Available online at: http://publikasi.mercubuana.ac.id/index.php/ijiem

IJIEM (Indonesian Journal of Industrial Engineering & Management)

ISSN (Print) : 2614-7327 ISSN (Online) 2745-9063

Hand Dimensions of Mechanics, Carpenters and Welders in Lagos, Southwestern Nigeria

Thomas Monday Onaivi, Sunday Ayoola Oke*
Department of Mechanical Engineering, University of Lagos, Lagos, 100213, Nigeria

ARTICLE INFORMATION

Article history:

Received: 22 September 2020
Revised: 05 October 2020
Accepted: 18 October 2020

Category: Research paper

Keywords:
Hand
Measurement
Index
Mechanics
Welders

A B S T R A C T

This paper presents the research conducted on three tradesmen, the mechanics, carpenters, and welders, to measure and compare the left and right hands' dimensions and evaluate the hand index to understand the measurements. Despite rea's utility, the area's utility research has analyzed these technical personnel's hand characteristics. Compared with manufacturing systems, small businesses and entrepreneurs are loss studied. Still, opportunities abound to recognize, appraise, and explore novel instances associated with new product development with detailed information on their hand measurements. Data was collected from mechanics, carpenters, and welders rating in Lagos, Nigeria. The analysis is divided into hand measurements, finger measurements, hand index of the mechanics, carpenters, and welders. The subjects ranged between 18 and 60 years, and measures were made while the subject stands erect. Vernier caliper and tape rules were made. Data concerning heights, hand's height and width, and other aspects of the hand were collected. It was observed that the carpenters have higher values of the hand length to the right third finger. By comparing the mechanics and welders, the mechanics have higher values throughout the experiment. The subjects' heights for carpenters have the highest values. The right and left-hand dimensions are close for the mechanics. There is a greater deviation for the left and right hand for the welders. The deviation is also observed for the carpenters.

*Corresponding Author
Sunday Ayoola Oke
E-mail: sa_oke@yahoo.com

1. INTRODUCTION

The human hand, a flexible part of the human skeleton, comprises bones, vessels and nerves, muscles, joints, ligaments, and tendons. A brief literature review follows. Bayraktar and Ozsahin (2018) obtained diverse anthropometric evaluations of high school students' hands and grouped them using the Krogiman indicators' lowsator. Measures of male right-hand lengths and widths were 183.9 0.88mm and 87.54 0.70mm, correspondingly. However, the hand index was 47.58, and the grouping using the Krogman hand indicator is brachyury. Measures of female right-hand lengths and widths were 169.75 2.01 mm and 77.63 1.21mm, correspondingly.

Nonetheless, the hand index was 45.72, and the grouping using the Knogman hand indicator is mesospheric. It was concluded that hand measurement variability exists because of genetic gender, environmental, and age factors in populations. Lee and Jung (2015) presented a literature review to showcase approaches used to appraise the hand function. The aspect of biomechanics that covers Kinetics, anthropometry electromyography, and Kinematics were discer-ned.

Shahriar et al. (2020) collected a dataset on anthropometry of hand measurements from farmworkers in Bangladesh. It was revealed that male hand dimensions were more than female owns. The contradictory size was observed in the Bangladeshi populace's weight against other populace. Alahman et al. (2019) studied school children in their hand dimension variation, focusing on percentage changes and their association with punch and grip strength. It was reported that the charges in hand dimensions in all genders showed statistically significant results. The punch strength, coupled with the handgrip, revealed significant association side-by-side of anthropometric evaluations and hand measurement. A further result revealed a weak association between body mass index and punch strength, and handgrip strength. It was also reported that palm length, hand length, age, hand span, and hand circumference exhibited modest to robust association with punch and grip strength.

Furthermore, the human hand enables craftsmen and artisans in trades such as mechanics, carpentry, and welding to engage in tasks requiring lifting, carrying, gripping, holding and turning (Mii et al., 2009; Sohara et al., 2014; Shahriar et al., 2020). Several articles have recognized the importance of hands in several vocations and instances such as schooling and education (Alahmari et al., 2019), welders (Alexander et al., 2016), carpenters (Heycock, 1966; Hammarskjöld et al., 1989, 1991; Cuendet et al., 2014), mechanics (Danborno and Elukpo, 2008; Mii et al., 2009; Sohara et al., 2014; De Langhe et al., 2015), farming (Dewangan et al., 2005; Vyavahare and Kallurkar, 2016; Shahriar et al., 2020), structural steelworkers (Lee and Cho, 2006). Discussion on the control of hand damages through vocations was initiated close to half a century ago in the occupational safety and health literature (Haycock, 1966). Haycock (1966) championed one of the discussions noting that injuries to hands may be substantial, requiring reconstruction and surgery. Although this information provided the foundation for today's studies on hand management invocations, particularly in the carpentry work, the theme is mostly varied from hand measurements. It may not provide suitable information in new hand tools development.

Besides, Mii et al. (2009), Sahara et al. (2015) examines the mechanics vocation. For the carpentry vocation, Uendet et al. (2014), Lee and Cho (2006), and Hammarskjold et al. (1989) discussed the centrality of the hand in the effective functioning of artisans/craftsman during the vocational practice. For welding, Alexander et al. (2016) recognized the importance of hands in the welding vocation. Severally in these publications, the emphasis has been placed on safety issues and the diseases associated with hands in the various vocations (Hammarskjold et al. 1989; Lee and Cho, 2006; Mii et al., 2009; Sohara et al., 2014; De Langhe et al., 2019; Alexander et al., 2016). Yet, little is known concerning the hand's dimensions in the various groups within the developing countries, particularly in Nigeria.

