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Anthropometric Profile of Male Rice Farmers in Oriental Mindoro, Philippines for Local Agricultural Tool, Machinery, and Workstation Design

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ABSTRACT

A survey intended to develop the anthropometric profile of male rice farmers in Oriental Mindoro, Philippines for local agricultural tools, machinery, and workstation design was conducted. Thirty-nine different body measurements were collected from 162 male rice farmers from various rice-producing municipalities and cities of Oriental Mindoro. The age distribution of the respondents ranged from 27 to 64 years old with an average age of 51 years old. Around 53.70% of the respondents have an age bracket from 51 years old to 64 years old which implies the ageing rice farmer of the province. The average standing height of the male rice farmers in the province was 161.9 cm with a standard deviation of 6.11 cm. The 5th and 95th percentile of standing height, which was the common reference for the design to accommodate 90 percent of the population, were 152.1 cm and 172.9 cm, respectively. The anthropometric data of the male rice farmers in Oriental Mindoro was compared to the data gathered from the male farmers in Laguna. In summary, 15 of the anthropometric data were not statistically significant while 18 were statistically significant. This only indicates that the physique of male farmers from Laguna was different from Oriental Mindoro. These variations in body measurements suggest that region-specific anthropometric data could be essential in optimizing the ergonomic design of locally made agricultural tools, machinery, and workstations. But in the absence of anthropometric data for other provinces in CALABARZON and MIMAROPA Regions, the anthropometric profiles of male rice farmers from Laguna and Oriental Mindoro can be used as guides in the design.

Keywords: *anthropometric profile, anthropometry, rice farmer*

INTRODUCTION

Oriental Mindoro is dubbed as the rice granary of the MIMAROPA region. With an average yield of 3.61 metric tons per hectare last 2023, it accounts to 30 % of the rice production in the region. MIMAROPA region, on the other hand, has an average yield of 3.90 metric tons per hectare last 2023 and accounts to 34 % of rice production in the country (PhilRICE, 2024). Based on the 2022 gross regional product report (Philippine Statistics Authority, 2024), 18 % of the region's economy depends on agriculture, fishery, and forestry. Hence, to promote sustainable growth in agriculture, mechanization has been one of the interventions provided by the government. However, the majority of the agricultural machinery available in the province was imported, thus, affecting the ergonomics design for the intended operators.

Anthropometric indicators in farmers, as important indices in designing agricultural tools and equipment, should be considered more than before (Mehrizi et al. 2022). These indices are significant since farming is generally recognized as a hazardous occupation, as shown by the high number of occupational accidents and health problems. Agriculture predisposes people to health problems, especially musculoskeletal disorders (MSDs) because of extremely labor-intensive work and size mismatch between the dimensions of farm machinery equipment imported from abroad and local machine fabricator (Jo et al. 2016). Mismatches between human anthropometry and equipment dimensions are claimed to be contributing factors in discomfort, fatigue, biomechanical stresses, accidents, injuries, cumulative traumas and decreased productivity (Mandahawi, 2008).

Designing and manufacturing agricultural machines fitted for Filipino farmers may take a long time. What is necessary now is to evaluate the existing designs of the machines based on the dimensions of the users and then modify the machines to increase the man-machine system's efficiency. While existing farm machineries imported overseas are thought to be effective in various farm operations, agricultural machines and equipment intended for

Filipino farmers should be adapted to their stature. Unfortunately, there is very nil anthropometric data, particularly for Filipino agricultural operators, available for reference. In 2007, Zubia pioneered the anthropometric data collection of male rice farmers in Laguna, Philippines (Zubia et al. 2010). In particular, no anthropometric data from Oriental Mindoro nor in MIMAROPA Region are available. In the absence of local anthropometric data of Filipino farmers, the available one can be used in the design. Thus, the anthropometric data of male farmers of Oriental Mindoro was compared with the anthropometric data of male farmers of Laguna to determine if there was a significant difference in the measurement. However, as continuation of the work of Zubia et al. (2010), there were unpublished research conducted by Center of Agri-Fisheries and Biosystems Mechanization of the University of the Philippines Los Baños establishing the anthropometric profile of male and female farmers in Cavite, Laguna, Batangas, Rizal and Quezon, thus, completing the anthropometric profile in the CALABARZON region (Amongo et al., 2014) and (Onal et al., 2014).

Various applications of anthropometric data can be observed in designing agricultural tools, machinery, and workstations. Among the applications for measuring different standing and sitting heights were the design of the location of controls and displays, work height indicator, reference level for handgrips, optimal height for the exertion of lifting force, visual field determination, seat design, and clearance between seat backs and obstructions. For body dimensions involving length, possible applications were workstation design, design of the location of controls and displays, reach dimensions, clearance between the seat back and obstacles in front of the knee, and use in defining the normal working area. For head, foot and hand measurements, these can serve as references in head gear design, clearance for foot and foot pedal design, handle design, and hand tool design. Girth measurements can be used as a reference for the accessibility in maneuvering. Breadth and depth measurements can serve as references for seat and control panel placement, clearance at seat level, and clearance between seat back and obstruction (Bridger, 2003). In the study of Mujiono and

Sujianto (2024), the standing elbow height, reach forward, sideways hand reach, standing navel height, and standing knee height were used in the design of coffee bean peeling machine in Indonesia. Furthermore, in the study of Dewangan et al. (2022), hand dimensions, stature, and body mass were collected from agricultural workers in India for the design of hand tools and protective gear.

Anthropometric data of farmers alone will not increase man-farm efficiency or level the agriculture machinery to the user's stature. With enough anthropometric data, machine design analysis favorable to its users is being considered and there will be enough basis for any fabricator to design the machine based on the majority of its users. With the proper design, farmer's health will not be compromised as well as farm productivity will be increased for food sustainability.

SIGNIFICANCE OF THE STUDY

Addressing the inadequacies of a machine is crucial in enhancing user experience and optimizing productivity. Whether it is a tool, machine, equipment, workstation, or a complex industrial system, considering ergonomic factors ensures that the developed hardware is user-friendly, efficient and safe (Gupta, 2023). To bridge the gap between machine design and human comfort, safety and efficiency, anthropometry comes as a need. Generally, to design any product for human use, engineers must rely on anthropometric data, otherwise, the product may turn out to be unsuitable from an ergonomic standpoint (Sanjit et al., 2003). In addition, using machines that are not well suited to farmers' body types can lead to discomfort, fatigue, and increase risk of work-related injuries.

One of the objectives of ergonomics is to minimize physical stress or injuries associated with work. In order for the designer to attain this, they must study the way in which people and technology interact (Goetsch, 2018). Dimensions of people in a certain place must be obtained by the designer to come up with a machine or equipment that fits with the user. Therefore, anthropometry is very important since it deals with measurements and the art of application

that establishes physical geometry, mass properties, and strength capabilities of human body.

By utilizing the anthropometric profiles of male rice farmers, engineers can design a machine that would fit the physical dimensions of the user. This customization leads to improved comfort, reduced fatigue, and a lower risk of injury, making farming activities, safer and efficient. Therefore, integrating the anthropometric profile into the design of an agricultural equipment presents an opportunity to significantly enhance the well-being, productivity and economic stability of rice farmers in Oriental Mindoro.

Since human factor design and engineering aims to optimize the design and functionality of human-machine systems with respect to complex characteristics of people and the relationship between system users, machines and outside environment, engineers must gather data about the male users that will serve as the parameters in designing the tools or machines that will reduce drudgery on the users. Anthropometric data differs from one race to another (Winter, 2009) and there is limited comprehensive collection of anthropometric data available for reference. It is a must to develop anthropometric data of Filipinos for them to work comfortably.

