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Hand Anthropometry: Baseline Data of The Major Ethnic Groups in Sabah

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ABSTRACT

Anthropometry, the quantitative interface between anatomy and physiology, is a scientific specialization concerned with applying measurement to appraise human size, shape, proportion, composition, development, and gross function. Anthropometric measurement is essential in many areas, including archaeology, anthropology, ergonomics, forensic sciences, anatomy, and nutrition. Although different researchers have studied the anthropometry of hand extensively in Malaysia, there is still a paucity of data among the major ethnicities (Kadazandusun, Bajau, Malay and Chinese) that exist in Sabah. The study was designed to create baseline data for normative values of hand length, handbreadth, middle finger length, second inter-crease length of the middle finger, and the hand span of major ethnic groups in Sabah. This cross-sectional study was conducted from February 2021 to January 2022 by applying a stratified random sampling method. At first, the students were stratified into ethnicities and were further stratified as males and females. The hand dimensions were measured using a digital calliper. The baseline data for Sabah's four major ethnic groups were compared for symmetry, gender, and ethnic differences. The right handbreadth was broader than the left hand ($p<0.01$). The result also demonstrated a statistically significant (0.001) difference between gender; however, there was no significant difference among

the four ethnicities. Further study at the community level is recommended for different age groups and ethnicities by addressing hand activity, hormones, and brain asymmetry to complement the findings of this study.

INTRODUCTION

Anthropometry, the quantitative interface between anatomy and physiology, is a scientific specialization concerned with applying measurement to appraise human size, shape, proportion, composition, development, and gross function. It is a fundamental discipline for problem-solving in growth, practice, performance, and nutrition. It puts an individual into objective focus and provides a precise appraisal of his or her structural status at any given time or, more importantly, provides for quantification of differential growth (Bláha, 2007). Anthropometry is commonly used to measure a person's body size and height. However, anthropometry may also include functional anthropometry such as measuring strength for a specific application (Nurul Shahida et al., 2016).

Anthropometric measurement is essential in many areas, including archaeology, anthropology, ergonomics, forensic sciences, anatomy, and nutrition. For instance, Body Mass Index (BMI) can be calculated by anthropometry, and it is critical in the treatment of malnutrition, including obesity and undernutrition. The stature of dead humans or parts of a dead gives characteristic features of a population for archaeological materials (Akman et al., 2006). Apart from that, people use various tools in everyday life, including hand tools, to complete various tasks. The equipment used must be compatible with the users' physical characteristics.

According to Mondol et al. (2009), upper limb bones and stature dimensions vary in different ethnicities, gender, and age groups, and it also varies with the opposite side of the body (Plato et al., 1980; Kulaksiz & Gözil, 2002). The difference needs to be addressed as it will affect the safety and comfort of workers when a hand device or tools (e.g., gloves) are designed from data for different gender. Yu et al. (2014) emphasized the importance of hand gloves fitting with the users' hands to prevent injury and increase working performance. Also, hand anthropometry is a necessary input for tool design that promotes task productivity and workers' health García-Cáceres 2012). In the context of ergonomics, these tools and equipment should be compatible with the physical characteristics of the workers for better productivity and work safety, and hand anthropometry is a fundamental parameter that must be utilized for designing hand tools (Shahriar et al., 2020). Therefore, various research has been done on anthropometrics and mentioned the importance of relevant standardized anthropometry data in designing equipment (Park et al., 2014; Yu et al., 2014).

Hand anthropometry was further emphasized using different variables, such as developing predictive models of other body dimensions and hand strength. Predictive models would be necessary when only the upper limb is available for any reason, such as explosions, train/plane crashes, or natural calamities (Chandra et al., 2015). Predicting stature from hand dimensions would narrow the search area to identify the missing person in a particular population. Hence, this study result may help identify the missing person, impersonation, and any accidental death, like (fire, navy or air accident and natural disaster). The hand normative values may be helpful to plastic and reconstructive surgeons in their reconstructions of different parts of the hands. They may also be helpful to garments, gloves, and artificial limb manufacturing companies for supplying products of different sizes for different frame sizes. Moreover, hand measurements were used to predict the handgrip strength of the elderly population for specific product design applications (Nurul Shahida et al., 2016). The study finding would be beneficial for designing ergonomics facilities (Dawal et al., 2015).

In Malaysia, several studies have been done on anthropometry study. A study on anthropometric measurement among adult populations of three different ethnicities was previously done to determine the differences between Malay, Indian, and Chinese in Malaysia (Karmegam et al., 2011). In the east part of Malaysia, a study on anthropometry was conducted to estimate stature from hand measurements among the Iban population. This study provided the first forensic anthropometry database for the Iban population in Sarawak that may be useful for dismembered body identification (Zulkifly et al., 2018).

Different ethnics may show different anthropometry dimensions (Widyanti et al., 2015). In considering Sabah Malaysia's multi-ethnic population, although different researchers have studied anthropometry of hand extensively in Malaysia, there is still a paucity of data among major ethnic groups of Sabah. Under these circumstances, the present study was conducted to create baseline data for the major ethnic groups in Sabah.

MATERIALS AND METHODS

This cross-sectional study was conducted from February 2021 to January 2022. The study was designed to create baseline data for normative values of hand length, handbreadth, middle finger length, second inter-crease length of the middle finger, and hand span.

Selection Criteria

Upon selecting the participants for the study for obtaining more valid information, specific inclusion criteria were imposed in selecting the participants. The participants qualified for being included in the research by fulfilling the following criteria:

(a) The age range must be 18 – 45 years old.
(b) They are from Kadazandusun, Bajau, Malay, or Chinese ethnicity.

The exclusion criteria were:

(a) Individuals who have medical conditions (for example, Rheumatoid arthritis, Parkinsonism, and any other conditions) that may affect hand anthropometry.
(b) Individuals having parents or grandparents who were not from the same ethnic group.

