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Proposal of initial parameters for an anthropometric database of the Honduran working population

Paola Michelle Pascua Cantarero[1], Clarissa Yarith Martínez Sorto [2]
Shannon Julissa Mejía Enamorado[3]
[1]Universidad Tecnológica Centroamericana (UNITEC), Honduras
paola.pascua@unitec.edu.hn, clarissamartinez19@unitec.edu;
[2]Universidad Tecnológica Centroamericana (UNITEC), Honduras
Shannon.enamorado@unitec.edu

Abstract **-** In Honduras, Central America, there is a shortage of anthropometric studies conducted in the workplace, making it necessaryto establish initial parameters. This research employed a quantitative approach that encompassed three cities: Tegucigalpa, San Pedro Sula, and El Progreso, taking into account 29 variables. Various techniques and tools, including anthropometric tapes and statistical methods, were utilized. The sample consisted of 60 volunteers from the three cities, selected through non-probabilistic convenience sampling. Measurements were collected in designated areas, involving a pilot phase and validation process. Averages calculated for each city highlighted the physical diversity present in the population. The final data provided maximum, minimum, and percentiles (5, 50, and 95) for the ergonomic design of workplaces. These outcomes stress the immediate necessity of anthropometric data in Honduras and endorse further research to enhance adaptability and workplace safety. The precision of pilot testing is of paramount importance. The El Progreso group exhibited distinct differences in 15 measurements. Comparing percentiles among the cities unveiled variations, particularly in stature. Certain measurements were identified as pivotal for ergonomic design. The substantial difference of up to 20 cm from U.S. tables emphasizes the requirement for specific tables in ergonomic studies.

Keywords**:** Anthropometry, database, measurements, ergonomics, percentiles.

1 INTRODUCTION

Since ancient times, investigating the different dimensions of the human body became a specialty and evolved into the discipline called "Anthropometry." These measurements vary according to age, gender, geographical origin, and socioeconomic status, making the comprehensive collection and analysis of this data crucial. Anthropometry has become a key pillar for understanding the diversity and physical characteristics of the population.

Therefore, this research aims to create an initial database of anthropometric measurements for occupational ergonomicsin Honduras. For this purpose, three departments of the country were selected, chosen due to their numerous industries and commercial activity: Francisco Morazán, Yoro, and Cortés. Moreover, focusing on the labor sector, only individuals from these departments of working age will be considered.

Due to the lack of anthropometric studies in Honduras, with only a few investigations primarily focused on obesity and nutrition, the absence of anthropometric tables in the country has been identified. This leads companies to use anthropometric measurements from other countries as a reference, which do not align with the physical characteristics of Hondurans. Consequently, this mismatch could potentially introduce biases in ergonomic analyses or studies, yielding ineffective results.As a result of this situation, the overarching objective is to define initial parameters for the subsequent establishment of an anthropometric database of the Honduran population. This database will serve as a reference for future studies aiming to contribute to the development of ergonomic designs, occupational health, and the optimization of workstations through the application of methods engineering.

For this research, it was necessary to investigate international and regional studies, which are presented below. In theUnited States, an anthropometric study was conducted in 2012 focusing on American truck drivers to design new cabins, prioritizing the safety and health of these drivers. They collected anthropometric dimensions from 1,950 truck drivers acrossthe United States, considering ethnic, gender, and age-related aspects. The results revealed significant differences in weightand physical characteristics compared to the general population of the U.S. and that of previous decades. The conclusion drawn was that these specific data were crucial for cabin design, something that wouldn't be achieved with a general study of the country or older data [2].

On the other hand, in Nigeria, a study was conducted in 2016 involving bus drivers for cabin design purposes. Using sampling at bus stations, they measured 15 variables among 161 drivers. The majority were men around 30 years old, with limited education. It was concluded that Nigeria requires more suitable vehicles for public transportation. The recommendation was to design vehicles based on the physical characteristics of the drivers to enhance comfort and efficiency. They proposed a public-private partnership to create a national database and improve automotive designs [3].