OBJECTIVES OF THE STUDY

The general objective of the study is to develop the anthropometric profile of male rice farmers in Oriental Mindoro, Philippines for local agricultural tool, machinery, and workstation design. Specifically, the study aims to:

1. identify the body measurements that are essential in local agricultural tool, machinery, and workstation design;
2. collect and measure identified body measurements of male rice farmers;
3. determine the level of inter-individual differences of the farmers in terms of body statistics; and
4. compare the collected anthropometric data with male rice farmers from Laguna, Philippines.

MATERIALS AND METHODS

Sample Size Determination

Oriental Mindoro was endowed with an abundant and rich agricultural base. It was dubbed as Rice Granary of MIMAROPA accounting to 35% of the rice production in the region and ranks 14th in the country (AGRI-INFO HUB. Agricultural Profile Oriental Mindoro, 2023). The total rice production in the province for 2021 was recorded at 575,272.21 MT with an average yield of 4.94 MT/ha. The consolidated rice data accounts for a total of 31,452 rice farmers in the province.

The number of respondents targeted per municipality was based on the total number of farmers present in the area. The sample size of male rice farmers respondents surveyed in Oriental Mindoro was computed using Equations 1 and 2.

$$ss = \frac{Z^2 * p * (1 - p)}{c^2} \quad \text{Equation 1}$$

$$new\ ss = \frac{ss}{1 + \frac{ss - 1}{pop}} \quad \text{Equation 2}$$

In equation 1, ss is the sample size, Z is the Z value, p is the percentage of picking a choice, and c is the confidence interval. In equation 2, new ss is the new sample size and pop is the population of the rice farmers in Oriental Mindoro. The Z value used in the equation was 1.96 at a 95% confidence level. The percentage of picking a choice was set at 90% since the project team made sure that the respondents were all rice farmers. The confidence interval set was 0.05. Based on the data of the provincial government of Oriental Mindoro, the total number of registered rice farmers as of 2021 was 31,452.

Using the sample size equation provided us with a finite target male rice farmers respondents in the province. After determining the sample size, stratified random sampling was used to determine how many farmers should be interviewed from each of the different municipalities and city of the province of Oriental Mindoro.

Stratified Random Sampling

Male rice farmers from ten municipalities and one city in the province of Oriental Mindoro were considered in the anthropometric survey. These municipalities and city were specifically considered for this study due to the number of registered rice farmers. The selected location for the conduct of anthropometric survey were Calapan City, Naujan, Victoria, Socorro, Pinamalayan, Gloria, Bansud, Bongabong, Roxas, Mansalay and Bulalacao. The number of target respondents per municipality was determined by stratified random sampling based on the number of registered rice farmers in the area. From sample size determination, a total of 139 male rice farmers were considered. Factors for culling out includes errors during measurement. **Table 1** shows the summary of the number of target and actual respondents obtained from each of the 10 municipalities and one city. On the other hand, **Figure 1** illustrates the distribution of the respondents in the province of Oriental Mindoro.

No respondents were considered in the municipalities of Baco, Pola, San Teodoro, and Puerto Galera since the majority of the rice-producing areas in those municipalities were rainfed. Only irrigated rice-producing areas were considered in selecting the respondents. Some municipalities have a lesser actual number of respondents being surveyed in comparison to the target number of respondents. Reasons for this were the unavailability of rice farmers during the conduct of the anthropometric survey and the culling conducted for better reliability of the anthropometric data collected. To consider for possible culling of data, the excess number of respondents assigned per municipality and city were interviewed and body measurements were collected. Due to the limitations in logistics, the team had no opportunities to return to the municipalities that turned out to have a lesser actual number of respondents compared to the target respondents upon culling.

Anthropometric Measurements

Different body dimensions that have direct bearing on agricultural tools, machinery and workstation design were measured from male rice farmers in the

Table 1. Number of target and actual male rice farmers per municipality.

MUNICIPALITY	NO. OF FARMERS*	NO. OF TARGET RESPONDENTS	NO. OF ACTUAL RESPONDENTS
Naujan	4224	21	19
Calapan City	4162	21	22
Bongabong	3068	15	21
Gloria	2706	14	26
Pinamalayan	2700	14	11
Victoria	2426	12	11
Bansud	2390	12	11
Bulalaco	1964	10	7
Baco	1755	0	0
Roxas	1688	9	23
Mansalay	1587	6	6
Socorro	1418	5	5
Pola	951	0	0
San Teodoro	412	0	0
Puerto Galera	1	0	0
Grand Total	31,452	139	162

*Source: <https://orminagri.com/agricultural-profile-oriental-mindoro/>

A total of 39 body measurements were collected from the male rice farmer respondents. The majority of these measurements were identified based on the study of Zubia et al. (2010) entitled, “Anthropometry of Male Farmers in Laguna, Philippines and its Potential Application in the Design of Agricultural Machines and Tools”. Other anthropometric measurements were obtained from Bridger (2003). Summarized in **Table 2** are the body measurements with description and application.

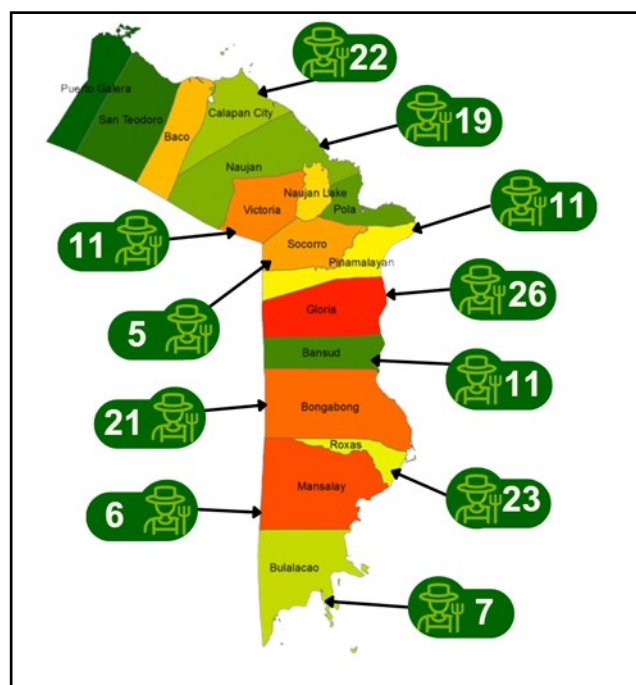


Figure 1. Distribution of the respondents in Oriental Mindoro.

predominantly rice farming areas in Oriental Mindoro. Measurements used standard posture, which was standing erect and sitting erect postures, with body joints at 0, 90, and 180 degrees, as can be seen in **Figures 2** and **3**, illustration of anthropometric measurements in standing position and sitting position, respectively.

Anthropometric Survey

The measurements were taken in two different postures, the standing and sitting positions. To achieve the standing erect position, the respondents were instructed to place their feet closed, heels together, and distribute their weight evenly across both feet as they stood against a wall. To measure vertical distances, a measuring tape mounted on the wall and a right-angle triangle were used. For the sitting position, the respondents were instructed to sit straight on an adjustable anthropometric chair. For accuracy, the respondent's feet were positioned correctly on a footrest that was perpendicular to the vertical plane. The right hand of the respondent was placed on an adjustable armrest while the farmer was seated. The body measurements taken from the male rice farmer respondents are shown in **Figures 2, 3, and 4**.

