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HEAD AND FACIAL ANTHROPOMETRY FOR DETERMINING THE CRITICAL GLASSES FRAME DIMENSIONS

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Abstract

Many products have been designed and developed to aid and support people in their daily activities. The products are created after a series of activities from generating ideas, converting the ideas into design, and bringing the design into a real product. Glasses consist of a sub-assembly and components namely a frame and a pair of lenses. The frame has three critical parts namely the rim, bridge width, and temple length. The aim of this research is to determine the head and facial anthropometry which can be used to find the critical glasses frame dimensions. The results of this research show that there are significant differences in the anthropometry between female and male. We proposed the same dimension for end piece and bridge for both female and male while the rim and temple dimension must be different between female and male.

Keywords: Head and facial anthropometry, Glasses frame, Critical dimensions.

1. Introduction

Many products have been designed and developed to aid and support people in their daily activities. The products are created after a series of activities from generating ideas, converting the ideas into design, and bringing the design into a real product. Some products are new and some others are an increment from previous designs. Generally, a design process will consider many aspects such as users, functions, ergonomics, and aesthetics. The users and ergonomics play a vital role in the product design [1].

Anthropometry is the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body [2]. Using anthropometry, a product dimensions must be able to be found from the human body dimensions. Anthropometry has been recognized as critical in successfully designing and sizing protective helmets, eyewear, and respirators [3]. Glasses are important eyewear product that is designed to aid the

Nomenclatures

BS	Bridge size, mm
HEB	Horizontal ear breadth, mm
OND	Occiput to nasion distance, mm
OTD	Occiput to tragion distance, mm
R	Rim of glasses frame, mm
TFW	Total frame width, mm
TL	Temple length, mm

human vision, protect the eyes, and also used as fashion accessory. Glasses consist of sub-assembly and components, namely a frame and a pair of lenses. There are two important aspects that must be considered in glasses frame design: style and comfort. The styles of glasses frame may be utilized to change the impressions of human face [4] and have strong relationship with physical attractiveness and personality traits [5].

Several researches have been conducted in the field of anthropometry. Hu et al. [6] conducted a research to determine the anthropometry of elderly people living in China, especially in Beijing area. The data are then used to describe the gender and national differences of anthropometric characteristics for the elderly people compared to Japanese data. The data are very useful in designing the healthcare facilities and living products. Another research was conducted by Del Prado-Lu [2] which measured the anthropometric data of Filipino manufacturing workers in 31 manufacturing industries. The results of the research can be used as valuable data in designing workstations, personal protective equipment, tools, interface systems, and furniture that aid in providing a safer, more productive, and user-friendly workplace for the Filipino working population.

The important of head and facial anthropometry to find the optimal dimensions of products related to the head and part of the face has attracted many researchers. Liu [1] conducted a research to incorporate anthropometry in the design of ear-related products. The research has found that there are three ear critical dimensions which can be used in determining the dimensions of the products. Ear-hole, ear-connection, and pinna length are the determinant of the ear-related dimensions. In a similar research, Liu et al. [7] determined six anthropometric characteristics in designing spoon for children. The research also investigated the effect of age on dimensions and found that the characteristics can be divided into several subsets and revealed the needs for different dimensions in each subset. A deeper analysis of facial anthropometric data has been conducted by Zhuang et al. [8]. They found statistically significant difference among race/ethnic groups, gender, and age in facial anthropometric measurements. It was an important research since the respective data are more than 40 years old. Beside that, the data up-date are needed due to the increased in body size and facial measurement and higher proportion of minorities in current US workforce. The main goal of the research is to determine the face shape and size differences among races and age groups for the design of more fitted respirators.

Kim et al. [9] conducted a research to determine the fitness of quarter mask respirators to the Korean face anthropometry. They also found that gender has a significant effect on facial anthropometry and the mask respirator dimensions must be re-determined according to the results of the research. Yang and Shen [10] conducted a survey in facial anthropometry and used the data to design a half–mask respirator and determine its size for Chinese people. The research found 10 facial anthropometry dimensions in determining the critical dimensions of the respirator. None of the above researches used the head and facial anthropometry in determining of glasses frame dimensions. Hence the aim of this research is to determine the critical dimensions of glasses frame using the head and facial anthropometry. In this research, we only consider the functional aspect of the glasses. This research is important since the glasses are used for many purposes such as for visual aid and eye safety and protection. The rest of this paper is organized as follows. In Section 2 we present the materials and method used in the research. Section 3 deals with the results and discussions, while the conclusions and directions for future research are drawn in the last section.