At a Latin American level, in Chile in 2017, the body composition of 415 Chilean soldiers (aged 18-50) from the Buin Regiment was studied. They found that around 20% were obese, with the prevalence increasing with age. Obesity rates were 14.3% according to BMI and 14% based on body fat percentage, rising to 50% in soldiers over 30 years old. The conclusion highlighted that BMI alone could misclassify individuals engaged in weightlifting, recommending nutritional measures and the inclusion of body fat percentage in assessments [4].

In Honduras specifically, a study conducted from 2010 to 2011 assessed 565 adolescents in Tegucigalpa to determine the prevalence of overweight/obesity. Nutritional categorization was based on body mass, with an average age of 14 years. After one year, 5% of initially normal-weight adolescents transitioned to overweight/obesity. The prevalence was 19.2% in the initial assessment and 18.5% the following year. The conclusion drawn was that the nutritional profile of adolescents and the risk factors in Honduras are similar globally for this age group [5].

This article will be comprised of the following sections: the first section, the introduction, which includes international and regional background, definition of the problem, general objectives, as well as specific objectives; the second section outlines the methodology used, including the approach, scope, population, sampling, sample, variables to be considered, instruments, and techniques; the third section contains the results and analysis of each of the stated objectives; and the fourth section will encompass the conclusions of this article.

2 METHODOLOGY

2.1 Approach and Scope

The present study is based on a quantitative approach, as it requires the collection of numerical data about the elements, events, or individuals under investigation. These data are subsequently subjected to analysis through statistical procedures to obtain the research results [6]. Likewise, it falls within a descriptive scope, as it focuses on identifying and describing initial standards for this specific purpose [6]. Quantitative studies with a descriptive scope measure, evaluate, or collect data from different variables, dimensions, or components of the phenomenon under study to subsequently describe what is being investigated [6].

2.2 Population, Sampling, and Sample

2.2.1 Population

For this research, three types of populations were considered, consisting of working-age residents from the following three cities in Honduras: Tegucigalpa in Francisco Morazán, San Pedro Sula in Cortés department, and El Progreso in Yoro department. These populations comprised 60 working-age individuals (aged 20-65 years) from the urban areas of each of the aforementioned cities.

2.2.2 Sampling

In this research, a non-probabilistic convenience sampling approach was chosen. This sampling method was selected based on the following criteria: firstly, due to the limited time available for the study; secondly, because there was certainty in accessing 60 individuals from each of the aforementioned 3 cities; and thirdly, because of the limited availability of the team and researchers for conducting the study. Considering all these factors, convenience sampling was deemed appropriate as it serves as an efficient strategy to address preliminary objectives, facilitating participant access for the study and resource optimization [7].

2.2.3 Sample

In this research, three different samples corresponding to the three different cities were analyzed, ensuring that individuals fell within the age range of 20 to 65 years, maintained good health conditions, and agreed to participate in the anthropometric study.

Sample 1: Comprised 60 individuals from the city of Tegucigalpa (Francisco Morazán). Sample 2: Comprised 60 individuals from the city of San Pedro Sula (Cortés).

Sample 3: Comprised 60 individuals from the city of El Progreso (Yoro).

2.3 Variables

For this study, the anthropometric variables displayed in Table I were taken into account, as these are considered by various authors for job workstation designs. Additionally, other variables such as age and clothing type were also considered, making a total of 31 variables.

Table I: Measurement Variables

ANTHROPOMETRIC MEA	**SUREMENTS (CM, KG)**
WEIGHT	THIGH CLEARANCE
BODY HEIGHT	GLUTEUS TO KNEE DISTANCE
EYE HEIGHT	CHEST DEPTH
SHOULDER HEIGHT	WAIST CIRCUMFERENCE
SHOULDER HEIGHT	HAND LENGTH
HIP WIDTH	PALM WIDTH
SITTING HEIGHT	FOOT LENGTH
SITTING EYE HEIGHT	FOOT WIDTH
SITTING SHOULDER HEIGHT	HEAD LENGTH
SITTING ELBOW HEIGHT	HEAD WIDTH
SHOULDER WIDTH	HEAD CIRCUMFERENCE
ELBOW-TO-ELBOW DISTANCE	FRONT GRIP
SEATED HIP WIDTH	ELBOW GRIP
SITTING POPITEAL HEIGHT	KNUCKLE HEIGHT
KNEE HEIGHT	