The anthropometric survey was divided into three stations. The first station was the conduct of an interview asking the demographic profile of the respondents assuring that they were really rice farmers. Measurements such as grip diameter, hand and foot length, hand and foot breadth, and weight were also obtained in this station. The second station was intended for measuring body measurements in standing position while the third station was intended for body measurements in sitting position.

Table 2. Definitions of body measurements used in the anthropometric survey and its application.

BODY DIMENSION	DESCRIPTION	APPLICATION
Standing Height	Distance from the floor to vertex of the head, measured from either front or back when subject is standing erect with heels together, back straight, and head in eye-ear horizontal plane	Workstation designs.
Standing Eye Height	Height above the ground of the eye, measured when subject is standing erect with heels together. Back straight, and head in eye-ear horizontal plane	Design of controls and displays
Standing Shoulder Height	Distance from medial plane of the body to tip of the right middle finger when subject attains maximum sideways reach with arm on standing straight position	Use in determining zones of comfortable reach; reference datum for location of fixtures, fittings, controls etc.
Standing Elbow Height	Height above the ground of the elbow, measured when subject is standing erect with heels together, back straight	Considered to be the best indicator of work height
Fingertip Height	Vertical distance from the floor to the tip of the middle finger	Lowest acceptable level for finger-operated controls.
Standing Knee Height	Vertical distance from the floor to the central portion of the knee	Clearance required beneath the underside of tables, etc.
Knuckle Height	Vertical distance from the floor to the knuckle	Reference level for handgrips; handgrips on portable objects should be at less than knuckle height; optimal height for exertion of lifting force.
Crotch Height	Distance from the floor to the distal part of the pubis	Low- clearance machines
Standing Hip Breadth	Distance across the hip, measured horizontally when the subject is standing erect, heels together, back straight	Seat and control panel placement
Waist Girth	Closed measurement following the body contour on the waist part	Access in maneuvering
Chest Girth	A measure of the circumference of the chest at the level of the sternum	Access in maneuvering
Standing Shoulder Breadth	Distance across shoulders	Clearances and control panel placement
Head Circumference	Measurement taken at the upper juncture of ear and around the head	Head gear design
Arm Length	Length of arm from top of clavicle to tip of middle finger with arm down by the side of the body	Workstation design, design of controls.
Sideways Reach	Distance from medial plane of the body to tip of the right middle finger when subject attains maximum sideways reach with arm on standing straight position	Workstation design, design of controls.
Total Span	Distance between tips of middle fingers at maximum arm stretch without straining.	Workstation design, design of controls.
Sitting Height	Vertical distance (measured along back) from top of seat to crest of head when subject is seated erectly on a seat with backs of knees against edge of seat, lower legs dangling freely and head in eye-ear horizontal plane	Control panel layout, workstation layout.
Eye Height above Seat	Distance from the seat to eye level, measured from either front or back when subject is seated erectly and head in eye-ear horizontal plane.	Design of controls and displays
Shoulder-Elbow Length	Distance from the tip of shoulder blade to tip of elbow measured when subject is sitting erect, with upper arm vertical, forearm horizontal	Display and control panel design.

Table 2. ... continued

BODY DIMENSION	DESCRIPTION	APPLICATION
Elbow Height above Seat	Distance between level of seat and elbow tip when subject is sitting erect with upper arm vertical, forearm horizontal	Display and control panel design, seat design, visual field determination.
Seat Height	Popliteal height when subject is seated erectly on a seat with backs of knees against seat edge and feet on the floor, lower leg vertical	Seat design
Sitting Knee Height	Vertical distance from the floor (at the base of heel) to top of muscle mass near end of thigh bone when the subject is seated with feet on the floor	Clearance required beneath the underside of tables, etc.
Thigh Clearance	Vertical distance of the thigh, measured when subject is seated as in sitting height measurement	Clearance required between the seat and the underside of tables or other obstacles.
Buttock-Popliteal Length	The horizontal distance from the plane of the most posterior point on the buttocks to the back of the lower leg at the knee	Reach dimension, defines maximum acceptable seat depth.
Buttock-Knee Length	Horizontal distance between buttock and skin over right kneecap when subject is seated as in sitting height measurement	Clearance between seat back and obstacles in front of the knee.
Belly Depth	Maximum front-to-back horizontal contact when the subject is seated as in the sitting posture	Clearance between seat back and obstructions.
Chest Depth	Dimension through chest (front to back) between the sternum and spinal groove	Clearance between seat backs and obstructions.
Forearm to Hand Length	Horizontal distance between the elbow and the tip of the middle finger when arm is flexed 90 degrees	Forearm reach; used in defining normal working area.
Forward Reach	Distance from the wall to tip of right middle finger when subject attains maximum forward reach with both arms on standing with heels, buttocks, middle of back, and back of heads against the wall	Design of controls and display panel, workstation layout.
Sitting Upward Reach	Vertical distance of tip of right middle finger when subject attains maximum upward reach of arm in sitting position with both feet flat on the ground	Workplace layout, design of controls
Sitting Bust Height	Height between the foot and the bust, measured when subject is in sitting position, back straight.	Clearance between seat backs and obstructions.
Breadth across Elbow	Distance between elbows, measured horizontally when subject is seated as in sitting height measurement	Seat design
Sitting Hip Breadth	Distance across the hip, measured horizontally when the subject is seated as in sitting height measurement	Clearance at seat level; the width of a seat should be not much less than this.
Hand Length	Distance from end of small wrist bone at base of thumb to tip of middle finger of right hand, palm up, with fingers together and extended	Handle design, control panel design, hand tool design.
Hand Breadth	Distance between outside projections of distal ends of second and fifth metacarpals of the right hand, fingers extended and together	Handle design, control panel design, hand tool design.
Foot Breadth	Maximum distance across left foot, when subject is standing with weight even on both feet	Clearance for foot, design of pedals.
Foot Length	Distance between heel and longest toe of left foot when subject is standing with weight on both feet	Clearance for foot, design of pedals.
Grip Diameter	The maximum diameter when the hand is in power grip position, from the tip of the middle while grasping an object across the palm until it touches the tip of the thumb	Handle design, control panel design, hand tool design.

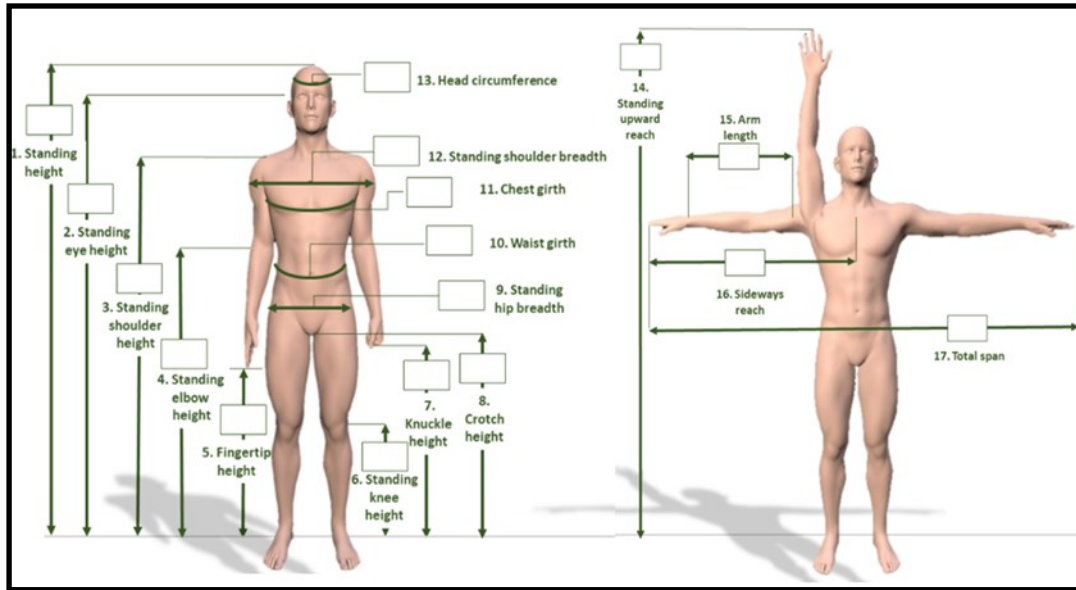


Figure 2. Illustration of anthropometric measurements in standing position.