2. Materials and Methods

In this research, we firstly identify the critical parts of the glasses frame. We found some websites containing descriptions about the critical dimensions of the frame. For example according to [11] and [12], a glasses frame has three critical dimensions which are the rim, bridge width, and temple length. According to [11-13], there are three measurable dimensions of a glasses frame and coded using seven digits code. The first two digits represent the horizontal rim size. The next two digits represent the bridge width, while the rest of the digits represent the temple length. The critical dimensions of the glasses frame are shown in Fig. 1. In Figs. 1, A, B, and C represent the bridge width, rim, and temple length respectively.

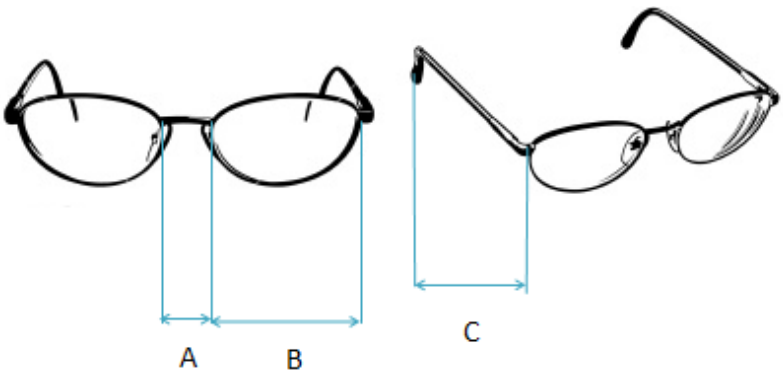

Fig. 1. Critical dimensions of glasses frame.

After determining the critical part of the frame, we proceed to determine the head and facial anthropometry from which the critical dimensions must be determined. The head and facial anthropometric measurement point can be found by tracing the glasses components which respect to the anthropometric point. We

use the nose breadth to find the bridge width since the bridge width is parallel to the nose breadth. We also measure the bar bridge of the glasses and find the proportion of the bridge width to the nose breadth. The mean of the proportions will be used to determine the bridge width. We assume that the users feel comfortable with their glasses.

The second critical dimension of the glasses is the rim, which is a part of the total frame width. The total frame width consists of left and right rim, endpieces, and bridge. Total frame width may be determined using the bitragion breadth. According to [14], as a rule of thumb the endpiece can be determined about 10% of the total frame width. Hence the rim can be determined using the following formula:

$$R = \frac{TFW-(0.2*TFW+BS)}{2} \quad (1)$$

In determining the temple length, three anthropometric data are used which are occiput to nasion distance, horizontal ear breadth, and occiput to tragion distance. The temple length can be found by the following formula:

$$TL = (OND - OTD) + HEB \quad (2)$$

2. Results and Discussions

We collect the anthropometric data from 100 people who wear glasses, 50 each for male and female. The subjects of our research are the students at Sebelas Maret University Surakarta Indonesia. All the subjects are above 18 years old. We also measure the glasses frame of the subjects which will compare to the results of critical dimensions based on the anthropometric data. Based on the comparison, we can find the optimal dimensions of the glasses frame. The mean and standard deviation of the anthropometric data are shown in Table 1. We perform hypothesis tests to check whether there are any significant differences between male and female anthropometric data. The results of the hypothesis tests are shown in Table 2. Table 2 shows that there are significant differences between male and female anthropometric data.

We calculate the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of the anthropometric data to find the size of the critical dimensions. Table 3 shows the results of the calculation for male and female data. After percentiles calculation, we proceed to determine the critical dimensions of the glasses frame.

The bridge dimension can be found using the mean of the nose breadth and mean of bridge dimensions. Those data are then used to calculate the ideal proportions between the nose breadth and bridge mean. The proportions are found to be 0.49 and 0.48 for female and male respectively. From the proportions we can find the bridge dimensions for each percentile by multiplying the proportions to the percentiles of the nose breadth. Bitragion width and bridge dimension are used to determine the dimension of the rim as the formulae in Eq. (1). The temple length can be determined by Eq. (2) using the following anthropometric data: the occiput to nasion distance, occiput to tragion distance, and horizontal ear breadth. Table 4 shows the results of the glasses frame dimensions which are used by the female subjects along with the results of the dimensions for each percentile. Table 5 shows the results for the male subjects.

Table 1. Mean and standard deviation of anthropometric data.

