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Proposed Road Bike Brake Lever Measurements for Filipino College Women in Mega Manila Area

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This study aims to develop sets of measurements for road bike brake lever that are suitable for Filipino college women in Mega Manila Area. Reaching the brake levers is a common problem among women, who generally have shorter hands. This study wishes to address this issue. Correspondences between anthropometric measurements and brake lever measurements were first established. Relevant hand anthropometric data, together with height, were collected from female students in three colleges in the Philippines to establish the said bike part measurements. Several statistical analyses were conducted. ANOVA was used to check the effect of school and height to hand length. Correlation coefficients were computed to determine the relationship of height to some hand anthropometric measures. Three sets of measurements—small, medium, and large—were computed based on the hand anthropometry. Another group of students tested a prototype of the proposal alongside an existing brand of brake lever. The validation suggested that more students preferred the prototype over the branded bike part, providing a case for the proposed measurements.

Keywords: anthropometric data, Filipina, hand anthropometry, road bikes, brake levers

Introduction

Road bike, compared to other bicycle types, is characterized by having more gear combinations, being lighter, and having skinnier tires and drop handlebars. It is suitable to be ridden on smooth pavement. Its brake levers and gears shifters, which control the brakes and gearing of the bike, respectively, are mounted on the handlebar. As brake levers and gears shifters are usually integrated, this study simply calls the set as brake lever for brevity.

A usual problem encountered by women cyclists with shorter hands is reaching for the brake lever

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(McCracken, 2015). While there are adjustment mechanisms, such as adding fillers to the brake levers to improve the fit, the necessary adjustments imply that current brake lever standards are biased against women.

Statistics from Del Prado-Lu (2007), Census at School Canada (n.d.), and Pheasant (1998) consistently provide evidence that hand lengths of females are generally shorter than the male counterparts.

In order to address the differences among bike users, cyclists resort to bike sizing and bike fitting. Bike sizing takes into consideration one's height and inseam length to identify an appropriate frame size and other bike parameters using rules of thumb. However, no known bike sizing guide is available for brake lever measurements. Bike fitting, meanwhile, is a more sophisticated professional service that really personalizes bike part dimensions by considering more body measurements and even movements. The cost of the service, however, limits its widespread use.

The main objective of this study is to develop sets of measurements related to brake levers that are appropriate for Filipina college students with ages 17 to 21. The study focuses on college students as Baltes (1996) implied that college students have a higher tendency of using bicycles relative to the general population.

Research Background

There are a number of studies that tackle the ergonomic aspects of bicycles. In 2010, Laios and Giannatsis proposed new measurements for five critical children bicycle dimensions. The study produced three sets of measurements corresponding to three sizes appropriate for Greek children aged seven to 14 based on an anthropometric database. A relatively similar study for young Dutch children was published earlier (Donkers, Toussaint, Molenbroek, & Steenbekkers, 1993). Just recently, Manas and Ingole (2015) proposed an adjustable handlebar design based on the anthropometric data of 100 males. None of these studies, however, tackle brake levers. These articles also emphasized that anthropometric data are very important input in evaluating bike part measurements.

In the Philippines, there are limited sources of anthropometric data accessible for research purposes. Two of these are from Zubia et al. (2010) and Del Prado-Lu (2007). The former covered the anthropometry of male farmers in Laguna, Philippines, while the latter studied Filipino manufacturing workers. The problem, however, for these two sets of anthropometric data is that they have limited information on different hand measurements that are relevant for bike brake dimensions. This requires the researchers to gather the necessary set of anthropometric data.

A study that emphasized that bicycles are usually designed based on male anatomy, even though there are significant anatomical differences between the two sexes (Ingole, Awate, & Manas, 2015). The same study, therefore, proposed some changes to the bicycle that would make it more favorable to women. While the said study provided recommendations for a number of bike parts, such as distance between saddle and handlebar, saddle height and shape, and handlebar rod diameter, it was noted that brake levers were not considered.

Research Organization

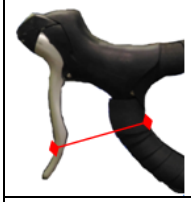
The study aimed to propose measurements related to the brake lever appropriate for the target demographics as mentioned earlier. Furthermore, the proposed measurements aimed to improve fit—how users reach the brake lever while cycling—rather than aesthetics. While more sophisticated design of brake levers and gear shifters are available, this study considered only the measurements of a simple design where the brake levers act as gear shifters as well when moved sideways.

Estimation of Relevant Brake Lever Measurements

Based on cycling experience, there are three common hand positions related to the use of brake levers as a cyclist uses a road bike. Each of these positions corresponds to a relevant measurement as summarized in Table 1. It also presents the approximate anthropometric measurements corresponding to the said dimension. As these are just approximations, other study may provide different estimates.