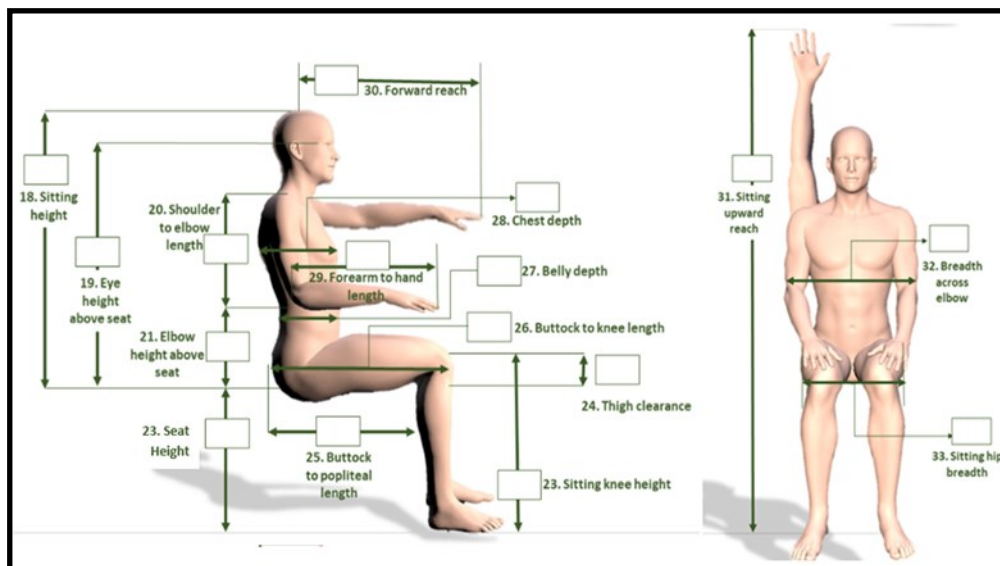


Figure 3. Illustration of anthropometric measurements in sitting position.

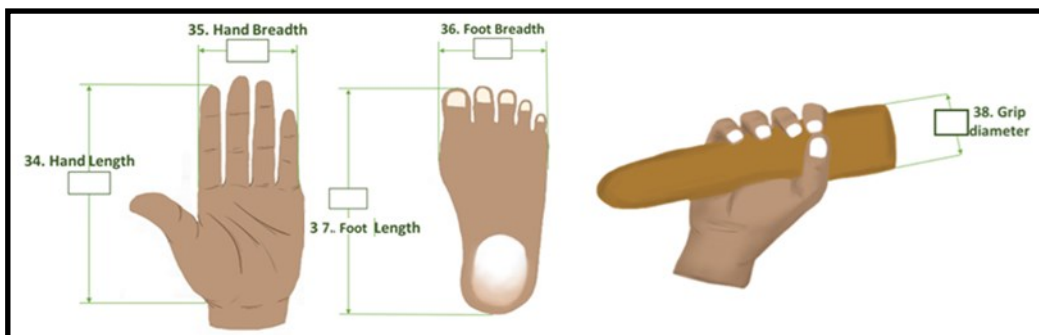


Figure 4. Illustration of grip diameter, hand and foot measurement.

To ensure the integrity of the data obtained, the reading of measurements was done twice. Head circumference and other circumferential measurements involve wrapping a tape measure tightly around the body part, compressing hair and soft tissue to ensure accuracy. Limb measurements maintain consistency and integrity through careful consideration of anatomical landmarks like joints.

Measuring Tools Used in the Anthropometric Survey

To aid in actual measurements, the materials and equipment that were used included an adjustable anthropometric chair, weighing scale, tape measures, calipers, wooden cone, tri-squares, meter sticks and portable stadiometer.

Anthropometric Chair

To facilitate measurements in a sitting position, an adjustable and collapsible anthropometric chair

was designed and fabricated. The chair was used to measure the body dimensions in sitting position wherein the respondents were ensured to sit comfortably at perfect fit where joints were set at 0, 90 and 180 degrees. Body positions were adjusted by moving the adjustable armrest, footrest, and backrest. For easy assembly and installation, the parts of the anthropometric chair were collapsible and joined by nuts and bolts. The computer-aided drawing (CAD) of the anthropometric chair used in the survey is presented in **Figure 5**.



Figure 5. CAD of anthropometric chair.

Wooden Cone

Two sets of wooden cones were used in measuring the hand grip diameter of the farmers. The two cones were designed specifically to measure the minimum and maximum value for grip diameter. The measurement for diameter was obtained by asking the subject to grip the cone across the palm to the maximum possible position such that the tip of the middle finger touches the tip of the thumb. This measurement was essential in designing handles. **Figure 6** shows the wooden cone used for the anthropometric survey.

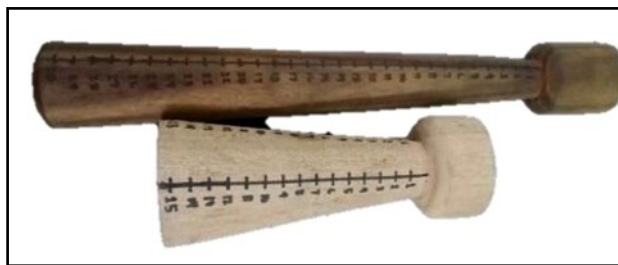


Figure 6. The wooden cones used for grip diameter measurement.

Modified Steel Caliper and Digital Vernier Caliper

The modified steel caliper was made of two legs and a steel frame. The two legs were both composed of a t-shaped flat bar with a galvanized iron pipe at its end. This pipe serves as a slider along the steel frame. One leg was fastened at the end of the steel frame through the pipe using a bolt while the other leg could freely slide along the length of the steel frame, as seen in **Figure 7a**. This tool was essential for measuring the width of the shoulders and hips in addition to the chest and waist circumferences. A digital Vernier caliper, as seen in **Figure 7b**, was used for measurements that were smaller in width, like those of the hand and foot.

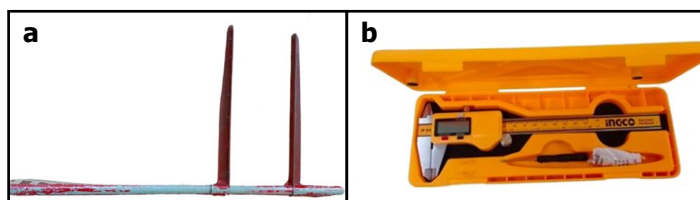


Figure 7. The modified steel caliper (a) and the digital vernier caliper (b).