Sample Size

The sample size per cell has been determined using the procedure outlined in International Organization for Standardization (ISO) 15535: 2003. This is the general requirement for establishing an anthropometric database. Following the requirement, the sample size has been determined by using the following formula: $n = (Z \times CV/a)2 \times 1.534 = (1.96 \times 2.87/1)2 \times 1.534 = 46$

Here, the coefficient of variance (CV) of hand length was 2.87% in a pilot study on the same population, a = 1 (The level of precision was chosen because that is the best level of interobserver error that experienced measurers have achieved), and the constant of 1.534 was based on converting the sample size formula from estimating confidence at the mean to estimating confidence at the 5th and 95th percentile (ISO 15535).

Therefore for each stratum, the study required a minimum of 46 subjects which amounts to total respondents of (46 × 2 × 4) 368 for four major ethnic groups' males and females.

Study Population

The Sabahan population consists of multi-ethnic groups. Kadazandusun, Bajau, Murut, and Malay ethnic groups are the majority among the ethnic groups in the Sabahan population. At the same time, the Chinese made up the largest non-indigenous group in Sabah (Sabah State Government, 2022). This study included all these ethnic groups to create baseline data of hand anthropometry for each of these ethnicities. The study included subjects based on ethnic groups where the subjects' parents and grandparents were from the same ethnic groups. Ensuring this criterion required subjects coming from specific districts of Sabah, as mostly Bajau can be found at Kudat, Tuaran, Kota Belud, and Papar, while Kadazandusun and Malay can be found at Tuaran, Ranau, Papar, and Tamparuli, and Chinese can be found in Kudat. However, during the COVID-19 global pandemic, data collection at the community level was not permitted. The researchers carried out the study at the university campus among the students who fulfilled the inclusion criteria and completed vaccination for COVID-19.

Sampling Techniques

Before sampling, a list of names and their permanent address was obtained from the university's academic services division (Bahagian Perkhidmatan Akademik). The researchers applied a stratified random sampling method. There were two types of strata in the sampling: ethnicity and gender. At first, the students were stratified into four ethnicities and were further stratified as males and females. Then forty-six subjects weres randomly selected from each stratum. The randomization process was a list of metrics numbers picked randomly from a container until each gender and the ethnic group met the intended sample size.

Procedure

The study design, objective, and methodology were explained to the respondent, and informed consent was obtained from them. Five hand dimensions were measured using mechanical digital callipers with an accuracy of 0.01 mm. The researcher started data collection only after the measurements were reliable, precise, accurate, and valid (Table 1). The Intra-class Correlation Coefficient (ICC) for all the parameters ranged from 0.972 to 0.998. The values of the ICC indicate the significant ($p<0.001$) correlation between the two readings for each parameter taken by the researcher. Researchers suggested that the lower the technical error of measurement (TEM) obtained, the better the appraiser's precision to perform the measurement (Arroyo et al., 2010). The TEM of the breadth of the hands and wrist circumference was the lowest (0.071). However, all the instruments demonstrated an acceptable (<1.5%) relative technical error of measurement (rTEM) value for all measurements (Pederson & Gore, 2004). Again based on the coefficient of reliability (R values >0.95), the measurements were sufficiently precise (Ulijaszek & Kerr, 1999).

Table 1 Hand dimensions and reliability, precision, accuracy, and validity test of the measurements

Variable		Mean±SD (cm)	ICC	TEM	rTEM (%)	R
Hand length	Right	17.48 ± 0.76	0.998*	0.036	0.21	0.998
	Left	17.55 ± 0.82	0.998*	0.037	0.21	0.998
Handbreadth	Right	8.04 ± 0.48	0.997*	0.027	0.33	0.997
	Left	7.93 ± 0.52	0.996*	0.033	0.42	0.996
Middle finger length	Right	7.43 ± 0.39	0.995*	0.025	0.34	0.996
	Left	7.51 ± 0.38	0.994*	0.035	0.46	0.992
2nd Interphalangeal length	Right	2.45 ± 0.20	0.987*	0.022	0.90	0.987
	Left	2.50 ± 0.16	0.972*	0.026	1.05	0.972

* Significant at $p<0.001$ level, ICC: Intra-class Correlation Coefficient, TEM: Technical Error of Measurement, rTEM= Relative Technical Error of Measurement, R: Coefficient of Reliability

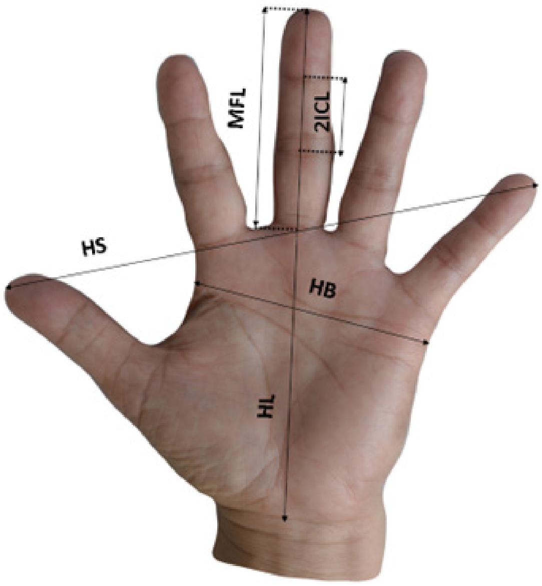

Figure 1 Hand measurement [HB: Handbreadth, HL: Hand length, HS: Hand span, MFL: Middle (third) 2ICL: finger length: 2nd inter crease length of the middle (third) finger]

Table 2 Operational definition for different hand dimensions

Hand dimension	Operational definition
Hand length (HL)	The hand's length was measured as the straight distance from the midpoint of the distal wrist crease to the most distal point of the middle finger (Sanli et al., 2005).
Handbreadth (HB)	The hand's breadth was measured as the hand's width from the lateral surface of metacarpal II to the medial surface of metacarpal V. The hand's breadth was measured at the level of the knuckles (Sanli et al., 2005).
Middle (third) finger length (MFL)	Measurement of the middle finger was taken from the proximal finger crease of the middle (third) finger to the tip of the middle (third) finger (Mollayousefi, 2008).
2nd inter crease length of the middle (third) finger (2ICL)	2nd inter crease length (middle phalanx) can be measured as the distance between the middle and distal finger creases (Hossain, 2009).
Handspan (HS)	Handspan was measured on the right hand from the tip of the thumb to the tip of the small finger, with the hand spreading as wide as possible (Ruiz et al., 2006).