Consequently, it is essential to understand the hand measurements for these vocations for progress in new product developments associated with hand use. This information will help us learn about the conditions and diseases that affect these artisans and craftsmen's hands. Vyavahare and Kallurkar (2016) argued for hand measurements' beneficial effects: reducing drudgery, enhancing

efficiency, comfort, and safety. This paper presents the research conducted on three vocations, namely, mechanics, carpentry, and welding, to measure and compare the left and right hands' dimensions and evaluate the hand index to understand the measurements. A brief review of the literature is essential to understand the available gap. Alexander et al. (2016) analyzed the frequency of health challenges and wore protective devices among India welders. They reported welding-associated trauma regarding the welders' hand. Cuendet et al. (2015) analyzed the stage and development of special skills in carpenters' training in Switzerland. It was reported that carpenter enhanced their skills over the preliminary training given to them.

Lee and Cho (2006) appraised carpenters' workload and related it to posture, behavior, and individual sensitivity. It was declared that the approach infeasible. Hammarskjold et al. (1991) examined the impact of severe vibration experience in manual accomplishment. Ten subjects conducted three activities (screwing, nailing, and sawing). It was reported that the most effective muscles, having EMG average values greater than 10%EMGmax, were trapezius (average values of 9-12%EMGmax, infraspinatus (average 6-18%EMGmax and flexor digitorum (average 15-21%EMGmax). Hammarskjold et al. (1989) developed a model to analyze the probable new causal factors of accidents with the construction industry and related the study to carpenter's hand tools using hands. It was declared that the anticipated strain was regularly associated with three separated stages while screwing was positioned as the hardest and hammering was rated as the easiest.

De Langhe et al. (2015) elaborated on a cause study of a woman's mechanics hands that were presented with dyspnea, Raynaud's incident, and slight growth in the eyelids and fingers. However, the diagnosis of interstitial lung disease and a suspected tissue disease was the case's outcome. In a similar study, Sohara et al. (2014) presented a clinical case of mechanic's hands linked to vascular diseases. In conclusion, the authors asserted that the occurrence of mechanic's hands with several skin lesions might be a sign to diagnose lung's participation regarding collagen vascular diseases. Mii et al. (2009) established the features of clinic and histopathologic outcomes regarding mechanics hands and verified if these two instances may be separated through histopathologic results concerning mechanic's hands are particular and varied from these concerning eczema.

In Nigeria, mechanics, carpenters, and welders are the three most common small scale business vocatives. The mechanics are a skilled person that works on vehicles, has mechanical inclination and hands-on experience on how the engine works. The mechanics work with tools requiring hands in their management. The carpenter is a skilled craftsman competent to build vehicular bodies (wood-based and building construction jobs. Carpenters use hands with diverse tools to shape and cut wood. The welder is a skill in fabrication processes where metals are joined under high heat. Besides, the welder repairs and fills holes on metal constructions in vehicles. From the foregoing, through the lens of selection, the three trades, namely mechanics, carpentry, and welding, were selected because of their relevance to vehicles. All these trades have functions in the repairs and maintenance of vehicles. For instance, the carpenter is needed for the upholstery works within the vehicle; the mechanic is responsible for the engine repairs, while the welder is needed to do repairs concerning joining metals within and outside the vehicles.

Interestingly, this is the first article to study these three trades' hand measurements concerning vocations in Lagos, Nigeria, and the developing countries in general. Unfortunately, the utility of this research area, limited research has analyzed the hand characteristics of these three vocations in one study. However, opportunities abound to recognize, appraise, and explore novel instances associated with new tools development with detailed information on their hand measurements. This study compares the left and right-hand dimensions and hand index to comment on any notable differences.

2. LITERATURE REVIEW

2.1. Study sample

The 54 participants were drawn from a cohort comprising of 10 carpenters, 13 welders, and three mechanics representing carpenters, welder, and mechanics in metropolitan Lagos. The mode of observation is the physical measurement of the subjects. The use of a tape and vernier caliper was

made as measurement instruments (Fig.1, Fig 2, and Fig 3).

Fig. 1. Tape rule

Fig. 2. Finger length

Fig. 3. Hand length

The subjects were randomly approached and, based on their consent, measured with our instruments. Finger measurements were made as the subjects were asked to release their left and right hands for measurements. This was measured using an a vernier caliper. Accordingly, the left fingers labeled as L1, L2, L3, L4, and L5 were measured, and the right fingers, labeled as R1, R2, R3, R4, and R5, were likewise measured. The lengths and breadths of the hands were accordingly measured. Based on the standard measures, the following were measure: left-hand breadth, left-hand palm thickness, right-hand length, right-hand breadth, right-hand thickness. All these measures relate to hand measurements. For the finger measurement, the following were evaluated: lengths of the left thumb left first fingers, left second finger, left third finger, right thumb, right first finger, right second finger, right third finger, and right fourth finger. Heights of subjects were also measured.

2.2. Hand measurements

In Aginhotri et al. (2007) and Fessler et al. (2005), indices regarding the foot were described and used to evaluate the human population of interest. The hand index formulations were obtained in Equations (1) to (8) by adopting these indices to hand. Besides, these formulations were screened with several other authors' suggestions, including Krishan and Sharma (2007), Kanchan et al. (2010), and elements from these studies were used to refine the definitions. In this work, the hand index refers to the hand bread ratio to the hand length. However, further hand index measurements, among others, relates each of the numeration and denominator of the hand index with the palm thickness. These are stated in Equations (2) and (3). Besides, the further hand index measurement finds the ratio of each of the fingers such as the thumb, first, second, third and fourth fingers on the left-hand side to the right-hand side. These are expressed in Equations (4) to (8).

$$\text{The Hand Index} = \frac{\text{hand breadth}}{\text{hand length}} \times 100 \quad (1)$$

where mean = $\frac{\Sigma x}{N}$

Hand index be PT-HL, showed as (Palm thickness/hand length) × 100 (2)

Hand Index PT-HB be (Palm thickness/hand-breadth) × 100 (3)

Hand Index be LT-RT for (Left thumb/Right thumb) × 100 (4)

Hand index be RFF-LFF = (Right-hand first finger/left-hand first finger) × 100 (5)

Hand index, RSF-LSF = (Right-hand second finger/left hand second finger) × 100 (6)

Hand index, LTF-RTF = (Left-hand third finger/Right hand third finger) × 100 (7)

Hand index be LFF-RFF = (Left-hand fourth finger)/(Right-hand fourth finger) ×100 (8)

2.3. Data collection method

The data was collected from the randomly chosen Lagos workshops, based on receiving positive responses from the owners. The workshops are those whose occupations are mechanics, carpentry, and welding. The instrument used for data collection includes the vernier caliper and tape rule. In the data collection, the subjects' age was fixed between 18 and 60 years is an inclusion criterion. Besides, the subjects were measured while ensuring that they stand erect. The tape rule was then used to measure their heights. However, other measures such as the hand length and hand width were obtained using the vernier caliper and recorded against the subjects' names. It should be noted that while the hand dimensions of the subject were measured using the vernier caliper, they were instructed to position the hands in straight positions. Accuracy using the measuring instrument was ensuring to avoid the error of parallax.

