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Ergonomic Ship Chair Design for Indonesian People

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Abstract:
An anthropometric study of Indonesian people use ship in economy class in East Java was conducted. Fifty-eight body dimensions, age, body weight, and hand squeeze strength for chair design importance were measured for 300 Indonesian males, comprising Javanese (150) and Madurese (150) tribes. The two tribes were compared to identity similarity and contrast existing in their respective body dimensions. Descriptive statistics provided mean, standard deviation, percentile value and coefficient of variance of each population. The survey also revealed that the mean values of hand squeeze strength of Javanese males were higher than the Madurese have. For ergonomically design for seat of ship is as follows seat height 38.7 cm, seat depth 42.2 cm, seat width per passenger 40.0 cm, height of back rest 89.1 cm, angle of tilt back rest is 105° to 115°, width of backrest is 44.5 cm, height of armrest is 94.8 cm, length arm of armrest is 26.7 cm, footrest width is 4.5 cm, legroom is 55.8 cm.

Keywords: *Anthropometric, male, Indonesian, ship seat*

1. Introduction

The use of ergonomic tools, methods, concepts and theories has been pleaded by many designers and researchers to improve safety of human. Anthropometric datum is one of the indispensable elements in designing machines and tools (Mebarki and Davies, 1990). Since the dimension of the system design that design of the workplace must be in conformity with the user's body dimensions, the designers had to notice to anthropometric data onto the design of workplaces. Hertzberg (1960) collected anthropometric data and conducted measurements of various positions on the human body of the key landmarks that they had made.

Anthropometry is a study of information on body dimensions and weight of the human body, further classified into groups usually based on gender, race, ethnicity and nationality. The aims of using of anthropometry data in machinery design and tools to improve safety, comfort and health of workers (Pheasant, 1997). Furthermore, studies reveal that consideration of anthropometric data could successfully improve worker performance and productivity (Klamklay et al., 2008). Similarly, it is expected that consideration of anthropometric information on design of agricultural tools could also help reduce drudgery in agricultural activities. Anthropometric data is one of the most important factors as reference for product design ergonomic and safe (Victor et al, 2002). Marras, and Kim (1993) stated that the advantages of applying ergonomic data in the initial phases of the design process are widely acknowledged. It is difficult to design a tool to suit all (majority) body types and sizes ergonomically without anthropometry.

Detailed surveys, contribute to the valuable data bank for practical use by designers and researchers. Several of such surveys have been conducted on anthropometry in the developed and developing countries, such as: Ray et al. (1995) conducted a study of Indian school kids aged 3-5 years; Jarosz (1999) studied anthropometry of the aged women in Poland; Liu et al. (1999) examined the anthropometry of female Maquiladora workers; Kothiyal and Tettey (2000) compiled the anthropometric data of aged people in Australia; Prado-Leon et al. (2001) studied Mexican primary school children; Bolstad et al. (2001) examined the anthropometry of Norwegian who worked in office and light industries; Victor et al. (2002) surveyed Indian farm workers; Mokdad (2002) examined the anthropometry of Algerian farmers; Wang et al. (2002) provided database of anthropometric children and young adults in Taiwan; Barroso et al. (2005) studied anthropometry of Portuguese workers; Dewangan et al. (2008) studied anthropometry of female farmers in north-eastern India; Klamklay et al. (2008) obtained anthropometric data from Southern Thai population; Hanson et al. (2009) reported the Swedish anthropometric data for product and workplace design; Mokdad and Al-Ansari (2009) analyzed the anthropometric data of Bahraini school children; Chuan et al. (2010) reported anthropometry of the Singaporean and

Indonesian population; and Dewangan et al. (2010) improved anthropometric data of male farmers for design of agricultural tools ergonomically.

Measurement of different body dimensions could have some specific application, whether in designing a seat for a tractor to increase safety for operator or designing a sprayer for safety. However, measurements of certain body dimensions probably have rather general utility, and summary data on some of these features can be presented for illustrative purposes. Corresponding data from surveys of other samples can vary from data from this survey. And as a word of caution, measurements of subjects wearing special gear, such as arctic clothing or heavy work clothing, can add inches to the persons' space requirements. Hughes (1996) stated that to solve problems of designing of equipment ergonomically, designer should consider the measurement data of static human position on the design.