Other Measuring Tools

To ensure that the joints position was at 0, 90 and 180 degrees and the tip of measuring tape was positioned at the proper place of the dimension of the body, other measuring tools were essential to acquire the correct body dimension. Other measuring tools used were protractor, weighing scale, leveling device, measuring tape, plumb bob, and meter stick, as shown in **Figure 8**.

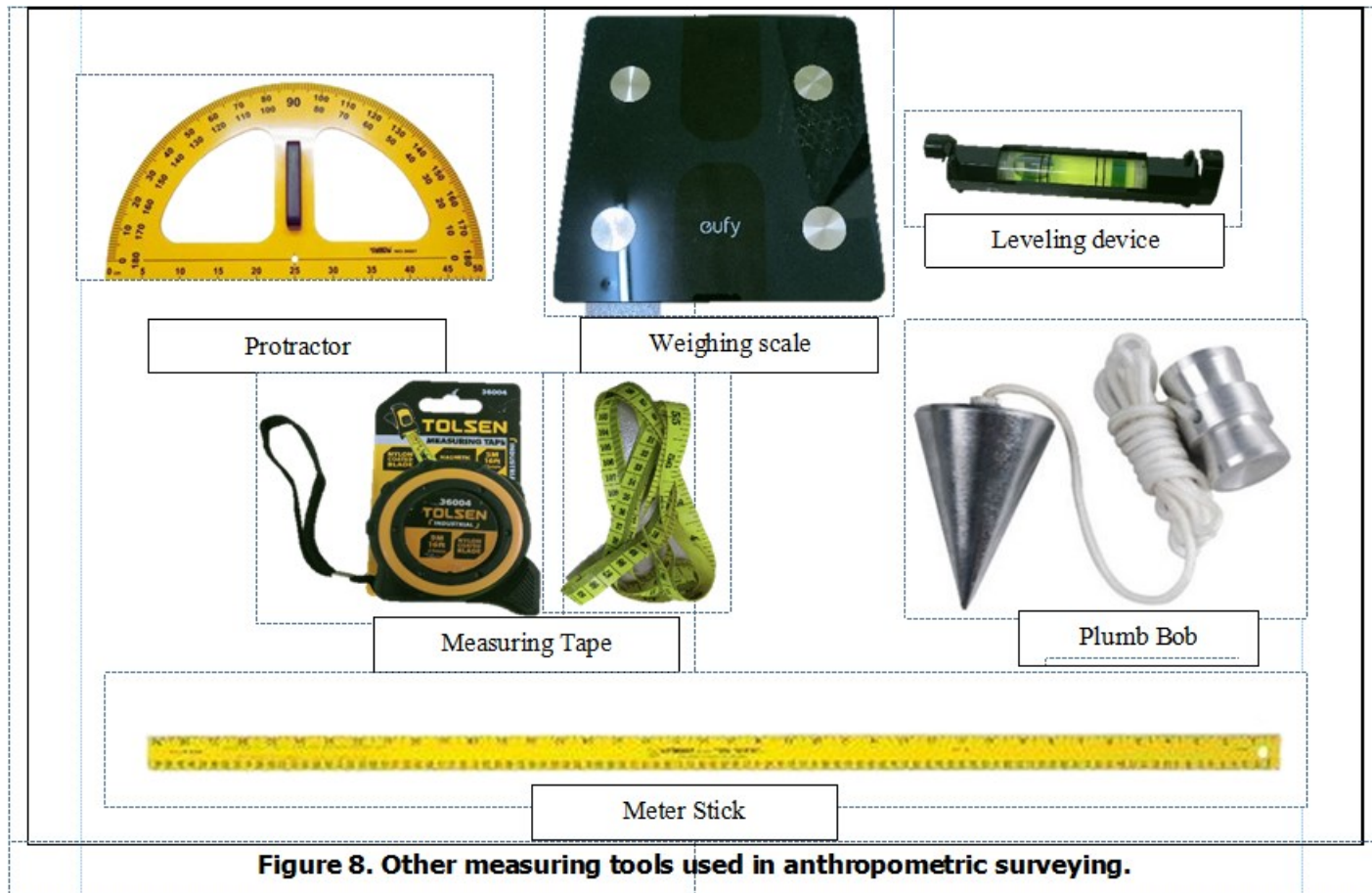


Figure 8. Other measuring tools used in anthropometric surveying.

Statistical Analysis

The anthropometric data collected from the male rice farmers of Oriental Mindoro were subjected to statistical analysis to characterize the population. Mean, mode, standard deviation, correlation coefficient, coefficient of variations, range, and percentiles (5th, 50th, 95th) were used to determine the characteristics of body measurements.

By ranking every data value in the sample and calculating the proportion of data that fall at or below a given datum value using the relevant measurement values associated with the chosen human physical characteristic, the percentile statistics was used. The 5th percentile of data for relevant body dimensions was typically used to limit design dimensions, such as reach distances, control movements, and positions that were restricted or limited by body or body part size. To guarantee that at least 95% of the user population can access a

particular portion of the equipment, the maximum height from floor level to any accessible part of the equipment, for instance, must be within the reach of the 5th percentile female maintainer. Since it only considers half of the population, the 50th percentile or average was typically not a good choice as design criteria (Nadadur, 2010).

Furthermore, even though the relationships or correlations between body measurements were highly variable among the various human characteristics and may vary across samples and populations, correlation statistics should be applied and interpreted if two or more human physical characteristics were applicable to a design problem. For instance, measurements of breadth have a stronger correlation with weight than with stature. A correlation coefficient value can be used to express how strong this relationship was.

RESULTS AND DISCUSSION

Age of Farming Population

The age distribution of the male rice farmer respondents considered in this study is summarized in **Table 3**. The youngest male rice farmer respondent was 27 years old while the oldest was 64 years old. More than half or 53.70% of the respondents have an age of at least 51 years old. Data also shows that the average age of male rice farmers in Oriental Mindoro was 51 years old. This population data implies that male rice farmers in Oriental Mindoro are also ageing, just like in other parts of the country. Further presented in **Figure 9** are the rice farmer respondents undergoing anthropometric surveys in standing and sitting positions.

Table 3. Summary of the age distribution of male rice farmers in Oriental Mindoro.

AGE RANGE	FREQUENCY	PERCENTAGE (%)
26-30 y.o.	4	2.47
31-35 y.o.	8	4.94
36-40 y.o.	8	4.94
41-45 y.o.	23	14.20
46-50 y.o.	32	19.75
51-55 y.o.	26	16.05
56-60 y.o.	40	24.69
61-65 y.o.	21	12.96
TOTAL	162	100.00



Figure 9. Respondents of the anthropometric survey in standing (a) and sitting (b) positions.

Body Statistics in Terms of Inter-Individual Differences and Gender

The collected anthropometric data of male rice farmers in Oriental Mindoro was subjected to statistical analysis to easily compare and interpret the results. The mean, median, and mode values as well as percentiles and correlation coefficient were used in the analysis. These statistical parameters make it simple to compare one set of data with another and to explain how the body measurements of the entire sample population relate to one another. These were used for all measurements taken with the respondent's sitting upright, standing upright, and for the essential circumference measurements.