The estimated population of the studied area at the time of investigation was 11,008, 357. But the sample drawn was 54 participants which reveal the limitation of the sample size for generalization of the results of the study. Consequently, the use of a higher statistically relevant sample size is required for future studies. The mindset at carrying out this study was to have a preliminary result, which has been achieved in the study. However, a sample size of scientific interest may be evaluated for a comprehensive study of the phenomenon discussed here based on the following. The hypothesis may be specified for testing with a test of the level of significance to specify the least influential size to study, which may be of scientific interest. Then the values of the other parameters may be approximated to calculate the power function. Besides, the anticipated power may be specified, and the final computation made.

3. RESULTS AND DISCUSSION

The results of the study are shown in Tables 1(hand measurements), Table 2 to Table 6 (finger measurements), Table 7 (hand indices), and Table 8 (summary of mean results).

Table 1. Hand measurements of people in the mechanic section

S/No.	Name	A	B	C	D	E	F
1	Mr. Abolaji	19.10	8.33	3.66	19.50	8.30	3.90
2	Mr. Julius	20.56	8.50	3.64	19.90	8.50	3.72
3	Mr. Sunny	18.80	7.40	3.40	19.60	7.84	3.50
4	Mr. Vincent	19.17	7.56	3.80	18.70	7.40	3.50
5	Mr. Ebebe	20.36	7.75	3.80	19.60	7.75	3.74
6	Mr. Bernard	20.90	8.43	3.77	20.90	8.56	3.65
7	Mr. Daniel	20.50	7.98	3.50	19.96	7.90	4.00
8	Mr. Olakunle	22.00	8.80	3.90	22.60	8.48	4.30
9	Mr. Udoh	19.30	7.96	3.57	19.40	7.57	3.70
10	Mr. Saheed	19.10	7.80	3.20	19.40	7.70	3.46
11	Mr. Lawal	17.17	8.10	3.70	17.14	8.30	4.00
12	Mr. Razak	19.90	8.00	3.80	20.90	8.30	4.00
13	Mr. Dada	20.26	8.35	3.70	18.50	7.86	3.78
14	Mr. Odun	21.20	8.80	3.90	21.80	8.70	3.70
15	Mr. Lateef	20.20	7.80	4.10	20.50	8.10	3.80
16	Mr. Sule	18.90	7.90	3.70	18.40	8.00	3.40
17	Mr. Saheed	19.60	7.50	3.90	19.60	7.70	3.20
18	Mr. Sule 1	20.30	7.95	3.60	20.10	8.20	3.70
19	Mr. Afeez	19.10	8.39	4.00	19.40	8.40	4.18
20	Mr. Ola	19.60	7.77	3.90	19.50	7.80	3.90
21	Mr. Ahmed	20.30	7.80	3.70	19.80	7.80	3.70
22	Mr. Ganiu	18.80	8.40	3.80	18.40	8.20	3.60
23	Mr. Razak	20.80	8.30	3.70	21.00	7.70	3.70
24	Mr. Cole	18.50	8.00	3.50	18.30	7.90	3.70

Table 1. Hand measurements of people in the mechanic section (continued)

S/No.	Name	A	B	C	D	E	F
25	Mr. Tunde	18.80	8.10	3.70	18.60	8.07	4.10
26	Mr. Tunde1	18.60	7.30	3.40	18.70	7.30	3.30
27	Mr. Paul	19.00	8.20	3.50	19.20	8.40	3.60
28	Mr. Joseph	19.10	7.80	3.40	19.20	8.00	3.60
29	Mr. Emmanuel	18.80	7.80	3.30	18.30	7.80	3.70
30	Mr. Adeyemi	19.20	8.10	3.70	19.40	7.90	3.60
31	Mr. Samuel	19.30	8.00	3.60	18.20	8.00	3.60

A - left hand's length (cm); B - left hand's breadth (cm); C - left hand's palm thickness (cm); D - right hand's length (cm); E - right hand's breadth (cm); F - right hand's palm thickness (cm)