Indonesian often use ships as one of the means of transport for them. Economy class ships are preferred by Indonesian because of their economical price. As one of the ship manufacturers in Indonesia, PT. Penataran Angkatan Laut (PAL), should have paid attention to ergonomic aspects in designing designs for ship, especially the design of passenger seats. The design of the existing economy-class ship passenger seats still has not paid attention to the ergonomic aspect because there are still many complaints from the economy ship passengers. The existing economic ship seats have a rigid shape that is less supportive of posture when sitting, lacking armrests. When using a ship for transportation, Indonesian will take a long time to sit in the economy class ship so may have more fatigue. To reduce fatigue for Indonesian people, ergonomic ship passenger seats are required in accordance with the anthropometry of Indonesian people.

Considering its sizeable population and ethnic diversity, Indonesia currently has limited anthropometric information. Published research on the anthropometry of Indonesian people (Manuba and Nala, 1969; Chuan et al., 2010) seems insufficient. Manuba and Nala (1969) provided anthropometric data of 5 farmers, while Chuan el al. (2010) examined university student (245 males and 132 females) in Indonesia by measuring 35 body dimension and body weight. Wibowo et al. (2012) studied anthropometry of Javanese and Madurese farmers in Indonesia. Since 1969 there appears lack of sufficient publication on anthropometry of indonesian people in Indonesia. Hence, to meet the design needs of ergonomic machines, tools, and chairs access to a comprehensive database was felt necessary.

This study, therefore, aims to record anthropometric data of important body dimensions of Javanese and Madurese who use ship as transportation that spread in East Java, Indonesia. The anthropometric data from the research are expected to be used as a reference in design/redesign of ship chair in accordance with anthropometry of Indonesian.

2. Metods

This research focused on Javanese and Madurese male who use ship for transportation. Retrival of data on the body dimensios took about 4 months in year 2018. Measurements followed the procedure that was used by Wibowo et al. (2013).

2.1. Subjects

A total of 300 male Indonesian participated in this study. The subjects were drawn from Javanese (150) and Madurese (150) ethnic groups who lived in Jember, Banyuwangi, Lumajang, Bondowoso, and Probolinggo East Java.

2.2. Body Dimensions

Information on 39 body dimensions, age, body weight, and hand squeeze strength were collected in this study. Subjects were approached during scholing or when they are at home. Measurements were made while male Indonesian wore T-shirt or naked chest and did not wear footwear. Measurements included in this study were as suggested by Pheasant and Haslegrave (2006).

2.3. Equipments Used

The measurements were performed by a team of university students who were thoroughly trained in laboratory, prior to field measurements. The measurements for standing and sitting posture were made using a Martin type anthropometer (Kroemer et al., 1986; Shao, 1985). Body weight of subjects was measured with a digital weighing scale. A spreading caliper and a digital caliper were used to measure hand and foot dimensions. A plastic tape was used to measure vertical hand grip when standing. A squeeze dynamometer was used to measure power of hand in squeezing action.

2.4. Procedure

The team of researchers was trained for a week on how to recognize the dimensions to be measured, to use measuring instruments and to record data into log sheet. Subjects were chosen randomly, having normal appearance and having no physical disabilities. Before the measurements are made, the subjects were given an explanation about the purpose of the study. Only subjects who gave their consent were considered further. During measurement of body dimensions, the subjects were requested to remove footwear and shirt while measuring their foot, chest and abdominal dimensions. Measurements were taken at the right and left side of the subjects. It took approximately 35-40 minutes per subject to complete the intended measurements.

3. Results and Discussion

3.1. Anthropometric Data of Javanese and Madurese Males Who Use Ship in Economy Class

Descriptive statistics of anthropometric data of Javanese and Madurese males that lived in East Java is summarized in Tables 1 and 2, respectively. These tables include mean, standard error of mean (SEM), coefficient of

variation (CV), standard deviation (SD), and 1st, 5th, 50th, and 99th percentile values of 39 body dimensions, age, body weight and hand squeeze strength.

The age of subjects was between 17-65 years. Measurements were taken in static position. He stated that all body dimensions should be reduced by about 0.3% of its value, while the elbow height to be increased by 0.5% for this conversion. The value of knee height remains unchanged. Forward reach is decreased by 30%, reach is increased around 20% if involving extensive shoulder and trunk. Ethnic diversity significantly influenced on the differences in anthropometry of Javanese and Madurese populations. The difference between two populations can be fairly described as general access to better nutrition that results in a better body growth (Chuan et al.,2010).