2.4 Instruments and Techniques

In this study, various instruments and techniques were utilized to achieve the outlined objectives. For the first objective, anthropometric instruments such as anthropometers, measuring tapes, a digital scale, and Microsoft Excel were employed for data collection. Measurement criteria based on standards were applied following the methodology outlined in ISO Standard 7250-1 [8] and ISO Standard 15535:2018 [9]. For the second and third objectives, Microsoft Excel was used as an analytical tool along with techniques of descriptive statistics, probabilistic statistics, and percentiles to carry out necessary calculations and comparisons between measured samples, including a sample from a foreign country. Regarding the fourth objective, Microsoft Excel was used as the analytical tool again, employing simple statistics for validation, akin to the reproducibility and repeatability study of 2010, which highlighted this method as an essential component in quality improvement programs [10], and the ETM study of 2010, emphasizing the importance of minimizing errors in anthropometric assessment, thus assessing the capacity of the measuring devices to conduct accurate studies [11].

3 RESULTS AND ANALYSIS

3.1 Anthropometric Measurements

In this research, anthropometric measurements are crucial. Methods Engineering was employed to investigate the necessary techniques, methods, and instruments. ISO Standards 7250-1[8] and ISO 15535[9] were adhered to for the positions. Following a pilot test involving 9 participants, the measurement process was refined. Subsequently, official measurements were taken in three Honduran cities, considering the improvements identified during the pilot phase. These measurements are vital for evaluating human body dimensions and will be detailed further. Before the final measurements, informed consent was obtained from each participant, ensuring transparency, ethics, and respect for their autonomy and privacy.

3.1.1 Pilot Test

A pilot test was conducted in Tegucigalpa over a week, involving 9 individuals with diverse ages, heights, and weights, selected based on recommendations from an expert advisor. 29 measurements were taken from each participant, revealing areas for improvement such as posture corrections and adjustments in measurement tools. The convenience of specific measurements with the subject seated was emphasized, particularly for taller individuals, which influenced the final measurements. In a study conducted in 2020, it was observed that after implementing a brief three-hour pilot test, positive feedback, especially from younger students, highlighted the significance of the pilot in fine-tuning and optimizing the program before its full implementation [12].

3.1.2 Final Anthropometric Measurements

After the pilot test, the aforementioned 29 anthropometric measurements were taken from 60 individuals in each population sample from the three cities (Tegucigalpa, San Pedro Sula, and El Progreso). Data collection commenced in Tegucigalpa, followed by travel to San Pedro Sula, and finally, measurements were conducted in the city of El Progreso, as described in previous paragraphs. Regarding informed consent, measurements were taken from willing participants.

Tables II and III display the anthropometric measurements collected from men and women in the three study cities. The variability in age (average of 29.2 years in men and 35.9 years in women) highlights generational diversity. The obtained data includes average weights of 74.9 kg in men and 64.0 kg in women. The average heights are 169.2 cm in men and 154.3 cm in women. These measurements are crucial for ergonomic workstations, product design such as hand tools adapted to grip measurements (68.8 cm in men and 66.2 cm in women), and clothing tailored to waist circumference (84.0 cm in men and 78.9 cm in women).