Table 1

Relevant Measurements and Corresponding Approximate Anthropometric Measurements

Measurement	Importance	Anthropometric measurements*
Handlebar to brake lever 	In the aggressive position, the palm leans on the drop bar while maintaining steady reach of the brake lever.	≈ O + C + B where, O (upper palm); C (index finger proximal phalanx); B (index finger middle phalanx).
Bracket to brake lever (top) 	In the relaxed position, the palm leans on the bracket while maintaining contact to the upper part of the brake lever.	≈ 0.5D + O + 0.5E where, D (lower palm); O (upper palm); E (middle finger proximal phalanx).
Bracket to brake lever (bottom) 	In the relaxed position, the cyclist brakes by pulling the lower portion of the brake lever as the palm leans on the bracket.	≈ 0.5D + O + E + F where, D (lower palm); O (upper palm); E (middle finger proximal phalanx); F (middle finger middle phalanx).

Note. * It refers to Appendix A for the illustration of hand parts.

Collection and Analyses of Anthropometric Data

As explained earlier, anthropometric data are important inputs to establish the relevant brake lever measurements. Female students from three schools from the Mega Manila Area were randomly selected to participate in the study. These are major universities with large and ethnically-diversed population. Height, measurement of the phalanges of the index and middle fingers, and lengths of upper and lower palms were measured using appropriate tools, such as anthropometer and calipers.

A statistical software was employed to perform some statistical analyses to the anthropometric data collected. These tests included normality tests and paired *t*-test to check the difference between right and left hand measurements and ANOVA to determine the effect of school and age to hand length. Correlation coefficients are likewise computed to measure the linear relationship between height and several hand measurements.

Computation of Bike Part Dimensions

Three sets of measurements were developed corresponding to small, medium, and large. The proposed measurements for the road bike brake levers were based on the 25th, 50th, and 75th percentile of the relevant

measurements. This is consistent with what is used in most of the commercial digital human modeling tools, which uses five groups: very small (fifth percentile), small (25th percentile), medium (50th percentile), large (75th percentile), and very large (95th percentile) (Mun & Rim, 2011).

Validation of Measurements

A prototype corresponding to the medium size was constructed. It was installed on handlebar mounted on a stationary bike. Another setup that features an existing model of brake lever was likewise made available. A group of students tested these two setups. Both the relaxed and aggressive positions were asked to be performed by the students. After that, they were asked to choose which between the two setups fits them better.

Results and Discussion

Number of Samples

Table 2 summarizes the number of students who took part in the study broken down into school and age groups. A total of 122 students took part of the study.

Table 2

Total Number of Respondents Grouped According to School and Age

School	Number of respondents per age group					Total
	17	18	19	20	21	
School A (NCR)	13	11	12	5	5	46
School B (Region 4A)	6	10	12	6	5	39
School C (Region 4A)	5	10	12	5	5	37
Total	24	31	34	16	15	122

Summary of Anthropometric Measurements

Table 3 presents key descriptive statistics of some important anthropometric measurements. For hand dimensions, only the right hand measurements are shown as little deviation exists between the corresponding left and right hand measurements.

Table 3

Descriptive Statistics of Anthropometric Measurements (in cm)

Measurements	Mean	Std. Dev.	Min.	Max.	Percentile		
					5th	50th	95th
Height	158.11	5.04	146	168	150.11	158.60	166.95
Index finger proximal phalanx	2.21	0.26	1.3	3.0	1.90	2.20	2.70
Index finger middle phalanx	2.13	0.26	1.1	3.0	1.71	2.10	2.50
Index finger distal phalanx	2.27	0.19	1.8	2.7	2.00	2.30	2.60
Middle finger proximal phalanx	2.50	0.32	1.8	3.3	2.00	2.50	3.00
Middle finger middle phalanx	2.43	0.28	1.8	3.2	2.00	2.50	2.90
Middle finger distal phalanx	2.40	0.24	1.7	3.1	2.10	2.40	2.80
Upper palm	3.68	0.50	2.5	5.0	2.80	3.70	4.50
Lower palm	4.98	0.59	3.6	6.7	4.20	4.95	6.10

Statistical Tests

Here are some of the results of the statistical tests made on the anthropometric measurements:

(1) Using Chi-square to test goodness of fit, there is no evidence to conclude that the observations do not come from a normal population;

(2) Paired *t*-tests conducted revealed that the average differences between corresponding left and right hand measurements are zero;

(3) Using a general linear model, analysis of variance suggested that school and age do not affect hand length, which is the total length of palm and middle finger (the result is presented in Table 4);

(4) Hand measurements only have weak to moderate linear correlation with height. The correlation coefficients are summarized in Table 5. This implies that an approach that approximates brake lever measurements using height of the cyclist has limited accuracy.

Table 4

Analysis of Variance for Right Hand Length Versus School and Age

Source	*d.f.*	Seq. SS.	Adj. SS.	Adj. MS.	*F* Stat.	*P*-value
School	2	3.446	3.405	1.703	1.43	0.243
Age	4	1.306	1.306	0.327	0.27	0.894
Error	115	136.764	136.764	1.189		
Total	121	141.516				

Table 5

Pearson Correlation Between Height and Right Hand Measurements

Hand measurements	Correlation with height
Right index finger	0.299
Right middle finger	0.363
Right palm	0.310
Right hand length	0.373

Comparison With Existing Anthropometric Measurements

A number of sources provide statistics for the hand length as shown in Table 6 below.