For ergonomic design of the ergonomic ship seats as follows:

- Seat Height. Height of chair = height of popliteal of data anthropometry. The data taken from the 5th percentile anthropometric data of popliteal height, which is 41.1 cm for Javanese and 38.7 cm for Madurese. For the design of the chair used size 38.7 cm.
- Depth of seats. Seat depth = Buttock-popliteal length in 5th percentile of anthropometric data i.e. 43.1 cm for Javanese and 42.2 cm for Madurese, excluding the addition of seat depth to support the back rest. For the design of the chair used size 42.2 cm.
- Length of Seats. Seat length = width of anthropometric data of hip of 95th percentile diminished 5 cm (2.5 cm right and 2.5 cm left, respectively). Data of anthropometric for hip breadth with 95th percentile that is 40.6 cm for Javanese and 40.2 for Madurese. For ergonomic design for seat length is minus 5 cm. So, the seat length becomes 35.6 cm for Javanese and 35.2 cm for Madurese. In considering sufficient space to meet consumers' needs for the seating, the designer can round out the 35.6 cm and 35.2 cm long seat to 40.0 cm for the economy-class rail seat length. With design of a seat length of 40.0 cm, it can reach anthropometry of population from the 5th percentile to the 95th percentile.
- Backrest height of seat. The backrest height of seat size that used as the backrest of seat design parameters is the height data of the person at the sitting position in the 95th percentile, which is 89.1 cm for Javanese and 88.6 cm for Madurese. For the design of the chair used size 89.1 cm.
- Seat angle or tilt. A good seat should have good contact with a backrest. The design of a good backrest has a slope of = 105o to 115o in the direction of passengers in the reclining position.
- The width of the chair back. Design of the seat back is determined as the width of the backrest = Shoulder breadth (bideltoid) of anthropometry data at 50th percentile, which is 44.5 cm for Javanese and 41.2 cm for Madurese, respectively. For the design of the chair used size 44.5 cm.
- Armrests Height. Armrest height = elbow height in sitting position. The anthropometric data used is the 5th percentile i.e. 97.1 cm for Javanese and 94.8 cm for Madurese. For the design of the chair used size 94.8 cm.
- Armrest Length. Based on Scott and Erin (2006) armrest length is 26.7 cm (10.5 inches).
- Footrest width. Foothold width = 0.2 times of foot length. The anthropometry data of foot length in the 5th percentile that is 21.8 cm for Javanese and 22.5 cm for Madurese. From the calculation, obtained the width of the footrest is 4.5 cm for both.
- Legroom. According to Panero and Zelnik (1979), ideal lateral legroom measures approximately 45.0 cm in order for the legs of the average person to get enough space for movement. Vertical legroom is used according to the height of the 95th percentile of anthropometry data of knee, which are 55.1 cm for Javanese and 55.8 cm for Madurese. For the design of the chair used size 55.8 cm.

3. Conclusions

This research successfully collected anthropometric data of Javanese and Madurese males who use ship in economy class of East Java, Indonesia, through field study. Anthropometric data of Javanese males were mostly higher than the data of Madurese males. Furthermore, hand squeeze strength of Javanese males is slightly higher than Madurese males.

For ergonomically design for ship seat is as follows: seat height 38.7 cm, seat depth 42.2 cm, seat width per passenger 40.0 cm, height of back rest 89.1 cm, angle of tilt back rest is 105° to 115°, width of backrest is 44.5 cm, height of armrest is 94.8 cm, length arm of armrest is 26.7 cm, footrest width is 4.5 cm, legroom is 55.8 cm.

4. Acknowledgement

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Appendix

No.	Dimension	Mean	SEM	CV(%)	SD	Percentile				
						1st	5th	50th	95th	99th
1	Stature	161.2	0.52	3.34	4.16	151.2	152.3	161.0	166.0	171.2
2	Eye height	150.9	0.50	3.03	4.22	139.5	141.7	150.4	157.3	162.3
3	Elbow height	101.6	0.34	2.82	3.06	96.1	97.1	101.2	105.6	108.6
4	Fingertip height	57.6	0.31	5.33	3.42	50,7	52.1	57.3	62.1	66.1
5	Knuckle height	68.4	0.35	4.63	3.81	62.0	63.2	68.3	73.1	77.0
6	Wrist height	75.2	0.42	4.23	3.98	69.5	70.3	75.1	81.3	85.3
7	Hip height	83.5	0.48	5.23	3.28	73.3	75.2	83.2	87.4	95.6
8	Shoulder height	132.3	0.42	3.35	5.12	121.0	123.4	132.2	137.1	144.5
9	Vertical grip reach (standing)	193.2	0.68	3.35	6.62	177.3	181.4	193.3	200.4	208.1
10	Elbow span	84.4	0.22	2.55	3.12	78.3	81.2	84.2	86.4	91.2
11	Span	165.2	0.33	1.66	3.14	157.2	158.9	165.2	167.2	173.6
12	Forward grip reach	73.9	0.21	2.31	2.32	68.6	70.3	73.25	75.4	78.2