Anthropometry Data	Female		Male	
	μ	σ	μ	σ
Bitragion Breadth	145.70	5.15	151.82	5.33
Occiput to Nasion Distance	169.14	6.74	175.74	7.36
Occiput to Tragion Distance	105.66	7.06	109.02	7.18
Nose Breadth	35.34	2.85	37.6	2.44
Horizontal Ear Breadth	29.98	3.19	31.24	3.02

Table 2.The Results of Hypothesis Test of Anthropometric Data.

No	Antropometric Data	Hypothesis		Hypothesis Test	
		H_o	H_1	Statistical Test (Z)	Conclusion
1	**Bitragion Breadth**	$\mu1 = \mu2$	$\mu1 \neq \mu2$	-5.839	Accept H1
2	**Occiput to Nasion Distance**	$\mu1 = \mu2$	$\mu1 \neq \mu2$	-4.676	Accept H1
3	**Occiput to Tragion Distance**	$\mu1 = \mu2$	$\mu1 \neq \mu2$	-2.359	Accept H1
4	**Nose Breadth**	$\mu1 = \mu2$	$\mu1 \neq \mu2$	-4.255	Accept H1
5	**Horizontal Ear Breadth**	$\mu1 = \mu2$	$\mu1 \neq \mu2$	-2.028	Accept H1

Table 3. Percentiles of Anthropometric Data.

Antropometric Data	Sex	Percentiles			
		5	10	25	50
Bitragion Breadth	**Female**	137.23	139.11	142.25	145.70
	Male	143.05	145.00	148.25	151.82
Occiput to Nasion	**Female**	158.05	160.51	164.62	169.14
Distance	**Male**	163.63	166.32	170.81	175.74
Occiput to Tragion	**Female**	94.04	96.62	100.93	105.66
Distance	**Male**	97.20	99.82	104.21	109.02
Nose Breadth	**Female**	30.64	31.69	33.43	35.34
	Male	33.58	34.48	35.96	37.60
Horizontal Ear Breadth	**Female**	24.73	25.90	27.84	29.98
	Male	26.27	27.37	29.22	31.24

Table 3. Percentiles of Anthropometric Data (cont'd)

Antropometric Data	Sex	Percentiles		
		75	90	95
Bitragion Breadth	**Female**	149.15	152.29	154.17
	Male	155.39	158.64	160.59
Occiput to Nasion Distance	**Female**	173.66	177.77	180.23
	Male	180.67	185.16	187.85
Occiput to Tragion	**Female**	110.39	114.70	117.28
Distance	**Male**	113.83	118.22	120.84
Nose Breadth	**Female**	37.25	38.99	40.04
	Male	39.24	40.72	41.62
Horizontal Ear Breadth	**Female**	32.12	34.06	35.23
	Male	33.26	35.11	36.21

From Tables 4 and 5, we can see that the existing bridge dimension of the glasses frame falls between 25th and 50th percentile for female and exactly at 50th percentile for male anthropometric data. The mean of the existing rim for female is 49.88 and falls between 50th and 75th percentiles, while the mean of the rim for male is 50.28 and falls between 10th and 25th percentiles. The results show that the existing rim dimension for female was taken from the higher percentiles than male. The mean of the temple dimensions for female is 136.28 mm which is far above the 95th percentile of the anthropometric data.The mean for male shows the similar result which is also far from 95th percentile of the anthropometric data. These findings conclude that the temple length of the existing glasses frame has been made longer than needed.

Table 4. The critical glasses frame dimensions for female.

Frame Parts	Dimensions (mm)			Anthropometry (mm)			
	Mean	**Min**	**Max**	**P5**	**P10**	**P25**	**P50**
Bridge	17.26	12.00	21.00	15.04	15.48	16.41	17.35
Rim	49.88	45.00	56.00	47.37	47.90	48.70	49.61
Temple	134.72	114.00	148.00	88.73	89.78	91.54	93.46

Table 4. The critical glasses frame dimensions and for female (cont'd).

Frame Parts	Dimensions (mm)			Anthropometry (mm)		
	Mean	**Min**	**Max**	**P75**	**P90**	**P95**
Bridge	17.26	12.00	21.00	18.28	19.14	19.65
Rim	49.88	45.00	56.00	50.52	51.35	51.84
Temple	134.72	114.00	148.00	95.38	97.14	98.19

Table 5. The critical glasses frame for male.

Frame Parts	Dimensions (mm)			Anthropometry (mm)			
	Mean	**Min**	**Max**	**P5**	**P10**	**P25**	**P50**
Bridge	18.20	13.00	24.00	16.26	16.69	17.41	18.20
Rim	50.28	41.00	55.00	49.09	49.66	50.60	51.63
Temple	136.3	125.00	145.00	92.70	93.87	95.82	97.96

Table 5. The critical glasses frame dimensions for male (cont'd).