Table 6

Hand Lengths of Different Populations

Reference	Population	Percentile, in cm		
		5th	50th	95th
Zubia et al. (2010)	Filipino male farmers in Laguna	16.0	17.5	19.0
Del Prado-Lu (2007)	Filipina manufacturing workers	15.5	18.0	20.0
	Filipino manufacturing workers	17.0	19.75*	21.5
National Aeronautics and Space Administration (1995)	American female NASA personnel	15.8	17.2	18.7
	American male NASA personnel	17.9	19.3	20.6
Pheasant (1998)	British female adults	15.9	17.4	18.9
	British male adults	17.3	18.9	20.5
This study	Female college students	14.4	16.0	17.9

Note. * Estimated using the mean as the data point is not available.

Based on Table 6, the median hand length of male Americans is about 20% longer than the median measured in this study, while median hand length of British male adults is 18% longer. If existing brake lever standards are based on Western male adult, it is safe to say that these may not perfectly fit a Filipina college student. Female American and female British median hand lengths are longer than that of the Filipina college students by 7.5% and 8.8%. The study produced the shortest set of hand length measurements among the references cited above.

It is also noteworthy to mention that the results of Del Prado-Lu (2007) produced the largest set of hand lengths, higher than corresponding foreign counterparts. This is in conflict with the result of Zubia et al. (2010) which suggests that Filipino hand lengths are generally shorter than hand lengths of American and British males.

Recommended Brake Lever Measurements

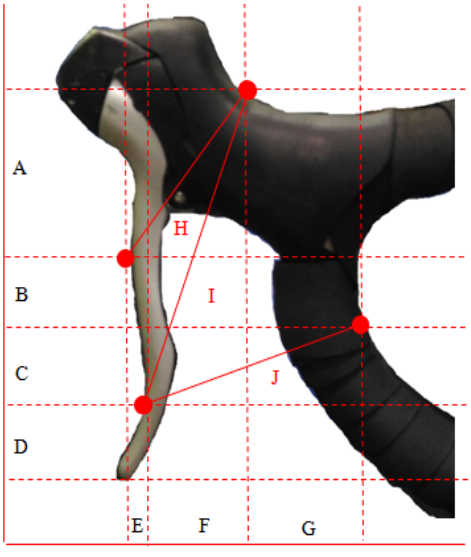
The collected anthropometric data enabled the study proponents to propose appropriate measurements for the target population as shown in Table 7 below. These are based on the formula discussed in Table 1, noting that 25th, 50th, and 75th percentiles correspond to small, medium, and large sizes, respectively.

Table 7

Proposed Brake Lever Measurements

Measurement	Proposed measurement (in cm)		
	Small	Medium	Large
Handlebar to brake lever	7.60	8.00	8.40
Bracket to brake lever (top)	7.05	7.35	7.78
Bracket to brake lever (bottom)	10.50	10.98	11.69

Actual brake level dimensions were computed using the said proposed measurements. Figure 1 illustrates the final proposal. It notes that since not all dimensions are related to the parameters in Table 7. Segment D, for example, is not related to segments H, I, and J.



Segment	Segment Length, in cm		
	Small	Medium	Large
A	5.5	5.7	6.1
B	2.4	2.5	2.7
C	2.1	2.2	2.3
D	2.0	2.0	2.0
E	1.1	1.1	1.1
F	3.3	3.5	3.7
G	4.0	4.2	4.4
H	7.05	7.35	7.78
I	10.50	10.98	11.69
J	7.60	8.00	8.40

Figure 1. Proposed dimensions of brake levers.

Result of Prototype Validation

Another group of 80 female students, aged 17 to 21, in "school C" were asked to evaluate two brake lever setups: (a) prototype of the proposed medium-sized brake lever and (b) a branded break lever. The students, who tried the setups in stationary bike, were asked to identify which between the setups fits them better. Table 8 summarizes the responses.

Clearly, based on the results, the proposed measurements helped improve the fit of the brake lever setup to the target demographics as indicated by respondents' preference. The prototype outperforms the existing brake lever setup particularly in the relaxed position configuration.

Table 8

Preferred Brake Lever Setup of Respondents

Relaxed position		Aggressive position		Overall	
Prototype	Existing	Prototype	Existing	Prototype	Existing
72%	28%	51%	49%	67%	33%

Conclusions

There are no established standards for Filipinos regarding the size of road bicycle and its parts. The current sizes of road bike parts and accessories are intended for Western standards and they may not be considered "fit" for Filipinos.

This study aimed to provide new sets of measurements for road bike brake levers that cater to the hand sizes of Filipino college women in Mega Manila Area aged 17 to 21. The researchers were able to achieve this objective by gathering the required anthropometric data of college students from three different schools in NCR and Region 4A. Three sets of measurements were developed—small, medium, and large.

To validate the new measurements, a prototype of the medium-sized brake lever and shifter was fabricated. Results of the validation highlighted the preference of respondents for the prototype as opposed to the existing set of brake levers.

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Appendix A: Hand parts