No.	Dimension	Mean	SEM	CV(%)	SD	Percentile				
						1st	5th	50th	95th	99th
13	Shoulder-grip length	63.1	0.19	2.52	2.88	59.3	60.4	63.1	64.1	65.8
14	Upper limb length	72.3	0.19	2.18	2.07	68.0	69.1	72.1	73.2	75.9
15	Sitting height	82.0	0.34	4.45	4.36	73.9	75.1	81.8	89.1	90.7
16	Sitting eye height	70.5	0.54	5.57	3.56	63.5	64.0	70.5	74.6	78.1
17	Sitting shoulder height	52.1	0.32	7.63	3.67	45.1	46.5	51.9	57.2	62.3
18	Sitting elbow height	23.6	0.26	9.55	2.22	19.3	21.0	23.4	27.2	28.2
19	Shoulder-elbow length	32.2	0.24	6.43	2.49	26.8	28.3	32.3	34.5	36.1
20	Thigh Thickness	13.8	0.16	6.32	0.67	11.5	12.4	13.4	14.9	16.1
21	Popliteal height	44.1	0.26	2.59	1.23	39.8	41.1	44.0	44.6	45.4
22	Knee height	53.9	0.27	2.33	1.82	50.3	51.1	53.8	55.1	57.0
23	Elbow-fingertip length	42.2	0.23	4.62	2.61	38.1	39.6	41.9	44.3	46.2
24	Head length	20.3	0.12	3.86	0.57	17.3	17.6	20.7	19.9	21.8
25	Head breadth	18.2	0.14	4.25	0.860	15.1	15.2	18.3	18.9	19.6
26	Shoulder breadth (biacromial)	36.8	0.22	4.32	1.50	32.2	34.4	36.8	39.2	40.9
27	Shoulder breadth (bideltoid)	44.8	0.28	5.16	2.13	39.4	41.0	44.5	47.2	53.8
28	Hip breadth	39.2	0.26	5.04	1.77	34.5	36.9	39.4	40.6	41.8
29	Vertical grip reach (sitting)	116.2	0.55	4.39	5.17	104.3	106.1	116.2	124.1	128.6
30	Chest (bust) depth	21.8	0.17	7.12	1.65	17.7	18.8	21.9	22.8	24.3
31	Abdominal depth	20.2	0.18	7.04	1.44	16.8	17.4	19.5	22.4	23.8
32	Buttock-knee length	52.4	0.32	3.56	1.76	49.3	49.9	52.5	55.3	59.4
33	Buttock-popliteal length	46.1	0.21	4.55	1.90	42.3	43.1	45.9	48.4	51.2
34	Palm length	10.9	0.15	12.44	1.23	8.7	9.6	10.8	11.2	17.6
35	Foot length	23.6	0.33	9.32	2.27	18.7	21.8	23.9	26.8	28.6
36	Heel breadth	5.8	0.09	8.07	0.42	4.8	5.4	5.7	6.4	6.9
37	Foot breadth	10.7	0.11	5.56	0.49	9.7	9.9	10.7	11.8	12.9
38	Hand breadth	8.5	0.09	7.28	0.58	6.5	7.8	8.7	9.5	10.1
39	Hand length	18.3	0.10	4.88	0.74	16.4	16.9	18.7	19.2	20.3
40	Body weight (kg)	55.7	0.87	11.43	6.83	41.3	48.4	55.2	66.8	70.9
41	hand squeeze strength (psi)	15.6	0.22	15.78	2.67	10.2	10.5	15.8	17.9	19.8

Table 1: Anthropometric Data of Javanese Male (Age 18-62 Years, N = 150)
(All Body Dimensions Are in Cm, Unless Specified)