Table II: Average anthropometric measurements for males in sample 1, Tegucigalpa

Average anthropometric measurements for males in sample 1,		
	AVERAGE	S. DEVIATION
WEIGHT	74.9	20.5
BODY HEIGHT	169.2	8.5
EYE HEIGHT	158.6	8.7
SHOULDER HEIGHT	143.5	9.0
SHOULDER HEIGHT	109.0	13.6
HIP WIDTH	35.5	4.1
SITTING HEIGHT	87.3	4.9
SITTING EYE HEIGHT	75.9	5.2
SITTING SHOULDER HEIGHT	62.0	4.8
SITTING ELBOW HEIGHT	25.5	4.2
SHOULDER WIDTH	48.4	6.7
ELBOW-TO-ELBOW DISTANCE	50.1	6.1
SEATED HIP WIDTH	38.3	4.7
SITTING POPITEAL HEIGHT	43.7	3.5
KNEE HEIGHT	51.2	4.1
THIGH CLEARANCE	15.2	2.4
GLUTEUS TO KNEE DISTANCE	60.9	6.2
CHEST DEPTH	24.9	3.7
WAIST CIRCUMFERENCE	84.0	15.0
HAND LENGTH	19.2	2.3
PALM WIDTH	9.4	2.0

FOOT LENGTH	27.3	2.0
FOOT WIDTH	10.7	1.9
HEAD LENGTH	19.1	2.5
HEAD WIDTH	17.0	2.2
HEAD CIRCUMFERENCE	56.1	2.3
FRONT GRIP	68.8	13.4
ELBOW GRIP	39.2	12.0
KNUCKLE HEIGHT	82.6	26.3

Table III: Average anthropometric measurements for females in sample 1, Tegucigalpa

Average anthropometric measurements for females in sample 1,		
	AVERAGE	S. DEVIATION
WEIGHT	64.0	12.0
BODY HEIGHT	154.3	5.4
EYE HEIGHT	142.8	5.5
SHOULDER HEIGHT	130.0	5.5
SHOULDER HEIGHT	96.1	4.1
HIP WIDTH	35.0	3.2
SITTING HEIGHT	82.0	3.3
SITTING EYE HEIGHT	70.1	3.1
SITTING SHOULDER HEIGHT	58.4	4.2
SITTING ELBOW HEIGHT	24.5	3.3
SHOULDER WIDTH	45.1	4.5
ELBOW-TO-ELBOW DISTANCE	46.6	4.4
SEATED HIP WIDTH	39.1	3.8
SITTING POPITEAL HEIGHT	40.5	4.2
KNEE HEIGHT	47.5	4.6
THIGH CLEARANCE	14.3	2.6
GLUTEUS TO KNEE DISTANCE	54.2	4.1
CHEST DEPTH	26.8	3.1
WAIST CIRCUMFERENCE	78.9	10.5
HAND LENGTH	17.6	2.2
PALM WIDTH	8.4	1.9
FOOT LENGTH	24.6	1.9
FOOT WIDTH	9.4	1.7
HEAD LENGTH	18.3	1.2
HEAD WIDTH	15.2	0.7
HEAD CIRCUMFERENCE	54.4	1.3
FRONT GRIP	66.2	3.7
ELBOW GRIP	31.8	2.4
KNUCKLE HEIGHT	68.3	3.7

3.2 Comparisons among the three samples

After collecting anthropometric measurements from the three selected cities, percentiles were calculated to compare and analyze differences among the samples. Standard percentiles such as the 5th, 50th, and 95th percentiles were used. Additionally, Kavo Percentiles were calculated for a more precise comparison of asymmetric samples, utilizing means, standard deviations, standard percentiles, and a value of k=4.14. These calculations were based on the book 'Methods, Standards, and Work Design' by Benjamin Niebel and Andris Freivalds [13]. The results are presented in Tables IV and V.

Table IV: Differences and similarities in percentiles among the three samples (males)

	MALE					
	TEGUCIGALPA		SAN PEDRO SULA		EL PROGRESO	
	Mean Percentile		95% Percentile		5% Percentile	
	U. Limit	L. Limir	U. Limit	L. Limir	U. Limit	L. Limir
SITTING HEIGHT	85.5	89.0	90.2	104.2	82.6	87.0
SITTING EYE HEIGHT	74.1	77.8	79.2	93.2	71.9	75.2
SITTING ELBOW HEIGHT	24.0	27.0	27.2	40.0	21.9	24.7
THIGH CLEARANCE	14.3	16.0	14.4	16.4	14.4	15.6
GLUTEUS TO KNEE DISTANCE	58.7	63.1	60.7	63.1	56.1	63.8