Statistical Analysis

Data were analysed using Statistical Package for Social Science (SPSS) version 24.0. As the data were normally distributed (Table 3 and Figure 2), mean and standard deviation were used for describing the hand dimensions, paired t-test was performed to explore the difference between hand dimensions of both sides of the body, unpaired t-test was conducted to investigate the difference between the genders and one-way ANOVA was used to test the difference between ethnic groups.

Table 3 Descriptive statistics of hand dimensions

Variables (n = 368)	Min.	Lower fence	Q1	Median	Q3	IQR	Upper fence	Max.	Outlier
RHL	15.35	14.46	16.92	17.74	18.55	16.36	21.00	20.51	0
LHL	15.19	14.48	16.88	17.68	18.48	16.00	20.88	20.51	0
RHB	6.47	6.04	7.43	7.86	8.35	9.22	9.73	9.46	0
LHB	6.49	6.00	7.36	7.83	8.27	9.07	9.63	9.43	0
RMFL	6.43	6.21	7.25	7.63	7.95	6.94	8.96	8.93	0
LMFL	6.29	6.20	7.25	7.64	7.96	7.02	9.01	8.92	0
R2ICL	2.03	2.02	2.46	2.60	2.75	2.95	3.19	3.16	0
L2ICL	2.04	2.03	2.47	2.60	2.76	2.91	3.20	3.19	0
RHS	12.05	11.99	15.27	16.22	17.46	21.87	20.74	20.49	0
LHS	12.99	11.95	15.25	16.45	17.45	21.98	20.74	20.10	0

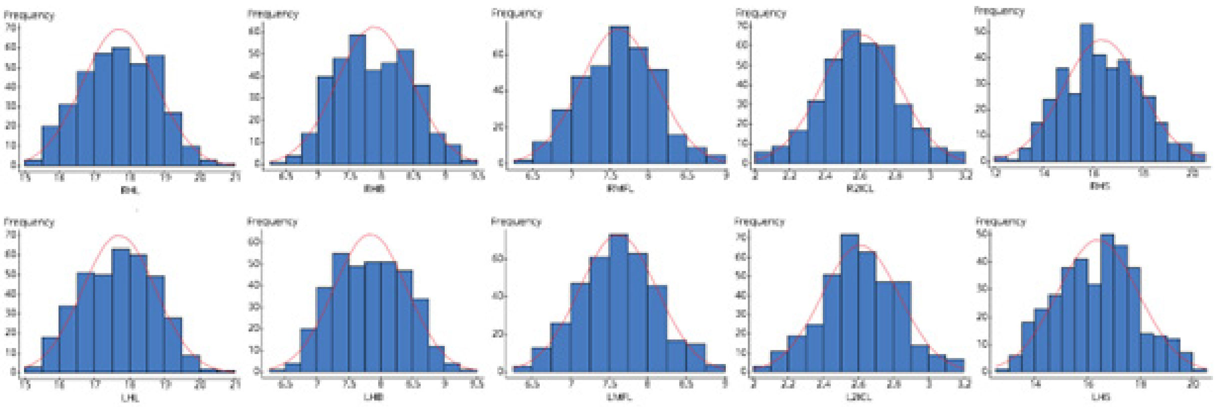

Figure 2 Histogram of the hand dimension data [RHB: Right handbreadth, RHL: Right-hand length, RHS: Right-hand span, RMFL: Right middle (third) finger length, R2ICL: Right 2nd inter crease length of the middle (third) finger, LHB: Left handbreadth, LHL: Left-hand length, LHS: Left-hand span, LMFL: Left middle (third) finger length, L2ICL: Left 2nd inter crease length of the middle (third) finger]

RESULTS

The mean and standard deviation of different hand dimensions are stratified according to ethnicity and gender in Table 4. The Malay males had the highest right and left-hand lengths and second inter-crease lengths, and Bajau males had the highest right and left handbreadths and hand spans. The Chinese males had the highest middle finger lengths. All the values of hand dimensions were noticeably higher for males than females, and there was no remarkable difference between the right and left side hand dimensions.

Table 4 Hand dimension distribution based on gender and ethnicity

	Kadazandusun		Bajau		Malay		Chinese	
	Male (n = 42)	**Female** (n = 42)	**Male** (n = 42)	**Female** (n = 42)	**Male** (n = 42)	**Female** (n = 42)	**Male** (n = 42)	**Female** (n = 42)
	Mean (±SD)	Mean (±SD)	Mean (±SD)	Mean (±SD)	Mean (±SD)	Mean (±SD)	Mean (±SD)	Mean (±SD)
RHL	18.45 (±0.87)	16.97 (0.82)	18.12 (±0.78)	16.88 (±0.86)	18.63 (±0.72)	16.92 (±0.76)	18.48 (±0.64)	17.16 (±0.64)
LHL	18.42 (±0.86)	16.93 (±0.78)	18.15 (±0.73)	16.89 (±0.84)	18.65 (±0.73)	16.91 (±0.75)	18.48 (±0.64)	17.14 (±0.65)
RHB	8.41 (±0.43)	7.49 (±0.32)	8.38 (±0.40)	7.50 (±0.34)	8.26 (±0.45)	7.34 (±0.36)	8.29 (±0.36)	7.33 (±0.83)
LHB	8.32 (±0.41)	7.42 (±0.32)	8.28 (±0.43)	7.47 (±0.32)	8.24 (±0.41)	7.33 (±0.37)	8.21 (±0.33)	7.39 (±0.43)
RMFL	7.92 (±0.47)	7.30 (±0.39)	7.77 (±0.40)	7.31 (±0.45)	7.80 (±0.42)	7.34 (±0.46)	7.90 (±0.32)	7.40 (±0.37)
LMFL	7.91 (±0.50)	7.29 (±0.38)	7.84 (±0.39)	7.28 (±0.49)	8.00 (±0.40)	7.31 (±0.43)	7.90 (±0.34)	7.37 (±0.36)
R2ICL	2.70 (±0.25)	2.53 (±0.19)	2.60 (±0.23)	2.53 (±0.25)	2.71 (±0.22)	2.54 (±0.20)	2.68 (±0.15)	2.51 (±0.19)
L2ICL	2.71 (±0.25)	2.52 (±0.22)	2.63 (±0.23)	2.54 (±0.24)	2.75 (±0.21)	2.54 (±0.19)	2.69 (±0.15)	2.50 (±0.19)
RHS	17.13 (±1.20)	15.25 (±1.11)	17.56 (±1.23)	15.49 (±1.31)	17.06 (±1.16)	15.44 (±1.34)	17.15 (±1.32)	15.63 (±1.41)
LHS	17.16 (±1.20)	15.25 (±1.17)	17.57 (±1.44)	15.29 (±1.24)	16.97 (±1.13)	15.60 (±1.41)	17.12 (±1.45)	15.99 (±1.27)