Summarized in **Table 4** is the statistical analysis of anthropometric measurements in standing position. Among the measurements included in standing position were standing height, standing eye height, standing shoulder height, fingertip height, standing knee height, knuckle height, crotch height, standing hip breadth, waist girth, chest girth, standing shoulder breadth, head circumference, standing upward reach, arm length, sideways reach, and total span. The 5th, 50th, and 95th percentiles of standing height were 152.1 cm, 162.0 cm, and 172.9 cm, respectively. Standing height was used as a reference in the computation of the correlation coefficient in comparison with other body measurements. Since it was well known that the trunk and limbs exhibit consistent ratios with one another and in relation to the total body height, the standing height was used as a reference when comparing the data. In addition, measuring someone's height was a simple process, making it the most often used anthropometric information that is freely accessible. Standing eye height, standing shoulder height, and total span shows high correlation coefficient with a value of 0.94, 0.84, and 1.05, respectively. It indicates that standing height can be used to determine the values of these body measurements. This information was valuable in designing local agricultural tool, machinery and workstation appropriate for the stature and reach of the target user population. Circumferential anthropometric measurements also play a crucial role in designing ergonomic agricultural machinery. Though often overlooked, circumferential measurements impact cabin space

allocation in larger machinery, facilitating unrestricted movement during long shifts as it also influences seat and cabin dimensions, preventing operator discomfort and allowing fluid arm movement during operation.

Presented in **Table 5** is the statistical analysis of anthropometric measurements in a sitting position. Among the measurements included in the sitting position were sitting height, eye height above the seat, shoulder to elbow length, elbow height above the seat, seat height, sitting knee height, thigh clearance, buttock to popliteal length, buttock to knee length, belly depth, chest depth, forearm to hand length, forward reach, sitting upward reach,

breadth across the elbow, and sitting hip breadth. The 5th, 50th, and 95th percentiles of sitting height were 77.3 cm, 84.0 cm, and 90.3 cm, respectively. Sitting upward reach shows high correlation coefficient with a value of 1.03 indicating that this measurement was highly correlated with standing height. The data is valuable in various applications for designing local agricultural tool, machinery and workstation. It can be used to determine appropriate seat heights and clearances for tractors or other agricultural machinery operated while seated.

The statistical analysis of anthropometric data of other measurements of male rice farmers are tabulated in **Table 6**. Included in these

Table 4. Statistical analysis of anthropometric data of male rice farmers in standing position.

MEASUREMENT (cm)	MEAN	MODE	MEDIAN	MIN	MAX	StDev	5 th	50 th	95 th	CV
Standing Height	161.9	160.0	162.0	147.0	180.0	6.11	152.1	162.0	172.9	1.00
Standing Eye Height	151.4	155.0	151.8	136.0	170.0	6.13	141.1	151.8	161.7	0.94
Standing Shoulder Height	135.3	136.0	135.4	122.0	149.5	5.88	125.1	135.4	145.9	0.84
Standing Elbow Height	102.9	104.0	102.7	87.0	127.6	5.15	95.2	102.7	110.8	0.64
Fingertip Height	60.1	61.0	60.0	50.7	69.5	3.74	53.8	60.0	66.2	0.37
Standing Knee Height	45.2	44.0	45.1	35.0	70.2	3.85	39.1	45.1	50.3	0.28
Knuckle Height	68.2	69.0	68.4	57.0	78.0	3.83	61.8	68.4	74.0	0.42
Crotch Height	71.7	72.0	72.0	45.0	85.0	5.26	63.3	72.0	79.8	0.44
Standing Hip Breadth	32.1	33.0	31.8	26.7	53.7	3.01	29.0	31.8	37.6	0.20
Waist Girth	88.5	87.0	88.0	63.0	120.0	9.94	73.1	88.0	105.0	0.55
Chest Girth	91.1	93.0	91.6	50.0	112.0	8.34	81.0	91.6	105.7	0.56
Standing Shoulder Breadth	42.8	43.0	42.7	30.5	61.7	3.12	38.5	42.7	48.0	0.26
Head Circumference	54.8	55.0	54.5	50.8	85.5	3.06	51.5	54.5	58.0	0.34
Standing Upward Reach	203.3	201.0	203.2	116.0	229.0	11.65	186.6	203.2	220.0	1.26
Arm Length	50.0	49.0	49.0	39.0	99.0	5.32	45.0	49.0	56.7	0.31
Sideways Reach	85.3	84.0	85.5	67.0	95.7	4.11	79.0	85.5	92.0	0.53
Total Span	169.9	173.0	172.0	17.8	191.0	14.00	158.1	172.0	183.4	1.05

Table 5. Statistical analysis of anthropometric data of male rice farmers in sitting position.

MEASUREMENT (cm)	MEAN	MODE	MEDIAN	MIN	MAX	StDev	5 th	50 th	95 th	CV
Sitting Height	83.5	87.0	84.0	42.7	95.2	5.93	77.3	84.0	90.3	0.52
Eye height above seat	73.7	76.0	73.9	61.7	82.0	3.44	68.0	73.9	79.5	0.46
Shoulder to Elbow Length	34.7	36.0	35.0	22.5	42.7	2.70	30.0	35.0	38.8	0.21
Elbow Height Above Seat	23.4	22.0	23.2	18.4	32.6	2.38	19.7	23.2	27.5	0.14
Seat Height	42.6	45.0	42.6	28.6	51.5	2.98	38.3	42.6	47.4	0.26
Sitting Knee Height	46.8	46.0	47.0	10.0	63.1	4.99	41.6	47.0	53.1	0.29
Thigh Clearance	10.4	11.0	10.0	6.2	43.0	3.02	7.5	10.0	13.0	0.06
Buttock to Popliteal Length	44.0	43.0	44.0	34.0	58.0	3.12	39.0	44.0	49.0	0.27
Buttock to Knee Length	53.9	55.0	54.0	30.5	62.6	3.33	48.7	54.0	58.3	0.33
Belly Depth	23.7	24.0	24.0	14.2	35.6	3.83	18.0	24.0	30.0	0.15
Chest Depth	22.0	20.0	21.8	16.8	44.3	2.96	18.1	21.8	26.0	0.14
Forearm to Hand Length	44.6	44.0	45.0	35.0	49.2	2.06	41.0	45.0	47.6	0.28
Forward Reach	69.9	70.0	70.0	57.3	77.2	3.48	64.2	70.0	75.2	0.43
Sitting Upward Reach	166.3	164.8	168.2	124.0	188.1	10.90	144.7	168.2	180.0	1.03
Breadth across elbow	41.7	43.0	41.5	31.0	55.0	4.77	34.1	41.5	50.0	0.26
Sitting hip breadth	34.7	36.0	34.5	24.0	55.2	3.84	29.1	34.5	41.7	0.21

Table 6. Statistical analysis of anthropometric data of male rice farmers in other measurements.

MEASUREMENT	MEAN	MODE	MEDIAN	MIN	MAX	StDev	5 th	50 th	95 th	CV
Hand Length, cm	18.0	17.0	18.0	10.0	21.0	1.36	16.0	18.0	20.0	0.11
Hand Breadth, cm	8.4	8.5	8.3	7.0	11.0	0.66	7.5	8.3	9.5	0.05
Foot Length, cm	24.3	24.0	24.0	20.0	29.0	1.41	22.0	24.0	27.0	0.15
Foot Breadth, cm	10.0	10.0	10.0	8.1	12.2	0.87	8.7	10.0	11.8	0.06
Grip Diameter, cm	4.3	4.1	4.2	2.3	37.7	2.65	3.6	4.2	4.6	0.03
Weight, kg	65.5	78.1	63.6	46.4	102.0	11.23	50.2	63.6	85.2	0.40

measurements were hand length, hand breadth, foot length, foot breadth, grip diameter, and weight. The 5th, 50th, and 95th percentiles of weight were 50.2 kg, 63.6 kg, and 85.2 kg, respectively. None of these measurements is correlated with standing height. Hand length and breadth are relevant in designing handles with appropriate grip dimensions for comfort and functionality. Foot length and breadth are important for designing footwear that provides proper fit and support for farm work and foot pedals incorporated in agricultural machinery. Data on weight can be used in combination with other measurements to ensure that the equipment was designed to support the load of the operator.

