to confirm that the variations detected in the measurements during the piloting were corrected, since the percentage of variation (%Var.study) was less than 10% and the relative ETM values did not exceed 2%. The validation tests confirmed a significant decrease in the variation of the measurements, ensuring the consistency of the measurement system used in the study.

In general, it can be said that when measuring individuals belonging to three departments of Honduras, it is highlighted that each department presents significant variations in anthropometric characteristics due to ethnic factors. By involving individuals from all geographic areas, it is ensured that the tables adequately reflect the ethnic diversity of the country and thus have greater accuracy in the design in all sectors, from health and welfare to industry and design.

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