RHL= Right hand length, LHL = Left hand length, RHB = Right handbreadth, LHB = Left handbreadth, RMFL = Right middle finger length, LMFL = Left middle finger length, R2ICL= Right second inter-crease length, L2ICL= Left second inter-crease length, RHS = Right hand span, LHS= Left hand span

The following hypothesis was tested to investigate the difference between right and left-hand dimensions using paired t-test was performed:

H_0: There is no difference between right and left-hand dimensions (length, breadth, middle finger length, second inter-crease length, and span).

H_1: There is a difference between the right and left-hand dimensions.

The participants were included in the study through stratified random sampling, and the number of male and female participants was more than 30 persons and was not more than 5% of the population. So, the observations were independent, and the sample fulfilled the assumptions for the intended t-test (Sullivan III, 2017).

Table 5 Paired difference between right and left-hand dimensions among the participants (n = 368)

	Mean difference (±SD)	95% Confidence Interval of the difference		t	df	p-value
		Lower	Upper			
RHL – LHL	0.006 (± 0.160)	–.010	.023	0.741	367	0.459
RHB – LHB	0.054 (± 0.161)	.038	.071	6.466	367	<0.001
RMFL – LMFL	–0.002 (±0.152)	–.018	.014	–0.240	367	0.811
R2ICL – L2ICL	–0.009 (±0.104)	–.020	.001	–1.692	367	0.091
RHS – LHS	–0.027 (±0.767)	–.106	.051	–0.686	367	0.493

The p-values for the t-statistics for the difference of means for hand length, middle finger length, second inter-crease length, and hand span were more than the level of significance, $\alpha = 0.05$ (Table 5). Therefore, there was insufficient evidence to reject the null hypothesis. On the contrary, the p-value for the handbreadth difference was less than 0.05. So, the sample suggested sufficient evidence to conclude that the right handbreadth was significantly different from the left handbreadth.

As the data fulfilled the assumptions of normality, randomness, and independence, an independent sample t-test was performed to investigate the difference between the hand dimensions of male and female participants. The hypothesis was determined to start the investigation:

H_0: There is no difference between male and female hand dimensions (hand length, breadth, middle finger length, second inter-crease length, and span).

H_1: Male participants have higher hand dimensions than female participants.

Table 6 Difference between hand dimensions among gender

Variables	Mean Difference	Std. error difference	t	df	p-value	95% Confidence Interval of the Difference	
						Lower	Upper
RHL	1.44	0.08	17.868	367	<.001	1.28	1.60
LHL	1.46	0.08	18.467	367	<.001	1.30	1.62
RHB	0.92	0.05	19.092	367	<.001	0.83	1.02
LHB	0.86	0.04	21.853	367	<.001	0.79	0.94
RMFL	0.55	0.04	12.819	367	<.001	0.46	0.64
LMFL	0.60	0.04	14.001	367	<.001	0.52	0.69
R2ICL	0.15	0.02	6.573	367	<.001	0.10	0.19
L2ICL	0.17	0.02	7.652	367	<.001	0.13	021
RHS	1.77	0.14	13.160	367	<.001	1.51	2.04
LHS	1.67	0.13	12.440	367	<.001	1.41	1.93

The p-value for the t-statistics for the difference of means for hand dimensions of both sides is <0.001 (Table 6), which is less than the level of significance, $\alpha = 0.05$. Therefore, the null hypothesis is rejected. Hence, there is sufficient evidence to state that males' hand dimensions were higher than females.

Finally, the difference in mean values of hand dimensions among the ethnicities was observed. The one-way ANOVA test was conducted to test the following hypothesis:

H_0: There is no difference in hand dimensions among the participants from Bajau, Kadazandusun, Malay and Chinese ethnicities.

H_1: At least one ethnicity have different hand dimensions than others.

Other than the samples being randomly selected and independent, the one-way ANOVA test requires that the populations from where the samples were obtained are normally distributed, and the populations must have the same variance (Sullivan III, 2017). As the assumption of normality is already satisfied, the assumption of having an equal variance and the standard deviations were compared. The largest standard deviation for each variable is smaller than twice the smallest. Thus, the requirement of equal population variances is satisfied.

Table 7 Difference between hand dimensions among ethnicities

Variables	Sum of Squares	df	Mean Square	F	p-value
RHL	5.480	3	1.827	1.649	0.178
LHL	4.763	3	1.588	1.440	0.231
RHB	1.369	3	0.456	1.312	0.270
LHB	0.611	3	0.204	0.615	0.605
RMFL	0.717	3	0.239	0.967	0.408
LMFL	0.548	3	0.183	0.695	0.556
R2ICL	0.192	3	0.064	1.269	0.285
L2ICL	0.213	3	0.071	1.359	0.255
RHS	6.434	3	2.145	0.874	0.455
LHS	6.492	3	2.164	0.921	0.431

As these p-values are more than the level of significance α = 0.05, the null hypothesis is retained. There is insufficient evidence to conclude that there is a difference in hand dimensions among the participants from Bajau, Kadazandusun, Malay, and Chinese ethnicities.