Table V: Differences and similarities in percentiles among the three samples (females)

	FEMALE					
	TEGUCIGALPA		SAN PEDRO SULA		EL PROGRESO	
	Mean Percentile		95% Percentile		5% Percentile	
	U. Limit	L. Limir	U. Limit	L. Limir	U. Limit	L. Limir
BODY HEIGHT	159.8	168.1	154.8	159.9	153.6	159.9
EYE HEIGHT	148.4	156.4	143.4	148.6	141.7	148.7
SITTING HEIGHT	85.6	97.2	83.4	94.0	77.6	81.3
SITTING ELBOW HEIGHT	24.8	35.9	24.2	34.5	20.9	22.7
THIGH CLEARANCE	13.8	15.3	13.4	15.4	13.8	15.1

In the sample of men from San Pedro Sula, consisting of 24 volunteers, significant differences are observed in certain measurements compared to the samples from Tegucigalpa, consisting of 34 men, and El Progreso, consisting of 35 men. These differences are more noticeable in seated height, eye height, and seated elbow height, which are greater in San PedroSula. However, the gluteal-knee distance and the free space to the thigh show less variability, indicating uniformity in these measurements among the samples. It is important to note that no pattern was identified relating to professions, suggesting the need for further research to understand these differences.

Regarding women, Tegucigalpa, consisting of 25 volunteers, shows greater variation in certain measurements compared to San Pedro Sula, consisting of 36 volunteers, and El Progreso, consisting of 26 volunteers, with particular emphasis on body height and eye height. In El Progreso, differences are observed in height and elbow height compared to the other cities, while the measurement of free space to the thigh is more consistent. No pattern related to professions is identified, suggesting the need for further research to understand these differences.

3.3 Comparisons with a sample of anthropometric measurements from the United States

After analyzing the body measurements of three cities (Tegucigalpa, San Pedro Sula, and El Progreso) and comparing them with an anthropometric table from the United States, standard percentiles (5%, 50%, and 95%) and Kavo Percentiles were used to contrast the samples. These were calculated using means, standard deviations, a 95% confidence interval for the mean, and a value of k=4.14. These calculations were conducted through probability distribution methods and percentiles, following the book 'Methods, Standards, and Work Design' [13]. Table VI compares sample 1 (Tegucigalpa) with the sample from the United States.

Table VI: Table of Sample 1 (Tegucigalpa) with the United States Sample

Medidas Corporales	**EE.UU Sex 50ava**		**TGU 50ava**	**EE.UU Sex 50ava**		**TGU 50ava**
1. Weight	Male	74	67.6	Female	61.1	64.5
2. Height	Male	173.6	166.1	Female	160.5	159.8
3. Eye height	Male	162.4	155.5	Female	148.9	148.4
4. Shoulder height	Male	142.8	140.3	Female	131.1	134.7
5. Elbow height	Male	109.9	104.1	Female	101.2	99.6
6. Sitting height	Male	90.6	85.5	Female	85	84.5
7. Eye height, seated	Male	78.6	74.1	Female	73.3	72.9
8. Elbow height, seated	Male	24.3	24.0	Female	23.3	24.3
9. Elbow breadth	Male	41.7	47.9	Female	38.4	45.7
10. Hip breadth, seated	Male	35.4	36.6	Female	36.4	38.5
11. Popliteal height	Male	44.2	42.4	Female	39.8	40.8
12. Knee height, seated	Male	54.3	49.7	Female	49.8	44.2
13. Thigh clearance	Male	14.4	14.3	Female	13.7	13.8
14. Knee-thigh distance	Male	59.4	58.7	Female	56.9	57.1
15. Chest depth	Male	24.2	23.6	Female	24.2	25.4
16. Knuckle height	Male	75.4	73.2	Female	70.2	69.1

Table VI also illustrates an example of comparisons from the lower 50th percentile of women from the USA and Tegucigalpa, finding variations in all measurements, indicating that women from Tegucigalpa have larger measurements in most, with an approximate maximum of 7.3 cm.