One possible application of the anthropometric profile of male farmers of Oriental Mindoro is in designing locally made two-wheel tractors. Among the design parameters of the two-wheel tractor where the anthropometric profile is crucial are the handle-to-handle distance, handle height, handle diameter, and handle length, among others.

An appropriate distance between handles ensures that the operator can grip it comfortably without stretching or straining his arms. The handles must be spaced adequately to accommodate the operator's overall body width to maintain the shoulder abduction angle within an acceptable range. Shoulder abduction refers to the movement away from the body's midline, and the shoulder abduction angle is the angle formed between the body's midsection and the upper arm as the elbow extends sideways. Recommended shoulder abduction angles typically range from 0 to 34 degrees (Openshaw et al., 2006). Despite the natural range of motion of the human body, it is crucial to ensure that the movement falls within the appropriate range to enhance both comfort and safety during operation. Keeping shoulder abduction angle within the recommended range allows operators to maintain

proper posture and exert force efficiently without experiencing strain or injury (Bridger, 2003).

The handle height should be carefully adjusted to avoid both excessive shoulder abduction and forward bending. Forward bending during activities can lead to significantly increased compressive stress on the vertebrae compared to standing upright. Bridger (2003) also emphasized the importance of positioning the handle below the elbow and above the hips to reduce fatigue and elbow stress. Determining the appropriate handle height requires consideration of various anthropometric dimensions.

During operation, the operator typically employs a power grasp, wherein the entire surface of the hand grips the handle, aligned parallel to the knuckles and often extending from one or both sides of the hand. Various research has affirmed the significance of comprehending the strength and range of motion capabilities of the hand and wrist, alongside the methodologies used to assess them, in design practices aimed at reducing the occurrence and severity of work-related upper extremity disorders. Karwowski (2005) enumerated many factors affecting hand and wrist strength and mentioned that grip strength resulting from a wraparound or power grip results from forces generated by all the fingers acting together. Furthermore, handles that are properly designed enhance both the safety and comfort of the operator (Matuszek and Drobin, 2018).

The length of the handle is a critical aspect in the design of a two-wheel tractor. A handle that is too short can compromise the operator's safety as it may result in insufficient space between the operator's feet and the implement. Conversely, a handle that is too long can lead to discomfort for the operator resulting in difficulty in controlling and balancing the tractor.

Comparison of Anthropometric Data of Oriental Mindoro and Laguna

An unpaired t-test was used to compare the mean of the anthropometric body measurements in the standing position of male rice farmers in the provinces of Oriental Mindoro and Laguna, Philippines, as presented in Table 7. Anthropometric data from Laguna, Philippines was selected as the basis of comparison because to date, only Laguna has an established anthropometric data for agricultural applications in the Philippines. The sample size of Oriental Mindoro was 162 while in Laguna was 123. By comparing the value of P with the 95% confidence interval of the difference, it was found that the standing height, standing eye height, standing hip breadth, standing shoulder breadth, head circumference, standing upward reach, and total span were not statistically significant. On the other hand, standing shoulder height and sideways reach were very statistically significant while standing elbow height, knuckle height, chest girth, and arm length were extremely statistically significant.

Presented in Table 8 is the unpaired t-test of the anthropometric body measurements in a sitting position of male rice farmers in the province of Oriental Mindoro and Laguna, Philippines. Results showed that eye height above seat, elbow height above the seat, thigh clearance, chest depth, forearm-to-hand length, and breadth across elbow were not

statistically significant. On the other hand, sitting height, seat height, and sitting hip breadth were very statistically significant while shoulder to elbow length, sitting knee height, buttock to popliteal length, buttock to knee length, and forward reach were extremely statistically significant.

Summarized in Table 9 is the unpaired t-test of the anthropometric body measurements in other measurements of male rice farmers in the province of Oriental Mindoro and Laguna, Philippines. Based on the results of the analysis, hand breadth and foot breadth were not statistically significant. On the other hand, hand length and weight were very statistically significant while foot length and grip diameter were extremely statistically significant.

In summary, 15 of the anthropometric data were not statistically significant while 18 were statistically significant. This only indicates that the physique of male farmers from Laguna was different from Oriental Mindoro. These variation in body measurements suggest that region-specific anthropometric data could be essential in optimizing the ergonomic design of locally made agricultural tool, machinery and workstations. If ergonomics is one of the design criteria, local anthropometric data should be used, however, in the absence of local data, existing anthropometric data can be considered. In some cases, adjustable design was made to consider a larger population.

Table 7. Unpaired t-test of anthropometric data in standing position of male rice farmers in Oriental Mindoro and Laguna, Philippines.

MEASUREMENTS	ORIENTAL MINDORO			LAGUNA			95% CONFIDENCE INTERVAL OF THE DIFFERENCE		SED	t	df	P (2-tailed)
	Mean	SD	SEM	Mean	SD	SEM	Lower	Upper				
Standing Height	161.9	6.13	0.48	161.8	6.25	0.56	-1.526	1.384	0.739	0.0959	283	0.9237 ^{ns}
Standing Eye Height	151.4	6.15	0.48	150.4	6.13	0.54	-2.440	0.431	0.729	1.3768	283	0.1697 ^{ns}
Standing Shoulder Height	135.3	5.90	0.46	133.3	5.98	0.54	-3.332	-0.539	0.710	2.7277	283	0.0068
Standing Elbow Height	102.9	5.16	0.41	100.8	4.97	0.45	-3.247	-0.854	0.608	3.3730	283	0.0008
Standing Knuckle Height	68.2	3.84	0.30	65.4	3.11	0.28	-3.655	-1.985	0.424	6.6506	283	0.0001
Standing Hip Breadth	32.1	3.02	0.24	32.0	4.28	0.39	-1.006	0.697	0.433	0.3574	283	0.7210 ^{ns}
Chest Girth	91.1	8.37	0.66	88.2	7.23	0.74	-5.287	-1.379	0.993	3.3579	283	0.0009
Standing Shoulder Breadth	42.8	3.13	0.25	42.7	3.06	0.28	-0.855	0.603	0.370	0.3409	283	0.7334 ^{ns}
Head Circumference	54.8	3.07	0.24	55.0	1.85	0.35	-0.910	0.713	0.412	0.2385	283	0.8116 ^{ns}
Standing Upward Reach	203.3	11.69	0.92	205.6	8.57	0.77	-0.157	4.768	1.251	1.8432	283	0.0663 ^{ns}
Arm Length	50.0	5.34	0.42	51.8	3.04	0.31	0.912	3.087	0.553	3.6184	283	0.0004
Sideways Reach	85.3	4.13	0.32	84.0	3.75	0.34	-2.226	-0.357	0.475	2.7207	283	0.0069
Total Span	169.9	14.04	1.10	168.0	7.50	0.68	-4.600	0.899	1.397	1.3247	283	0.186 ^{ns}

Note: ^{ns} - not statistically significant

Table 8. Unpaired t-test of anthropometric data in sitting position of male rice farmers in Oriental Mindoro and Laguna, Philippines.