DISCUSSION

The present study was conducted on the young adult Sabahan population from four major ethnic groups. The length of the hand, breadth of the hand, middle finger, second inter-crease length of the middle finger, and a hand span of both sides were measured by direct physical methods. The study was designed to get normative values of the variables for the young adult population of major ethnic groups of Sabah. Differences between right- and left-hand dimensions were observed. The study also investigated gender and ethnic differences in different hand dimensions. The present study was compared with the population of Egypt, Western Australia, India, Rajasthan, Bangladesh, Gujarat, Thailand, East Malaysia (Sarawak), and West Malaysia. Similarity and dissimilarity were compared with the researcher of other countries.

Comparison Between Males With Other Studies

The right hand's mean (±SD) length was 17.70 (±1.06) centimetres. Hossain Parash et al. (2022) also found similar hand lengths in their study. This result did not match with Khancan et al. (2010), Habib and Kamal (2010), Ishak et al. (2012), Dey and Kapoor (2013), Moorthy and Zulkifly (2015), Varu et al. (2016), Zulkifly et al. (2018), Kim et al. (2018), Asadujjaman(2019) and, Romphothong and Traithepchanapai (2019) where the mean (±SD) value of the length of hand was higher than the result of the present study. The left hand's mean (±SD) length was 17.69(±1.05) centimetres. This value was similar to the value found by Varu et al. (2016) and Hossain Parash et al. (2022). The left-hand length did not match with Khancan et al. (2010), Habib and Kamal (2010), Ishak et al. (2012), Dey and Kapoor (2013), Moorthy and Zulkifly (2015), Zulkifly et al. (2018), Kim et al. (2018), Asadujjaman(2019) and, Romphothong and Traithepchanapai (2019) where the mean (±SD) value of the length of hand was higher than the result of the present study.

The right hand's mean (±SD) breadth was 7.88 (±0.66) centimetres. This value coincided with that of Zulkifly et al. (2018). This result did not correspond to Khancan et al. (2010), Habib and Kamal (2010), Ishak et al. (2012), Dey and Kapoor (2013), Varu et al. (2016), Zulkifly et al. (2018), Kim et al. (2018), Asadujjaman(2019) and, Romphothong and Traithepchanapai (2019) where the mean (±SD) value of the length of hand was higher than the result of the present study. The value was not similar to Moorthy and Zulkifly (2015) and Hossain Parash et al. (2022), where the value was lower than the present study. The left hand's mean (±SD) breadth was 7.44 (±0.36) centimetres. This value did not match with Khancan et al. (2010), Habib and Kamal (2010), Ishak et al. (2012), Dey and Kapoor (2013), Varu et al. (2016), Kim et al. (2018), Asadujjaman(2019) and, Romphothong and Traithepchanapai where the mean (±SD) value of the length of hand was higher than the result of the present study. The left handbreadth was not similar to Moorthy and Zulkifly (2015), Zulkifly et al. (2018), and Hosaain Parash et al. (2022), where the value was lower than in the present study.

The mean (±SD) length of the right and left middle finger was 7.60 (±0.51) and 7.61 (±0.51) centimetres. Both sides correspond to Zulkifly et al. (2018). This result did not match with Khancan et al. (2010), Habib and Kamal (2010), Ishak et al. (2012), Dey and Kapoor (2013), Moorthy and Zulkifly (2015), Varu et al. (2016), Zulkifly et al. (2018), Kim et al. (2018), Asadujjaman (2019), Romphothong and Traithepchanapai (2019) and, Hossain Parash (2022) where the mean (±SD) value of the length of hand was higher than the result of the present study.

The mean (±SD) second inter-crease length of the right and left middle finger were 2.60 (±0.22) and 2.61(±0.23) centimetres. This result did not correspond to Zulkifly et al. (2018), Jee and Yun (2015), and Habib and Kamal (2010), where the mean (±SD) value of the second inter-crease length on both sides was higher than the result of the present study.

The mean (±SD) of the right and left-hand span was 16.34(±1.57) and 16.37(±1.53) centimetres. The right-hand span was less than adult Bangladeshi males (Mostafiz 2011). The left-hand value could not be compared due to a lack of data.

Comparison Between Females From Other Populations

The right hand's mean (±SD) length was 17.0(±0.71) centimetres. The right hand's length was similar to Moorthy and Zulkifly (2015), Zulkifly et al. (2018), and Kim et al. (2018) and was dissimilar to Habib and Kamal (2010), Ishak et al. (2012), Dey and Kapoor (2013), and Romphothong and Traithepchanapai (2019) where the mean (±SD) value of the length of hand was higher than the result of the present study. This result did not match with Khancan et al. (2010), Varu et al. (2016) and Asadujjaman(2019) as the mean and SD(**±SD) were lower than the present study. The left hand›s mean (±SD) length was 16.96** (±0.76) centimetres. The left-hand length value corresponded to Khancan et al. (2010), Dey and Kapoor (2013), and Moorthy and Zulkifly (2015); however, it did not correspond with Zulkifly et al. (2018), Habib and Kamal (2010) and Ishak et al. (2012), where the mean and SD **(±SD) was higher than the present study. This result did not match with** Varu et al. (2016), Asadujjaman(2019), and Romphothong and Traithepchanapai (2019), where the mean (±SD) value of the length of the left hand was lower than the result of the present study.

The right hand's mean (±SD) breadth was 7.44 (±0.36) centimetres. This value coincided with Khancan et al. (2010) and Romphothong and Traithepchanapai (2019). This result did not correspond to Ishak et al. (2012), Dey and Kapoor (2013), Moorthy and Zulkifly (2015) and Kim et al. (2018), and Asadujjaman (2019), where the mean (±SD) value of the breadth of hand was higher than the result of the present study. The value was not similar to that of Varu et al. (2016) and Zulkifly et al. (2018), where the value was lower than the present study. The left hand's mean (±SD) breadth was 7.40 (±0.36) centimetres. This value match with Romphothong and Traithepchanapai (2019). This result did not correspond with Ishak et al. (2012), Dey and Kapoor (2013), Moorthy and Zulkifly (2015), Kim et al. (2018), and Asadujjaman (2019) here, the mean (±SD) value of the breadth of hand was higher than the result of the present study. This study did not match Khancan et al. (2010), Varu et al. (2016), and Zulkifly et al. (2018), where the value was lower than the present study.