Table 2. Finger measurements of people in the mechanic section

S/No.	Name	Left hand from thumb (cm)					Right hand from thumb (cm)					Height
		L1	L2	L3	L4	L5	R1	R2	R3	R4	R5	(feet)
1	Mr. Abolaji	6.50	7.33	7.84	7.40	5.73	6.90	7.10	7.73	7.35	5.10	5.63
2	Mr. Julius	6.40	7.24	8.20	6.90	5.50	6.43	7.16	7.85	7.34	5.54	5.83
3	Mr. Sunny	6.60	6.65	7.60	7.25	5.90	7.70	6.75	7.40	6.90	5.45	5.56
4	Mr. Vincent	5.90	6.30	7.20	6.60	5.00	7.10	6.51	7.10	6.54	5.22	5.50
5	Mr. Ebebe	6.20	6.80	7.80	7.00	5.46	7.75	6.80	7.77	7.00	5.60	5.15
6	Mr. Bernard	6.70	7.76	8.70	7.30	5.68	7.35	7.40	8.50	7.56	6.00	5.83
7	Mr. Daniel	6.20	6.96	7.97	7.10	6.20	6.94	7.10	8.00	7.50	6.15	5.67
8	Mr. Olakunle	8.50	8.27	9.40	8.60	6.15	7.40	8.20	9.46	8.65	6.57	6.08
9	Mr. Udoh	6.80	6.60	7.60	6.40	4.80	6.50	6.40	6.90	6.26	5.20	5.70
10	Mr. Saheed	6.30	7.10	7.80	7.70	6.00	6.20	6.80	8.00	7.70	6.30	5.50
11	Mr. Lawal	5.90	6.57	7.25	6.65	4.85	4.70	6.16	6.50	6.40	4.80	4.91
12	Mr. Razak	7.10	7.20	7.60	7.40	5.50	7.10	7.00	7.85	7.70	5.60	5.58
13	Mr. Dada	7.00	7.00	7.60	7.40	5.60	6.80	6.70	7.40	6.80	5.70	5.58
14	Mr. Odun	6.90	7.20	8.30	7.70	5.70	6.40	7.20	8.30	7.80	5.80	5.98
15	Mr. Lateef	6.20	7.50	8.20	7.40	5.70	6.70	7.50	8.50	7.40	6.10	6.03
16	Mr. Sule	6.20	6.00	7.00	6.80	5.20	6.10	6.08	7.00	6.50	4.60	5.58
17	Mr. Saheed	7.10	7.30	7.90	7.40	7.30	7.40	7.00	8.10	7.50	6.20	5.12
18	Mr. Sule 1	6.84	7.10	8.16	7.90	6.40	7.10	6.90	8.10	8.20	6.20	6.08
19	Mr. Afeez	5.80	7.20	7.80	7.30	5.30	5.70	7.30	7.80	6.80	5.70	5.67
20	Mr. Ola	6.50	7.00	8.10	7.20	5.40	6.55	7.00	8.20	7.30	5.50	5.73
21	Mr. Ahmed	7.50	7.80	8.60	7.60	5.90	7.50	7.50	8.30	7.60	5.40	5.75
22	Mr. Ganiu	6.90	6.60	7.60	7.30	5.50	7.10	6.90	7.40	7.10	5.00	5.42
23	Mr. Razak	7.40	7.60	8.10	7.60	6.00	7.50	7.20	8.00	7.30	5.70	5.88
24	Mr. Cole	6.00	6.70	7.60	7.00	5.00	6.40	6.40	7.90	7.30	4.90	5.21
25	Mr. Tunde	6.50	6.80	7.60	7.20	7.40	6.30	6.50	7.50	7.40	5.80	5.58
26	Mr. Tunde1	5.90	6.60	7.20	6.60	5.50	5.90	6.60	7.40	6.80	5.30	5.17
27	Mr. Paul	6.10	6.80	7.60	6.90	5.50	5.60	6.60	7.40	6.80	5.30	5.17
28	Mr. Joseph	6.40	6.90	7.70	7.30	5.30	6.60	7.00	7.60	7.30	5.40	5.67
29	Mr. Emmanuel	6.00	6.50	7.60	6.80	5.20	6.10	6.50	7.60	7.00	5.00	5.29
30	Mr. Adeyemi	6.90	7.40	8.00	7.40	5.90	7.00	7.30	7.80	7.10	5.30	5.58
31	Mr. Samuel	6.20	6.60	7.90	7.00	5.50	6.30	6.30	7.30	6.60	5.50	5.71

L1, L2, L3, L4 and L5 – parts of the left hand; R1, R2, R3, R4 and R5 – parts of the right hand

Table 3. Hand measurement of people in the welding workshop

Names	Left hand length (cm)	Left hand breadth (cm)	Left hand thickness (cm)	Right hand length (cm)	Right hand breadth (cm)	Right hand thickness (cm)
Mr.Samson	17.60	7.57	4.00	17.15	7.64	4.16
Mr. Banjo	18.67	8.20	4.46	18.87	8.30	4.00
Mr. Sola	18.80	7.45	3.17	18.30	7.60	3.10
Mr. Tunde	18.90	8.50	3.50	19.00	8.20	3.80
Mr. Femi	19.80	7.90	3.80	19.20	8.00	3.80
Mr. Ajayi	17.60	7.40	3.60	17.20	7.30	3.30
Mr. Ola	19.50	8.30	3.70	19.80	8.00	3.70
Mr. Mustapha	18.40	7.60	3.20	17.10	7.60	3.20
Mr..Mummy	19.60	8.20	3.70	19.50	8.30	3.77
Mr. Aminu	19.90	8.30	4.00	18.50	8.20	3.90
Mr. Samuel	19.04	7.60	3.20	19.20	7.20	3.60
Mr. Shakiru	20.10	8.10	3.6	20.03	7.96	3.70
Mr. Abiodun	19.20	7.80	3.20	19.30	7.90	3.20

Table 6. Finger measurements of people in the carpentry section

S/No.	Names	Left hand (cm)					Right hand (cm)					Height (feet)
		L1	L2	L3	L4	L5	R1	R2	R3	R4	R5	
1	Mr. Akintoyin	6.60	7.80	7.70	7.20	5.40	6.90	7.46	7.96	7.40	5.80	5.50
2	Mr. Saheed	7.20	6.90	8.10	7.40	6.05	7.50	7.30	8.00	7.60	6.10	5.75
3	Mr. Ibrahim	6.90	7.20	8.20	7.10	5.70	6.80	6.90	7.80	7.40	6.00	5.25
4	Mr. Femi2	6.80	6.80	7.70	6.80	4.70	6.60	7.10	7.15	6.30	4.50	5.67
5	Mr. Bello	7.20	7.60	8.70	7.80	5.90	6.40	7.50	8.60	8.00	6.04	5.33
6	Mr. Ayo	6.80	6.80	8.00	7.40	5.50	7.00	7.10	8.30	7.70	5.80	5.79
7	Mr. Tunde	6.60	6.50	7.30	7.00	5.20	6.90	6.60	7.40	6.40	5.20	5.25
8	Mr. John	7.40	7.30	8.05	7.70	5.80	7.30	7.20	7.80	7.60	5.70	5.92
9	Mr. Azeez	7.20	7.70	8.90	8.10	6.30	7.80	7.70	8.80	7.90	6.10	6.00
10	Mr. Taiwo	7.10	7.20	7.90	7.20	5.80	6.60	6.90	7.60	7.10	5.77	5.83