MEASUREMENTS	ORIENTAL MINDORO			LAGUNA			95% CONFIDENCE INTERVAL OF THE DIFFERENCE		SED	t	df	P (2-tailed)
	Mean	SD	SEM	Mean	SD	SEM	Lower	Upper				
Sitting Height	83.5	5.95	0.47	85.5	3.43	0.31	0.791	3.155	0.601	3.2855	283	0.0011
Eye Height Above Seat	73.7	3.46	0.27	74.1	3.34	0.30	-0.382	1.220	0.407	1.0290	283	0.3044 ^{ns}
Shoulder to Elbow Length	34.7	2.71	0.21	32.5	1.53	0.14	-2.740	-1.668	0.272	8.0908	283	0.0001
Elbow Height Above Seat	23.4	2.39	0.19	22.9	1.12	0.10	-0.902	0.015	0.233	1.9045	283	0.0579 ^{ns}
Seat Height	42.6	2.99	0.24	43.2	1.70	0.15	0.001	1.185	0.301	1.9720	283	0.0496
Sitting Knee Height	46.8	5.01	0.39	51.7	1.95	0.18	3.966	5.845	0.477	10.280	283	0.0001
Thigh Clearance	10.4	3.03	0.24	10.8	1.28	0.12	-0.132	1.015	0.291	1.5156	283	0.1307 ^{ns}
Buttock to Popliteal Length	44.0	3.13	0.25	46.3	2.19	0.20	1.594	2.895	0.331	6.7883	283	0.0001
Buttock to Knee Length	53.9	3.34	0.26	56.7	2.57	0.23	2.078	3.504	0.362	7.7030	283	0.0001
Chest Depth	22.0	2.97	0.23	22.3	2.24	0.20	-0.391	0.871	0.321	0.7480	283	0.4551 ^{ns}
Forearm to Hand Length	44.6	2.06	0.16	44.9	2.02	0.18	-0.154	0.809	0.245	1.3378	283	0.1820 ^{ns}
Forward Reach	69.9	3.49	0.27	83.5	5.04	0.46	12.537	14.528	0.506	26.747	283	0.0001
Breadth Across Elbow	41.7	4.78	0.38	42.5	3.54	0.32	-0.161	1.858	0.513	1.6540	283	0.0992 ^{ns}
Sitting Hip Breadth	34.7	3.85	0.30	36.5	5.81	0.52	0.679	2.936	0.573	3.1523	283	0.0018

Note: ^{ns} - not statistically significant**Table 9. Unpaired t-test of anthropometric data in other measurements of male rice farmers in Oriental Mindoro and Laguna, Philippines.**

MEASUREMENTS	ORIENTAL MINDORO			LAGUNA			95% CONFIDENCE INTERVAL OF THE DIFFERENCE		SED	t	df	P (2-tailed)
	Mean	SD	SEM	Mean	SD	SEM	Lower	Upper				
Hand Length	18.0	1.36	0.11	17.5	1.36	0.12	-0.857	-0.217	0.163	3.3041	283	0.0011
Hand Breadth	8.4	0.66	0.05	8.4	0.71	0.06	-0.131	0.191	0.082	0.3697	283	0.7119 ^{ns}
Foot Length	24.3	1.41	0.11	25.4	1.48	0.13	0.757	1.435	0.172	6.3567	283	0.0001
Foot Breadth	10.0	0.87	0.07	9.9	0.80	0.07	-0.365	0.030	0.100	1.6737	283	0.0953 ^{ns}
Grip Diameter	4.3	2.66	0.21	4.5	0.28	0.03	-1.318	-0.369	0.241	3.4976	283	0.0005
Weight	65.5	11.27	0.89	61.6	9.96	0.90	-6.464	-1.415	1.283	3.0713	283	0.0023

Note: ^{ns} - not statistically significant

Differences in the anthropometric profile of male farmers of Laguna and Oriental Mindoro can arise from several factors including nutritional intake, physical activity and workload, socioeconomic conditions, and healthcare access. For nutritional intake, farmers might have more diverse dietary options due to proximity to markets with increasing urbanization and industrialization in parts of Laguna (Pelobello et al., 2023) while farmers in Oriental Mindoro often depend on locally available produce and have limited market access that may constrain dietary diversity (PhilRICE, 2024). In terms of physical activity and workload, farmers in both provinces engage in physically demanding tasks, but variations in farm sizes and cropping patterns could influence energy expenditure. Smaller farm sizes in Laguna and a trend toward mixed agricultural-

industrial work might reduce total physical activity (Pelobello et al., 2023) compared to larger farm sizes in Oriental Mindoro where periods of labor-intensive activity were prolonged (PhilRICE, 2024). For socioeconomic conditions, urban proximity in Laguna might provide higher secondary incomes allowing for improved nutrition and healthcare access while in Oriental Mindoro, with a primarily agrarian economy, farmers may have less disposable income for healthcare and diet improvements. In terms of healthcare access, Laguna has better healthcare facilities and programs especially near urban centers while Oriental Mindoro has limited access to healthcare due to rural isolation, contributing to disparities in health and nutritional outcomes (Pelobello et al., 2023). Traditional dietary habits and perception of health vary across provinces

and can affect body composition. For instance, reliance on carbohydrate-heavy diets may be more prevalent in areas with limited food diversity. Thus, anthropometric profile difference among male farmers of Laguna and Oriental Mindoro reflects a combination of geographic, economic, and social factors that influence both lifestyle and nutritional status.

CONCLUSION

This study provides valuable anthropometric data on male rice farmers in Oriental Mindoro, Philippines. The findings reveal an aging farming population with an average age of 51 years, highlighting the need for age-appropriate and ergonomic agricultural tools and machinery.

The statistical analysis of anthropometric measurements in standing, sitting, and other positions provides vital insights for designing ergonomic agricultural equipment. Key findings include significant correlations between standing height and various body measurements, emphasizing the importance of this parameter in design considerations.

Comparison with existing anthropometric data from Laguna, Philippines, revealed significant differences in several body measurements, highlighting the importance of region-specific anthropometric data for optimal ergonomic design. Factors such as nutrition, physical activity, socioeconomic conditions, and healthcare access likely contribute to these inter-regional variations.

These findings emphasize the need for region-specific anthropometric data to be incorporated into the design and development of agricultural tools and machinery in the Philippines. This will ensure that these tools are better suited to the physical characteristics and needs of the Filipino farming population, ultimately improving their comfort, safety, and productivity.

RECOMMENDATIONS

In the design of local agricultural tool, machinery and workstation, anthropometric data plays a vital

role. Tailoring these designs to the physique of the user can prevent musculoskeletal disorders, thereby enhancing efficiency in labor inputs and productivity. However, there are limited anthropometric data of male farmers in the country, thus, data collection in different regions of the country is necessary.

Application of these generated data sets in the design of local agricultural tool, machinery, and workstation is highly recommended to develop a comfortable fit for users and not just the functionality of the design. It is therefore recommended to use the generated anthropometric profile of male farmers of Oriental Mindoro in designing locally made agricultural technology.

To promote gender equality in the province, it is recommended to collect also the anthropometric profile of female farmers in Oriental Mindoro. The collected data can be used in the design of gender-sensitive agricultural technologies.

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