The mean (±SD) length of the right and left middle finger was 7.33(±0.42) and 7.31(±0.42) centimetres. Both sides correspond to Rastogi et al. (2015). This result did not match with Ishak et al. (2012), Zulkifly et al. (2018), Asadujjaman (2019), and Romphothong and Traithepchanapai (2019), where the mean

(±SD) value of right and left middle finger were lower than the result of the present study.

The mean (±SD) of the right 2nd-inter-crease was 2.53 (±0.21). The length corresponded with Habib and Kamal (2010) and Zulkifly et al. (2018). This result did not match Jee and Yun's (2015), where the mean and SD (±SD) were higher than in the present study. The mean (±SD) of the Left 2nd inter-crease was 2.61(±0.23). This value did not match Habib and Kamal (2010), where the mean value was higher, and Zulkifly et al. (2018), where the mean value was lower than the present study.

The mean (±SD) of the right and hand span was 15.45(±1.29) and 15.53(±1.30) centimetres. Again, the paucity of data regarding the adult hand span contributed to the inability to discuss the data.

Comparison From Other Population

This present study demonstrated lower in most hand dimensions as compared to the study done by Ishak et al. (2012) in western Australia. Historically, the Bangladeshi population has diverse origins from various communities that entered this region over many centuries. According to William (2018), between 1787 and 1868, approximately 168,00 convicts from Britain and Ireland were sent to Australia. Either parents of Australian mixed or British or Irish descent have contributed to this dissimilarity. This different origin and geographical location have a strong impact on anthropometric dimensions (**İşeri** & Arslan, 2009).

The present study found some similarities and dissimilarities with other populations. A study by Varu et al. (2016), for instance, on male respondents only found similarity with the left-hand length but not with the right-hand length. For females, both right and left-hand lengths were lower than in the present study. This different finding might be explained due to the sample of the study being cadavers aged 20 years and above. The exclusion criteria were any injury, disease or anomaly, decomposed, charred or mutilated dead bodies were also excluded from the study.

Symmetry

Results from Table 5 demonstrated that the right-hand length and right handbreadth were higher than the left-hand length and left handbreadth, whereas the left middle finger length, second inter-crease length, and handspan were higher than the right side. None of these differences was statistically significant except between the handbreadths of both sides. Kulaksiz and Gözil (2002) also had similar findings. On the contrary, Plato et al. (1980) found that all right-hand dimensions were higher than the left-hand. Although the difference between the handbreadths in the present study was statistically significant, it was not very important (upper limit: 0.071). Kulaksiz and Gözil (2002) investigated five groups based on hand usage strength strong right preferent, weak right preferent, ambidextrous, weak left preferent, and strong left preferent groups. The difference was evident in the strongly right preferent group. As the main objective of this study was to create baseline data, the subjects of this study were not categorized based on their degree of hand dominance. Not categorizing the subjects might not have yielded a practically significant difference in the present study, which was found in other studies.

Gender Differences

In this study, male-female differences were statistically significant ($p<0.01$) in all hand dimensions (Table 6). The hand dimensions of males were more prolonged and broader in all hand measurements than in females. This study's findings were in line with a previous study by Shahriar et al. (2020), where the male had a more extended and broader hand dimension as compared to the female ($p< 0.05$). On the contrary, Kulaksiz and Gözil (2002) did not find any asymmetry based on gender.

These gender disparities can be attributed to how the skeletal system grows and develops as a result of genetic and environmental influences (Frayer & Wolpoff, 1985). Males have an additional two or more years of skeletal growth than females due to hormonal influence, which causes early maturity and the cessation of bone growth in females (Krishan & Sharma, 2007).

Ethnic Variation

The present study also investigated the difference between the ethnicities of Sabah. The present study found no significant difference among the Kadazandusun, Bajau, Malay, and Chinese populations among ethnicities in their hand measurements, and this finding did not correspond with Karmegam (2011). That study's result demonstrated significant differences ($p<0.05$) in most of the measurements taken between the three ethnicities (Malay, Chinese and Indian). The Malay and Chinese populations within the sample frame of the present study have different origins than West Malaysia. Among the Chinese, the Hakkas are prominent in Sabah, Cantonese, Hokkien, Teochew, Hainanese, and Shantung (Pugh-Kitingan, 2015). On the other hand, Hokkien, Cantonese, Foochows, and other groups are the majority in West Malaysia (Tan, 2005). The Malays are mostly of Bruneian and Kadayan origin (Pugh-Kitingan, 2015) while Malay sub-ethnic groups in peninsular Malaysia are Melayu Kelantan, Melayu Minang, Melayu Jawa and Melayu Bugis (Hatin et al., 2011). This difference in their origin might have played a role in the dissimilarities in the findings of the studies. Meanwhile, Numan et al. (2013) studied the significant differences in Nigerian ethnics which were only found between Yuroba and Hausas but not between Hausas and Igbos and between Igbos and Yuroba ($p< 0.05$).

Kulaksiz and Gözil (2002) opined that environmental factors such as hand activity, hormones, and brain asymmetry might influence hand preference on hand anthropometric measurements. However, the present study was limited to hand symmetry, gender, and ethnicity. The data collection at the community level was not possible. Instead, the study included the students of the university who fulfilled the inclusion criteria, which may not be representative of the major ethnic groups of Sabah. Nonetheless, the subjects were from different parts and major ethnic groups of Sabah, and they had similar lifestyles, food habits, and cultures. Again, while selecting samples, the medical conditions that might influence hand anthropometry were screened using a questionnaire, and no investigation confirmed it.

CONCLUSION

This study has provided baseline data for hand dimensions that may be useful for designing hand tools and other equipment for the Sabahan population. The data showed significant differences exist between the genders in Sabah Malaysia and other populace from other countries. Practitioners must be aware of these differences in job performance, health, and safety in the work environment when a hand device is designed from data for different gender and different population. However, to obtain complete data on the Sabahan population, further study at the community level is recommended for different age groups and ethnicities by addressing hand activity, hormones, and brain asymmetry.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest in publishing this article.