Table 7. Hand indices for mechanic, welding, and carpentry sections

S/No.	Mechanic section		Welding section		Carpentry section	
	Names	Hand index (%)	Names	Hand index (%)	Names	Hand index (%)
1	Mr. Abolaji	43.60	Mr. Samson	43.01	Mr. Akintoyin	42.31
2	Mr. Julius	41.30	Mr. Banjo	43.92	Mr. Saheed	41.15
3	Mr. Sunny	39.36	Mr Tunde	39.63	Mr. Ibrahim	39.32
4	Mr. Vincent	39.44	Mr. Femi	39.89	Mr. Femi2	42.44
5	Mr. Ebebe	38.06	Mr Ajayi	42.04	Mr. Bello	36.71
6	Mr. Bernard	40.33	Mr. Ola	42.56	Mr. Ayo	43.37
7	Mr. Daniel	38.93	Mr. Mustapha	41.30	Mr. Tunde	44.19
8	Mr. Olakunle	40.00	Mr. O. mummy	41.84	Mr. John	39.70
9	Mr. Udoh	41.24	Mr Aminu	41.71	Mr. Afeez	38.38
10	Mr. Saheed	40.84	Mr. Samuel	39.91	Mr. Taiwo	40.10
11	Mr. Lawal	47.17	Mr. Shakiru	40.29		
12	Mr. Razak	40.20	Mr. Abiodun	40.62		
13	Mr. Dada	41.21				

Table 7. Hand indices for mechanic, welding, and carpentry sections (continued)

S/No.	Mechanic section		Welding section		Carpentry section	
	Names	Hand index (%)	Names	Hand index (%)	Names	Hand index (%)
14	Mr. Odun	41.51				
15	Mr. Lateef	38.61				
16	Mr. Sule	41.79				
17	Mr. Saheed	38.26				
18	Mr. Sule1	39.16				
19	Mr. Afeez	43.93				
20	Mr. Ola	39.64				
21	Mr. Ahmed	38.42				
22	Mr. Ganiu	44.68				
23	Mr. Razak1	39.90				
24	Mr. Cole	43.24				
25	Mr. Tunde	43.08				
26	Mr. Tunde1	39.25				
27	Mr. Paul	43.16				
28	Mr. Joseph	40.84				
29	Mr. Emmanuel	41.49				
30	Mr. Adeyemi	42.19				
31	Mr. Samuel	41.45				

Table 8. Summary of results

Description	Mechanic	Welding	Carpentry	Remark
Left hand length (cm)	19.59	19.01	20.18	Lowest in welding
Left hand breadth (cm)	8.028	7.92	8.21	Close in values
Left hand palm thickness (cm)	3.67	3.62	3.75	Welding section lowest
Left hand thumb (cm)	6.56	5.67	6.98	Low in welding
Left hand first finger (cm)	7.01	6.57	7.18	Low in welding
Left hand second finger (cm)	7.85	7.46	8.05	Low in welding
Left hand third finger (cm)	7.23	6.85	7.37	Close in values
Left hand fourth finger (cm)	5.68	5.62	5.64	Close in values
Right hand length (cm)	19.5	18.70	17.895	Lowest in carpentry
Right hand breadth (cm)	8.01	7.86	8.15	Close in values
Right hand (cm)	3.72	3.63	3.72	Close in values
Right hand thumb (cm)	6.68	6.34	6.98	Lowest in welding
Right hand first finger (cm)	6.89	6.59	7.18	Lowest in welding
Right hand second finger (cm)	7.76	7.57	7.94	Lowest in welding
Right hand third finger (cm)	7.21	6.99	7.34	Lowest in welding
Right hand fourth finger (cm)	5.37	5.61	5.70	Lowest in mechanic
Height of observer (meter)	1.70	1.66	1.716	Lowest in welding

3.1. Further hand index calculation

The various formulae are used to compute the hand index for an individual, Abolaji in the mechanic section. These formulae are applicable to the other sections of welding and carpentry.

From Equation (2), for the left hand, illustrating with Mr. Abolaji's data,

$$\text{PT-HL}_{\text{MrAbolaji}} = \frac{3.66}{19.10} \times \frac{100}{1} = 19.16\% .$$

Similarly, for the right hand, PT-$HL_{Mr\ Abolaji}$ = 20.00%. Besides, the application of Equations (3) to (8) yields the following results.

Equation (3), for left and right hands, PT-$HB_{Mr\ Abolaji}$ are 43.94% and 46.99%, respectively
Equation (4), for left hand, LT-$RT_{Mr\ Abolaji}$ = 94.20%
Equation (5), RFF-$LFF_{Mr\ Abolaji}$ = 96.86%
Equation (6), RSF-$LSF_{Mr\ Abolaji}$= 98.60%
Equation (7), LTF-$RTF_{Mr\ Abolaji}$ = 100.68%
Equation (8), LTF-$RTF_{Mr\ Abolaji}$ = 112.35%
The same calculations are carried out for other people in this and other sections in Tables 9, Table 10, and Table 11.