Frame Parts	Dimensions (mm)			Anthropometry (mm)		
	Mean	**Min**	**Max**	**P75**	**P90**	**P95**
Bridge	18.20	13.00	24.00	18.99	19.71	20.14
Rim	50.28	41.00	55.00	52.66	53.60	54.16
Temple	136.3	125.00	145.00	100.10	102.05	103.2

Based on the results of this research, we proposed the design dimensions of the glasses frame for female and male as seen in Figs. 2 and 3 respectively. For both female and male, we suggest the 95th percentiles to make the frame suitable for most population. The total frame width is equal to the bitragion width. We

found that the width is 154.17 mm and 160.59 mm for female and male respectively. The endpiece dimensions are found from the total frame width which by the rule of thumb it is 10% from the total frame width for each endpiece. From the calculations, we found the endpiece dimension is 15.42 mm and 16.06 mm for female and male respectively. From Tables 4 and 5, the bridge dimensions are 19.65 mm and 20.14 for female and male respectively. Since the difference between female endpiece dimension and male endpiece dimension is less than 1 mm, we propose the same dimensions for female and male. The bridge dimension has the same case, so we take the male dimensions to represent the endpiece and bridge for both female and male. For the rim, the respected dimension is found to be 51.84 mm and 54.16 mm for female and male respectively. The temple length is equal to the 95th percentile for both female and male with the respected dimension is 98.19 mm and 103.22 mm respectively.

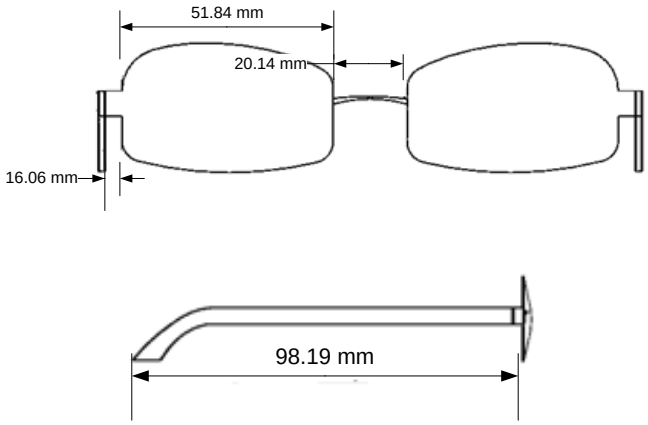

Fig. 2. The frame dimensions for female.

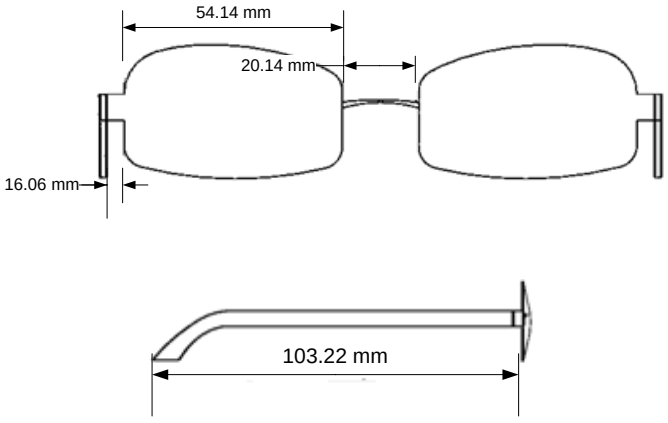

Fig. 3. The frame dimensions for male.

4. Conclusions

In this research, we determined the critical dimensions of glasses frame using head and facial anthropometric data. We consider the bridge width, rim, and temple length as the critical parts of the frame. We used the nose breadth to determine the bridge width. The rim is determined from the subtraction of the total frame to the endpiece and bar bridge. The total frame is found from the bitragion breadth. The temple length is found from occiput to nasion, occiput to tragion distance and horizontal ear breadth. We conclude that based on the results of anthropometric data analysis, the endpiece and bridge dimensions have small difference between female and male so we proposed the same dimensions. The mean of existing bridge dimension for female closed to 50 percentile of the anthropometric data, while for male it was exactly at 50th percentile of the data. The mean of the existing rim dimension for female fell between 50th and 75th percentile, while for male it fell between 10th and 25th percentile. The existing temple length is far beyond the 95th percentile for both female and male. It means that the temple length dimensions are made longer than needed. For all dimensions, we proposed the 95th percentiles of the data so they will be suitable for the most population. For the next research, a prototype can be built and tested to customers to determine their opinion about the suitability and comfortness of the resulted design.

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