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REFERENCES

Akman, Ş. D., Karakaş, P., & Bozkir, M. G. (2006). The morphometric measurements of humerus segments. *Turkish Journal of Medical Sciences*, *36* (2), 81 – 85.

Akter, M. T., Amin, N. F., & Arif, A. (2021). Association of the dominant handgrip strength with the hand dimensions of adult Bangladeshi female laborers. *Asian Journal of Medical and Biological Research*, *7* (3), 230 – 237. https://doi.org/10.3329/ajmbr.v7i3.56133

Ali, İ., & Arslan, N. (2009). Estimated anthropometric measurements of Turkish adults and effects of age and geographical regions. *International Journal of Industrial Ergonomics*, *39* (5), 860 – 865. https://doi.org/10.1016/j.ergon.2009.02.007

Asadujjaman, M., Molla, M. B. A., & Al Noman, S. N. (2019). Stature estimation from hand anthropometric measurements in Bangladeshi population. *Journal of Forensic and Legal Medicine*, *65*, 86 – 91. https://doi.org/10.1016/j.jflm.2019.05.006

Bláha, P. (2007, June). Biometric methods – selected anthropometric methods used in biological anthropology. Intensive course in biological anthropology. *1st Summer School of the European Anthropological Association*. Retrieved from http://eaa.elte.hu/Blaha1.pdf

Chandra, C. A., Chandna, P., Deswal, S., Mishra Kumar, R., & Kumar, R. (2015). Stature prediction model based on hand anthropometry. *International Journal of Medical, Health, Biomedical and Pharmaceutical Engineering*, *9* (2), 201 – 207.

Dawal, S. Z. M., Ismail, Z., Yusuf, K., Abdul-Rashid, S. H., Md Shalahim, N. S., Abdullah, N. S., & Mohd Kamil, N. S. (2015). Determination of the significant anthropometry dimensions for user-friendly designs of domestic furniture and appliances –Experience from a study in Malaysia. *Measurement*, *59*, 205 – 215. https://doi.org/10.1016/J.MEASUREMENT.2014.09.030

Dey, S., & Kapoor, A. K. (2015). Hand length and hand breadth: a study of correlation statistics among human population. *International Journal of Science and Research*, *4* (4), 148 – 150.

Frayer, D. W., & Wolpoff, M. H. (1985). Sexual dimorphism. *Annual Review of Anthropology*, 429 – 473. https://doi.org/10.1146/annurev.an.14.100185.002241

García-Cáceres, R. G., Felknor, S., Córdoba, J. E., Caballero, J. P., & Barrero, L. H. (2012). Hand anthropometry of the Colombian floriculture workers of the Bogota plateau. *International Journal of Industrial Ergonomics*, *42* (2), 183 – 198. https://doi.org/10.1016/j.ergon.2011.12.002

Habib, S. R., & Kamal, N. N. (2010). Stature estimation from hand and phalanges lengths of Egyptians. *Journal of Forensic and Legal Medicine*, *17* (3), 156 – 160. https://doi.org/10.1016/j.jflm.2009.12.004

Hatin, W. I., Nur-Shafawati, A. R., Zahri, M. K., Xu, S., Jin, L., Tan, S. G., Rizman-Idid, M., Zilfalil, B. A., & Hugo Pan-Asian SNP Consortium. (2011). Population genetic structure of peninsular Malaysia Malay sub-ethnic groups. *PloS One*, *6* (4), e18312. https://doi.org/10.1371/journal.pone.0018312

Hossain Parash, M. T., Rahman, M. M., Naushaba, H., Haque, S., & Shimmi, S. C. (2022). Simple linear regression approach for evaluating models to estimate stature based on upper limb dimensions of adult Bangladeshi males. *Egyptian Journal of Forensic Sciences*, *12* (1), 1 – 9. https://doi.org/10.1186/s41935-022-00277-3

Hossain, M. G., Zyroul, R., Pereira, B. P., & Kamarul, T. (2012). Multiple regression analysis of factors influencing dominant handgrip strength in an adult Malaysian population. *Journal of Hand Surgery (European Volume)*, *37* (1), 65 – 70. https://doi.org/10.1177/1753193411414639

Hossain, S. (2009). *An anthropometric study of the upper limb dimensions as related to stature and determination of frame index and palm index in Christian Garo adult females* (Unpublished masters thesis). Bangabandhu Sheikh Mujib Medical University, Dhaka.

Ishak, N. I., Hemy, N., & Franklin, D. (2012). Estimation of stature from hand and handprint dimensions in a Western Australian population. *Forensic Science International*, *216* (1 – 3), 199-e1. https://doi.org/10.1016/j.forsciint.2011.09.010

Jee, S. C., & Yun, M. H. (2015). Estimation of stature from diversified hand anthropometric dimensions from Korean population. *Journal of Forensic and Legal Medicine*, *35*, 9 – 14. https://doi.org/10.1016/j.jflm.2015.06.014

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

Karmegam, K., Sapuan, S. M., Ismail, M. Y., Ismail, N., Shamsul Bahri, M. T., Shuib, S., Mohana, G. K., Seetha, P., TamilMoli, P., & Hanapi, M. J. (2011). Anthropometric study among adults of different ethnicity in Malaysia. *International Journal of Physical Sciences*, *6* (4), 777 – 788. https://doi.org/10.5897/IJPS10.310

Khan, H. B. M. A., & Moorthy, T. N. (2016). Stature estimation from foot outline measurements in adult Lun Bawang ethnics of east Malaysia by regression analysis. *Medico-Legal Update*, *16* (2), 187 – 192. https://doi.org/10.5958/0974-1283.2016.00087.6

Kim, W., Kim, Y. M., & Yun, M. H. (2018). Estimation of stature from hand and foot dimensions in a Korean population. *Journal of Forensic and Legal Medicine*, *55*, 87 – 92. https://doi.org/10.1016/j.jflm.2018.02.011

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

Kulaksiz, G., & Gözil, R. (2002). The effect of hand preference on hand anthropometric measurements in healthy individuals. *Annals of Anatomy – Anatomischer Anzeiger*, *184* (3), 257 – 265. https://doi.org/10.1016/S0940-9602(02)80119-4

Lin, Y. C., Wang, M. J. J., & Wang, E. M. (2004). The comparisons of anthropometric characteristics among four peoples in East Asia. *Applied Ergonomics*, *35* (2), 173 – 178. https://doi.org/10.1016/j.apergo.2004.01.004

Mondal, M. K., Jana, T. K., Das, J., & Biswas, S. (2009). Use of length of ulna for estimation of stature in living adult male in Burdwan district and adjacent areas of West Bengal. *Journal of the Anatomical Society of India*, *58* (1), 16 – 18.