Table 9. Further hand index results of mechanic section

S/N	Name	PT-HL Left Hand (%)	PT-HL Right Hand (%)	PT-HB Left Hand (%)	PT-HB Right Hand (%)	LT-RT (%)	RFF-LFF (%)	RSF-LSF(%)	LTF-RTF (%)	LFF-RFF (%)
1	Mr. Abolaji	19.16	20.00	43.94	46.99	94.20	96.86	98.60	100.68	112.35
2	Mr. Julius	17.70	18.69	42.82	43.76	99.53	98.89	95.73	94.01	99.28
3	Mr. Sunny	18.08	17.86	45.95	44.64	85.71	101.50	97.37	105.07	108.26
4	Mr. Vincent	19.82	18.72	50.26	47.29	83.09	103.30	98.61	100.92	95.78
5	Mr. Ebebe	18.66	19.08	49.03	48.26	80.00	100.00	99.62	100.00	97.50
6	Mr. Bernard	18.04	17.46	44.72	42.64	91.16	95.36	97.70	96.56	94.67
7	Mr. Daniel	17.07	20.07	43.86	50.63	89.34	102.01	100.38	94.67	100.81
8	Mr. Olakunle	17.73	19.03	43.38	50.71	114.86	99.15	100.64	99.42	93.61
9	Mr. Udoh	18.49	20.10	44.72	48.88	104.61	96.97	90.79	102.24	92.31
10	Mr. Saheed	16.75	17.84	41.03	44.94	101.61	95.77	102.56	100.00	95.24
11	Mr. Lawal	21.55	21.00	45.68	43.90	125.53	93.76	89.66	103.91	101.04
12	Mr. Razak	19.09	19.14	47.50	48.19	100.00	97.22	103.29	96.10	98.21
13	Mr. Dada	18.26	20.43	44.31	48.28	102.94	95.71	97.37	101.47	98.25
14	Mr. Odun	18.39	17.55	44.32	42.53	107.81	100.00	100.00	98.72	98.28
15	Mr. Lateef	20.29	18.54	52.56	46.91	92.54	100.00	96.47	100.00	93.44
16	Mr. Sule	19.58	18.48	46.84	42.50	101.64	101.33	100.00	104.61	113.04
17	Mr. Saheed	19.89	16.33	52.00	41.56	95.94	95.89	102.53	98.67	117.74
18	Mr. Sule 1	17.73	18.41	45.28	45.12	96.34	97.18	99.26	96.34	103.23
19	Mr. Afeez	20.94	21.55	47.68	49.76	101.75	101.33	100.00	107.35	92.98
20	Mr. Ola	19.89	20.00	50.19	50.00	99.24	100.00	101.23	98.63	98.18
21	Mr. Ahmed	18.23	18.69	47.44	47.44	100.00	96.15	96.51	100.00	109.26
22	Mr. Ganiu	20.21	19.57	45.24	43.90	97.18	104.54	97.37	102.82	110.00
23	Mr. Razak	17.79	17.62	44.58	48.05	98.67	94.74	98.77	104.11	105.26
24	Mr. Cole	18.92	20.22	43.75	46.84	93.65	95.52	103.95	95.89	102.04
25	Mr. Tunde	19.68	22.04	45.68	50.81	104.13	95.59	98.68	97.29	127.04
26	Mr. Tunde1	18.28	17.65	46.58	45.21	100.00	100.00	102.78	97.06	103.77
27	Mr. Paul	18.42	18.75	42.68	42.86	108.9	97.06	97.37	101.47	101.85
28	Mr. Joseph	17.80	18.75	43.59	45.00	96.97	101.45	98.70	100.00	98.15
29	Mr. Emmanuel	17.55	20.22	42.31	47.44	93.75	100.00	100.00	97.14	104.00
30	Mr. Adeyemi	19.27	18.56	45.68	45.57	98.57	98.65	97.50	104.23	111.32
31	Mr. Samuel	18.65	19.78	45.00	45.00	98.41	96.97	92.41	106.06	100.00

Table 10. Further hand index for welding section

S/N	Name	PT-HL Left Hand (%)	PT-HL Right Hand (%)	PT-HB Left Hand (%)	PT-HB Right Hand (%)	LT-RT (%)	RFF-LFF (%)	RSF-LSF(%)	LTF-RTF (%)	LFF-RFF (%)
1	Mr. Samsudeen	22.65	24.26	52.84	54.45	97.90	99.36	93.42	95.38	90.91
2	Mr. Banjo	23.89	21.19	54.39	48.19	100.49	99.39	100.95	94.37	94.74
3	Mr. Sola	16.86	16.94	42.55	40.79	92.06	100.00	96.00	104.55	103.70
4	Mr. Tunde	18.52	20.00	41.18	46.34	110.34	100.00	100.00	105.88	98.31
5	Mr. Femi	19.19	19.79	48.10	47.50	101.64	104.92	101.39	109.23	107.27
6	Mr. Ajayi	20.45	19.19	48.65	45.21	109.62	94.83	94.29	111.67	104.08
7	Mr. Ola	18.91	18.69	44.58	46.25	98.51	98.53	102.67	102.94	100.00
8	Mr. Mustapha	17.39	18.71	42.11	42.11	100.00	100.00	98.55	106.45	100.00
9	Mr. O. Mummy	18.88	19.33	45.12	45.42	100.00	98.61	92.68	100.00	101.64
10	Mr. Aminu	20.10	21.08	48.19	47.56	98.51	91.04	97.33	103.03	98.21
11	Mr. Samuel	16.81	18.75	42.11	50.00	96.88	104.35	98.75	102.05	103.57
12	Mr. Shakiru	17.91	18.47	44.44	46.48	101.35	98.63	101.22	93.83	95.24
13	Mr. Abiodun	16.87	16.58	41.03	40.51	97.06	97.10	96.29	104.17	103.45

Table 11. Further hand index for carpentry section

Name	PT-HL Left Hand (%)	PT-HL Right Hand (%)	PT-HB Left Hand (%)	PT-HB Right Hand (%)	LT-RT (%)	RFF-LFF (%)	RSF-LSF(%)	LTF-RTF (%)	LFF-RFF (%)
Mr. Akintoyin	20.63	20.21	48.75	46.43	95.65	95.64	103.37	97.29	93.10
Mr. Saheed	18.66	18.81	45.35	48.41	96.00	105.79	98.76	102.70	99.18
Mr. Ibrahim	16.99	18.01	43.21	48.10	101.47	95.83	95.12	95.95	95.00
Mr. Femi 2	22.15	20.31	52.18	45.35	103.03	104.41	92.86	107.94	104.44
Mr. Bello	17.39	19.90	47.37	51.28	112.50	98.68	98.85	97.50	97.68
Mr. Ayo	19.89	18.43	45.88	48.05	97.14	104.41	103.75	96.10	94.83
Mr. Tunde	19.89	19.35	45.00	44.44	95.65	101.54	101.37	109.37	100.00
Mr. John	17.73	17.09	44.66	42.68	101.37	98.63	96.89	101.31	101.75
Mr. Azeez	15.17	15.79	39.51	38.82	93.51	100.00	98.88	102.53	103.28
Mr. Taiwo	17.82	18.23	44.44	43.21	107.57	95.83	96.20	101.41	100.52