SN	Dimension	Mean	SEM	CV(%)	SD	Percentile				
						1st	5th	50th	95th	99th
1	Stature	158.3	0.94	4.33	7.03	145.3	146.3	158.1	171.2	173.1
2	Eye height	146.1	0.96	5.91	6.90	135.5	136.2	146.5	160.2	163.4
3	Elbow height	100.4	0.55	4.67	4.87	92.3	94.8	100.3	107.8	108.1
4	Fingertip height	56.0	0.50	8.63	4,78	48.2	49.6	55.7	64.1	66.4
5	Knuckle height	66.4	0.56	6.67	4.64	58.1	60.0	65.6	74.4	75.3
6	Wrist height	73.6	0.64	7.12	5.47	65.4	66.5	73.2	84.2	85.3
7	Hip height	81.2	0.85	8.33	6.67	71.4	72.1	80.3	94.7	95.8
8	Shoulder height	128.4	0.91	5.34	6.84	117.3	119.7	128.8	142.4	145.8
9	Vertical grip reach (standing)	189.4	1.23	5.67	9.75	170.3	173.3	188.8	204.5	207.6
10	Elbow span	84.1	0.43	3.78	3.43	77.2	78.5	84.1	90.1	92.2
11	Span	163.3	0.69	3.87	4.94	151.7	153.3	163.2	171.3	174.7

SN	Dimension	Mean	SEM	CV(%)	SD	Percentile				
						1st	5th	50th	95th	99th
12	Forward grip reach	72.3	0.42	3.36	2.89	65.7	67.2	72.1	75.5	77.5
13	Shoulder-grip length	62.3	0.33	3.12	2.68	56.3	57.2	62.3	65.4	66.5
14	Upper limb length	71.3	0.43	3.67	2.57	65.1	66.2	71.4	75.2	76.8
15	Sitting height	78.6	0.55	6.45	5.32	70.3	71.7	78.3	88.6	90.4
16	Sitting eye height	67.8	0.65	7.68	5.67	60.1	61.3	67.5	76.8	78.3
17	Sitting shoulder height	50.2	0.67	10.33	4.76	42.2	44.2	50.3	60.3	61.8
18	Sitting elbow height	23.1	0.34	11.45	2.67	17.4	20.2	23.4	26.8	27.5
19	Elbow-shoulder length	30.2	0.32	10.22	3,12	16.1	26.2	29.5	36.4	36.3
20	Thigh thickness	13.4	0.25	7.45	1.34	10.2	12.6	13.3	14.8	15.2
21	Popliteal height	42.4	0.23	4.45	1.87	38.6	38.7	41.2	44.5	45.9
22	Knee height	52.4	0.34	4.54	2,78	48.3	49.3	52.7	55.8	57.7
23	Elbow-fingertip length	41.2	0.56	7.64	3.78	35.6	36.7	40.6	46.1	48.6
24	Head length	19.8	0.09	4.21	0.89	17.6	17.9	19.8	20.7	21.8
25	Head breadth	17.8	0.10	4.11	0.85	15.6	16.5	17.8	18.6	18.9
26	Shoulder breadth (biacromial)	34.8	0.45	8.23	2.56	31.3	32.4	34.5	42.5	43.1
27	Shoulder breadth (bideltoid)	41.7	0.56	7.21	3.89	37.2	39.0	41.2	49.2	50.4
28	Hip breadth	37.8	0.22	4.58	1.43	34.6	36.4	37.8	40.2	41.7
29	Vertical grip reach (sitting)	112.3	0.79	6.31	7.45	99.2	102.2	112.3	123.6	126.2
30	Chest (bust) depth	19.8	0.16	7.23	1.30	17.2	17.7	19.9	22.5	24.7
31	Abdominal depth	19.8	0.56	9.76	1.93	16.8	17.1	19.9	22.8	24.9
32	Buttock knee length	51.3	0.38	5.32	2.37	47.6	48.1	50.5	56.1	58.4
33	Buttock-popliteal length	45.1	0.43	6.12	3.46	41.3	42.2	44.7	50.2	52.2
34	Palm length	10.2	0.09	5.21	0.45	9.6	9.8	10.2	11.3	12.9
35	Foot length	23.6	0.41	7.58	1.63	21.8	22.5	23.4	27.2	29.4
36	Heel breadth	5.7	0.12	10.23	0.89	3.8	4.9	5.9	6.8	6.9
37	Foot breadth	19.7	0.28	15.84	1.67	8.6	9.1	10.6	11.8	14.8
38	Hand breadth	8.8	0.11	8.26	0.43	6.9	7.4	8.6	9.7	10.6
39	Hand length	17.9	0.28	6.98	1.87	16.1	16.6	17.7	20.9	21.8
40	Body weight (kg)	57.8	0.97	13.53	6.12	36.3	41.2	56.8	67.3	69.6
41	hand squeeze strength (psi)	14.8	0.43	17.58	2.44	8.7	10.1	15.3	17.4	19.2

Table 2: Anthropometric Data of Madurese Male (Age 17-65 Years, N = 150)
(All Body Dimensions Are in Cm, Unless Specified)