Comparisons between men from the USA and San Pedro Sula showed that in most measurements, American men are larger, with a maximum difference of approximately 3.5 cm, except in three measurements where men from Tegucigalpa are larger by 8.1, 2.0, and 1.3 cm respectively.

Regarding women, comparisons between the USA and San Pedro Sula indicated that American women are larger in most measurements, with a maximum difference of approximately 6.7 cm, except in three measurements where women from San Pedro Sula are larger by 8.1, 2.0, and 1.3 cm respectively.

Comparisons between men from the USA and El Progreso showed that in most measurements, American men are larger, with a maximum difference of approximately 9.8 cm, except in three measurements where men from El Progreso are larger by 10.4, 2.5, and 1.5 cm respectively.

Similarly, in the comparisons between women from the USA and El Progreso, it was observed that American women are generally larger in most measurements, with a maximum difference of approximately 7.4 cm, except in three measurements where women from El Progreso are larger by 11.5, 2.1, and 3.3 cm respectively

A. Validation

To minimize the error rate and ensure the acquisition of accurate and reliable data, three types of validation were applied: piloting, conducting Repeatability and Reproducibility (R&R) tests to assess the observed variability in measurement data [16], and calculating the Technical Measurement Error (TME), which evaluates the quality of anthropometric measurements and repeated sets of anthropometric variables [17].

4 CONCLUSIONS

In an anthropometric study, it is crucial to conduct piloting encompassing various characteristics, as this practice significantly reduces bias or error in the final data. An anthropometry study that omits this practice could have a lower reliability index.

Through the analysis of averages obtained from the three samples, it was determined that the sample from the city of El Progreso, both women and men, tend to have a greater height or physical size compared to the other two samples, with 15 out of 29 measurements larger. Therefore, it is concluded that there are significantly distinctive anthropometric characteristics for the sample obtained in this region, which may have relevant implications for ergonomic studies, job position designs, or adjustments and adaptations in different work environments.

When comparing and analyzing the Kavo percentiles of the samples from Tegucigalpa, San Pedro Sula, and El Progreso, it was determined that the samples differ from each other, especially in measurements such as standing and seated body height, eye height (standing and seated), and seated elbow height. Therefore, it is concluded that it is crucial to consider the specific anthropometric measurements of each population when ergonomically designing job positions in various locations, to achieve optimal adaptation in furniture, workspaces, and machinery.

The samples of men and women from selected cities in Honduras, as expected, significantly differ from the anthropometric table of the United States by up to 20 cm in some measurements. It is concluded that using tables from other countries is not viable, highlighting the need for specific anthropometric tables for the design of job positions and efficient ergonomic studies.

General Conclusion

Through the validation of the process for creating an initial parameter proposal for an anthropometric database of Honduras, efficient data was obtained to compare and analyze percentiles between samples from three selected cities and the anthropometric table of the USA. It is concluded that it is necessary to have specific anthropometric tables for each region and country for the design of job positions or ergonomic studies. According to the results obtained in this study, there are always variations among individuals from one place to another.

5 RESEARCH RECOMMENDATIONS

1) As a crucial point in the research process, it is recommended that, following an understanding of the indications established by ISO 7250-1 [6], pilot tests should be conducted over a period of two days to one week. These tests should involve the participation of individuals with diverse anatomical characteristics and of different ages.
2) Having a dedicated assistant to the evaluator is recommended as it not only alleviates the workload but also minimizes the possibility of errors in data collection.

3) Precisely establish the body dimensions to be measured, systematically setting the order and position of the individual, whether standing or seated. It is crucial to clearly inform the volunteer about the measurements to be taken and provide visual instructions or an informative pamphlet illustrating the required postures graphically.
4) Grouping participants in joint sessions offers advantages beyond time optimization. This practice also facilitates thecreation of a collaborative environment among volunteers, which could positively influence the results.

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