3.2. Findings

This study focuses on hand measurements in three occupations, namely welding, mechanics, and carpentry, in a sample in Lagos, Nigeria. The hand is a natural part of the human body. It impacts hand-oriented jobs such as welding, carpentry, and mechanics, where most of the activities involve the use of hands in lifting objects, moving things, and pushing materials from one location to the other. The hand is of vital importance in several small scale jobs in Nigeria. The three mentioned jobs are chosen based on their contributions to the nation's economy and the wide number of people engaged in them within the Lagos community

studied. The hand is of significant importance in holding tools such as hammers, wrenches, and pliers, among other tools for all the mentioned jobs. Outside these studied jobs, the hand is also crucial in tailoring, motor driving, sweeping, bricklaying, and land digging, which contribute enormously to the national economy as small scale jobs and are of interest to ergonomists and industrial engineers considering its anthropo-metric features and the optimization of hand movements. Because the hand is an integral part of productivity for many small scale industries in developing countries and Nigeria in particular, it is fundamental for the country's economic sustainability and development and the maintenance of the strong leadership role that the small scale industries in Nigeria participate.

As studied in this work, the hands were measured by finger lengths and palms for both the left and right hands. The left fingers were labeled as L1, L2, L3, L4, and L5, while the right hand was labeled as R1, R2, R3, R4, and R5, respectively. Interests were in the following dimensions of the hand: Lengths of the left thumb left the first finger, left second finger, left third finger, right thumb, right first finger, right second finger, a right third finger, and right fourth finger. Besides, the heights of the subjects were measured. For the sample studied, the outstanding results are as follows. The left hand contains longer lengths in fingers and palm. Furthermore, the carpentry subjects have higher values from the hand length to the right third finger of the three occupations. Moreover, for the observer’s height, the carpentry section has the highest value.

The opportunities for tool design modifications for welders, carpenters, and mechanics stem from the ability of the original tool company to have access to local data of the subjects in the various occupations and use them to make custom-oriented tools for the community based on the hand anthropometric features of the craftsmen and artisans in the occupation. This will yield an improved tool design that will enhance the productivity and morale of the workers. It is an opportunity to produce tools with dimensions, which are hitter to not achievable through other methods for the Nigerian community and the developing countries in general. The scientific underpinnings of hand applications in welding, mechanics job, and carpentry are of diverse disciplines, including ergonomics, impulse generations, and energy measurements. Because of the hand's inter-disciplinary connections and the poor scientific understanding of hand measurements in the community studied, this study highlights this crucial concern.

In the vocations studied, the special requirements of the jobs entail the use of hands of specified sizes to handle the tools. Consequently, it is not expected that those having short hands should engage in the job. Unfortunately, often for the jobs studies, no discrimination exists. Still, subjects sometimes engage in such vocations because they drop out of school or without financial resources and the ability to pursue better-paid jobs. So the businesses' owners are persuaded to take any available individual for the job by the parents or relations of such subjects. However, it is expected that there should be a screening of candidates according to the hands' characteristics' standard requirements.

Furthermore, the study has limitations concerning consistency. Since the researchers did not have control over the workplaces' activities, subjects were interviewed, and measurement is taken at the small-scale vocational units' owners' will. In some instances, the investigators have direct access to the subjects, most often when they are not working. However, in other instances, when the subject was engaged in jobs, depending on the pressure to complete the job from the customer, the subject may not be released from the job. So, the measurement of subjects in comparatively different conditions, such as relaxed and energy-abundant as well as tensed up and energy-exhausted states, were carried out.

The implication of this is that some of the hand's nerves and joints may reveal different values in the hand's measurement for the same person at the two states of not having done any job for the day and taking a break from the job to measures. These individuals' measurements at different instances may introduce inconsistency into the results since they appear not to be taken using the same scale. Another instance is that the study was constrained to span through the whole day, from morning to evening, to capture enough subjects for the study coupled with the pressure of coping with lectures for one of the investigators. It is reasonable to assume that the weather conditions and variations

from the cool morning hours to the very sunny hours of the day may produce different inducements on the body of the subjects. Hence, the body muscles may have different degrees of relaxation at different hours, resulting in the inconsistency of results. Thus, future studies may consider fixing the data collection to a range of hours during the day when the subjects have not engaged in the day's job.

4. CONCLUSION

The purpose of this work is to compare the right and left-hand dimensions in three occupations, namely the welders, carpenters, and mechanics. A field study was conducted in Lagos in which subjects were asked to present their hands and selves for measurements. Accordingly, the following conclusions were reached. The essence of the hand measurements in this work is to be able to accurately predict the dimensions of the hands for the population that fits to use the tools manufactured in Nigeria. As such, an accurate and reliable standard concerning the three vocations of mechanics, carpenters, and welders have been created. It is concluded that for the vocations studied, inconsistency in results exists due to the non-standardization of guidelines to use in employing new entrants to the vocation for training. However, the measurements have demonstrated the feasibility of having defined measures for designing equipment for use in the three vocations.