Moorthy, E., & Zulkifly, N. (2015). Regression analysis for stature determination from hand anthropometry of Malaysian Malays for forensic investigation. *Sri Lanka Journal of Forensic Medicine, Science & Law*, *5* (2). https://doi.org/10.4038/sljfmsl.v5i2.7753

Numan, A. I., Idris, M. O., Zirahei, J. V., Amaza, D. S., & Dalori, M. B. (2013). Prediction of stature from hand anthropometry: A comparative study in the three major ethnic groups in Nigeria. *British Journal of Medicine and Medical Research*, *3* (4), 1062. https://doi.org/10.9734/BJMMR/2013/1932

Nurul Shahida, M. S., Siti Zawiah, M. D., & Case, K. (2015). The relationship between anthropometry and handgrip strength among elderly Malaysians. *International Journal of Industrial Ergonomics*, *50*, 17 – 25. https://doi.org/10.1016/j.ergon.2015.09.006

Park, S. J., Min, S. N., Lee, H., Subramaniyam, M., & Ahn, S. J. (2014, June). 3D Hand anthropometry of Korean teenagers and comparison with manual method. In *International Conference on Human-Computer Interaction* (pp. 491 – 495). Springer, Cham. https://doi.org/10.1007/978-3-319-07854-0_85

Plato, C. C., Wood, J. L., & Norris, A. H. (1980). Bilateral asymmetry in bone measurements of the hand and lateral hand dominance. *American Journal of Physical Anthropology*, *52* (1), 27 – 31. https://doi.org/10.1002/ajpa.1330520105

Pugh-Kitingan J. (2015). Cultural and religious diversity in Sabah and relationships with surrounding areas. *Malay Civilization*. http://malaycivilization.com.my/items/show/150850

Rahman, M. M. (2011). An anthropometric study of the upper limb dimensions in adult Muslim Bangladeshi male (Unpublished masters thesis). University of Dhaka.

Rastogi, P., Kanchan, T., Menezes, R. G., & Yoganarasimha, K. (2009). Middle finger length – A predictor of stature in the Indian population. *Medicine, Science and the Law*, *49* (2), 123 – 126. https://doi.org/10.1258/rsmmsl.49.2.123

Romphothong, M., & Traithepchanapai, P. (2019). Sex determination through anthropometry of hand and foot in Thais. *Chulalongkorn Medical Journal*, *63* (1), 47 – 55.

Ruiz, J. R., España-Romero, V., Ortega, F. B., Sjöström, M., Castillo, M. J., & Gutierrez, A. (2006). Hand span influences optimal grip span in male and female teenagers. *The Journal of Hand Surgery*, *31* (8), 1367 – 1372. https://doi.org/10.1016/j.jhsa.2006.06.014

Sabah State Government. (2022, July 24). Retrieved from https://sabah.gov.my/cms/?q=en/content/people-history

Sanli, S. G., Kizilkanat, E. D., Boyan, N., Ozsahin, E. T., Bozkir, M. G., Soames, R., Erol, H., & Oguz, O. (2005). Stature estimation based on hand length and foot length. *Clinical Anatomy*, *18* (8), 589 – 596. https://doi.org/10.1002/ca.20146

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

Sharifi-Mollayousefi, A., Yazdchi-Marandi, M., Ayramlou, H., Heidari, P., Salavati, A., & Zarrintan, S. (2008). Assessment of body mass index and hand anthropometric measurements as independent risk factors for carpal tunnel syndrome. *Folia Morphologica*, *67* (1), 36 – 42. https://www.fm.viamedica.pl

Sullivan III, M. (2017). *Statistics: Informed decisions using data* (5th ed.). Pearson.

Tan, C, B. (2005). Chinese in Malaysia. In M. Ember, C. R. Ember, & I. Skoggard (Eds.), *Encyclopedia of diasporas*. Springer. https://doi.org/10.1007/978-0-387-29904-4_72

Tur, J. A., & Bibiloni, M. (2019). Anthropometry, body composition and resting energy expenditure in human. *Nutrients*, *11* (8), 1891. https://doi.org/10.3390/nu11081891

Varu, P. R., Gajera, C. N., Mangal, H. M., & Modi, P. M. (2016). Determination of sex using hand dimensions. *International Journal of Medical Toxicology and Forensic Medicine*, *6* (1), 23 – 28.

Widyanti, A., Susanti, L., Sutalaksana, I. Z., & Muslim, K. (2015). Ethnic differences in Indonesian anthropometry data: Evidence from three different largest ethnics. *International Journal of Industrial Ergonomics*, *47*, 72 – 78. https://doi.org/10.1016/j.ergon.2015.02.008

Williams, L. (2018). *Convicts in the colonies: Transportation tales from Britain to Australia*. Casemate Publishers.

Yu, A., Yick, K., Ng, S., Yip, J., & Zhang, X. (2014, January). Modification of finger web gusset for improving fit and comfort of pressure therapy gloves. In *Textile bioengineering and informatics symposium proceedings*.

Zulkifly, N. R., Wahab, R. A., Layang, E., Ismail, D., Desa, W. N. S. M., Hisham, S., & Mahat, N. A. (2018). Estimation of stature from hand and handprint measurements in Iban population in Sarawak, Malaysia and its applications in forensic investigation. *Journal of Forensic and Legal Medicine*, *53*, 35 – 45. https://doi.org/10.1016/j.jflm.2017.10.011