REFERENCES

Alahmari, K. A., Kakaraparthi, V. N., Reddy, R. S., Silvian, P. S., Ahmad, I., & Rengaramanujam, K. (2019). Percentage difference of hand dimensions and their correlation with hand grip and pinch strength among schoolchildren in Saudi Arabia. *Nigerian Journal of clinical practice*, *22*(10), 1356. https://doi.org/10.4103/njcp.njcp_121_19

Alexander, V., Sindhu, K. N. C., Zechariah, P., Resu, A. V., Nair, S. R., Kattula, D., ... & Alex T, R. G. (2016). Occupational safety measures and morbidity among welders in Vellore, Southern India. *International journal of occupational and environmental health*, *22*(4), 300-306. https://doi.org/10.1080/10773525.2016.1228287

Agnihotri, A. K., Shukla, S., & Purwar, B. (2007). Determination of sex from the foot measurements. *Internet J Forensic Sci*, *2*(1), 4702-4706 https://www.ijmhr.org/ijar.5.4/IJAR.2017.450.pdf

Bayraktar, N. K., & Özşahin, E. (2018). Anthropometric measurement of the hand. *Eastern Journal of Medicine*, *23*(4), 298-301. https://doi.org/10.5505/ejm.2018.03164

Cuendet, S., Dehler-Zufferey, J., Arn, C., Bumbacher, E., & Dillenbourg, P. (2014). A study of carpenter apprentices' spatial skills. *Empirical Research in Vocational Education and Training*, *6*(1), 1-16. https://doi.org/10.1186/s40461-014-0003-3

Danborno, B., & Elukpo, A. (2008). Sexual dimorphism in hand and foot length, indices, stature-ratio and relationship to height in Nigerians. *The Internet Journal of Forensic Science*, *3*(1), 379-383. https://print.ispub.com/api/0/ispub-article/3916

De Langhe, E., Lenaerts, J., Bossuyt, X., Westhovens, R., & Wuyts, W. A. (2015). Mechanic's hands in a woman with undifferentiated connective tissue disease and interstitial lung disease–anti-PL7 positive antisynthetase syndrome: a case report. *Journal of medical case reports*, *9*(1), 1-5. https://doi.org/10.1186/s13256-015-0571-2

Dewangan, K. N., Kumar, G. P., Suja, P. L., & Choudhury, M. D. (2005). Anthropometric dimensions of farm youth of the north eastern region of India. *International Journal of Industrial Ergonomics*, *35*(11), 979-989. https://doi.org/10.1016/j.ergon.2005.04.003

Ducharme, R. E. (1977). Women workers rate male tools inadequate. *Human Factors Society Bulletin*, *20*(4), 1-2.

Fessler, D. M., Haley, K. J., & Lal, R. D. (2005). Sexual dimorphism in foot length proportionate to stature. *Annals of Human Biology*, *32*(1), 44-59. https://doi.org/10.1080/03014460400027581

Hammarskjöld, E., Harms-Ringdahl, K., Ekholm, J., & Samuelson, B. (1991). Effect of short-time vibration exposure on work movements with carpenters' hand tools. *International*

Journal of Industrial Ergonomics, *8*(2), 125-134. https://doi.org/10.1016/0169-8141(91)90013-C

Hammarskjold E., Ekholm J. & Harms-Ringdahl K. (1989). Reproducibility of work movements with carpenters' hand tools. *Ergonomics*, *32*(8), 1005-1018. https://doi.org/10.1080/00140138908966861

Heycock, M. H. (1966). On the management of hand injuries caused by woodworking tools. *British journal of plastic surgery*, *19*, 58-67. https://www.jprasurg.com/article/S0007-1226(66)80008-5/abstract

Kanchan, T., Krishan, K., Sharma, A., & Menezes, R. G. (2010). A study of correlation of hand and foot dimensions for personal identification in mass disasters. *Forensic Science International*, *199*(1-3), 112-e1. https://doi.org/10.1016/j.forsciint.2010.03.002

Krishan, K., & Sharma, A. (2007). Estimation of stature from dimensions of hands and feet in a North Indian population. *Journal of forensic and legal medicine*, *14*(6), 327-332. https://doi.org/10.1016/j.jcfm.2006.10.008

Lewis, W. G., & Narayan, C. V. (1993). Design and sizing of ergonomic handles for hand tools. *Applied ergonomics*, *24*(5), 351-356. https://doi.org/10.1016/0003-6870(93)90074-J

Lucia E, Leema F, Tesfaye F, Demisse F. & Ismail S. (2002). The use of arm spans measurement to asses the multinational status of adults in four Ethiopian ethnic groups. *European Journal of Clinical Nutrition*, 56(2):91-95. https://doi.org/10.1038/sj.ejcn.1601289

Lee, K. S., & Jung, M. C. (2015). Ergonomic evaluation of biomechanical hand function. *Safety and health at work*, *6*(1), 9-17. https://doi.org/10.1016/j.shaw.2014.09.002

Lee, J. B., & Cho, C. Y. (2007). A Study on Workload Evaluation of Hand-intensive tasks of carpenters and structural steel workers. *Korean Journal of Construction Engineering and Management*, *8*(3), 134-141. https://www.koreascience.or.kr/article/JAKO200734515089261.page

Shahriar, M. M., Parvez, M. S., & Lutfi, M. (2020). A survey of hand anthropometry of Bangladeshi agricultural farm workers. *International Journal of Industrial Ergonomics*, *78*, 102978. https://doi.org/10.1016/j.ergon.2020.102978

Mii, S., Kobayashi, R., Nakano, T., Harada, H., Okada, M., Matsui, Y., ... & Eto, H. (2009). A histopathologic study of mechanic's hands associated with dermatomyositis: a report of five cases. *International journal of dermatology*, *48*(11), 1177-1182. https://doi.org/10.1111/j.1365-4632.2009.04164.x

Sohara, E., Saraya, T., Sato, S., Tsujimoto, N., Watanabe, T., Takata, S., ... & Goto, H. (2014). Mechanic’s hands revisited: is this sign still useful for diagnosis in patients with lung involvement of collagen vascular diseases?. *BMC research notes*, *7*(1), 303. https://doi.org/10.1186/1756-0500-7-303

Vyavahare, R. T., & Kallurkar, S. P. (2016). Anthropometry of male agricultural workers of western India for the design of tools and equipments. *International Journal of Industrial Ergonomics*, *53*, 80-85. https://doi.org/10.1016/j.ergon.201510.008