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Evaluation Of The Correlation Between Hand Anthropometry And Grip Strength in Sedentary Undergraduate Students

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ABSTRACT

Sedentary are people with mild activity in their daily routines so there are differences to whole anthropometry among male and female subjects. Generally people with big body have a great strength and grip strength is one of indicators to measure the strength. Therefore, the aim of the research was to investigate the correlation between hand anthropometry and grip strength and predicted the grip strength based on hand anthropometry by using linear regression formula method in Sedentary Undergraduate Students. Grip strength was measured with Smedley Hand Dynamometer and Hand Anthropometry Variables were measured with modified anthropometer, large anthropometer-Lafayette, anthropometry chair, finger goniometer, and body tape. The measurement of hand anthropometry was conducted in 94 sedentary college students from Industrial Engineering Department in Atma Jaya Catholic University of Indonesia aged 18-21 years old. As the results, hand anthropometry had positive significant correlation to grip strength for both male and female subjects. The higher the value, of measurement of hand anthropometry, then the higher the value of grip strength and conversely. Based on the results, the best model regression formula in male was regression equation of Grip Strength to (Forefinger Width and Forefinger thick) and female was regression equation of Grip Strength to (Arm Rotation and Palm Rotation). So the conclusion of the study is hand anthropometry had significant correlation to grip strength in Sedentary Undergraduate Students and the college students can increase their grip strength by doing sports and workout.

Key words: Correlation, Hand Anthropometry, Grip Strength, and Sedentary

1. INTRODUCTION

Grip strength was an indicator to measure the strength of people especially strength of some muscles in the hand and some muscles in the forearm [2, 8]. Besides, people with big body were considered to have great strength [4]. In fact, everyone including sedentary certainly had different body size. The one factor that differentiated anthropometry was work factor [27]. The factor would influence body size of sedentary because basically a job would make the size of people's body were different. Sedentary were people with mild activity with their daily routines.

There were few considerable researches in this area. Refer to previous research, it showed that the relationship between anthropometric variables likes height, weight, age, and BMI and grip strength positively correlated in Nigerian Secondary School Students. The students in Nigerian Secondary School Students did sports activities at least once in a week [7].

Moreover, in other previous research about relationship between anthropometric variables and grip strength among baseball players said that grip strength was an essential element in baseball players. That was because the value of grip strength in baseball players represented the intrinsic hand muscles strength and extrinsic forearm muscles strength to grip a baseball in a game [23]. Therefore, the grip strength must be investigated in baseball players. The other previous researches said that the measurement of grip strength was very important for athletes because the appropriate level of grip strength was needed to win the games [9]. Therefore, the factors could affect the grip strength especially anthropometry must be investigated [23].

Moreover, the previous research did not analyze in detail about palm in relationship between hand anthropometry and grip strength [5]. The previous research had only measured general hand anthropometry like palm length and palm width. Therefore, this research wished to measure hand anthropometry in more detail. Besides, the hand anthropometry variable namely palm should be explored whether those hand anthropometry had correlation to grip strength. In this research, anthropometry dimensions that used were the hand anthropometry. The hand anthropometry were chosen because hand anthropometry were the parts that related directly to grip strength measurement, so the hand anthropometry deemed essential to investigate. So this research aimed to focus on the relationship between hand anthropometry and grip strength in sedentary.

The objective of this study was to assess the relationship of hand anthropometry namely height, weight, BMI, and the other hand anthropometry toward grip strength and predicted the grip

strength based on hand anthropometry by using linear regression formulas method in Sedentary Undergraduate Industrial Engineering students of Atma Jaya Catholic University of Indonesia, Jakarta.

2. METHODOLOGY OF THE STUDY

2.1. The Subjects of the Study

The amount of the subjects in this study were 94 sedentary Industrial Engineering students in Atma Jaya Catholic University of Indonesia. The subjects in this study were randomly selected from Industrial Engineering Department in Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia. The subjects also were divided in gender with 47 sedentary Industrial Engineering male students and 47 sedentary Industrial Engineering female students. The subjects in this study were college students that classified as a sedentary by using Physical Activity Questionnaire.

2.2. Hand Anthropometry and Grip Strength Measurements

First, to characterize whether the subjects were sedentary or active, was used the Physical Activity Questionnaire [14]. The Physical Activity Questionnaire include item 1 (spare time activity), item 2-7 (physical education, lunch, right after lecture, evening, weekends), and item 8 (physical activity in each days of the last week). At the last of the questionnaire also include item 9, which identified whether college students had unusual activity for the last week and this item was not a part of the scoring for the Physical Activity Questionnaire. The scoring used the scale of 1 to 5. The final result of Physical Activity Questionnaire was the mean of the 8 items in the questionnaire (item 9 was not used in scoring). The low physical activity was 1 and the high physical activity was 5.

The hand anthropometry in this study divided into hand dimensions, weight, height, and BMI. Next, weight was measured by using digital scale and height was measured by using meter. During the measurement of body height and weight, subjects did not use foot wear. Body Mass Index of the subjects were collected by using the formula of weight (kg)/height² (m^2) [28]. To gauge the hand anthropometry, we used finger goniometer, large anthropometer-Lafayette, modified anthropometer, anthropometry chair, body tape, and meter.

The finger goniometer was used to quantify the finger dimensions. Subjects were asked to spread their hand during the measurement of finger dimensions. The large anthropometer-Lafayette was used to measure the palm thick dimensions. The modified anthropometer was used to measure the hand rotation dimensions. The anthropometry chair was used to gauge the forearm length, upper arm length, and vertical arm length. To measure the forearm length and upper arm length, subjects were asked to take a seat and bent the elbow ahead at ninety degrees. Besides, to measure the vertical arm length, subjects were asked to take a seat and straightened their hand at one hundred eighty degrees. The body tape was used to measure the hand circumference dimensions like forearm circumference, wrist circumference, hand circumference, and maximum hand circumference. Besides, meter was used to measure the other hand dimensions that cannot be used by using finger goniometer, modified anthropometer, large anthropometer-Lafayette, anthropometry chair, and body tape like hand length. For hand shape index dimension was calculated by using this formula: (Hand width multiplied by 100 and divided by Hand length) [5]. From table 1, it presented the measurement procedures of hand anthropometry variables.

Further, the grip strength was measured by using Smedley Hand Dynamometer with standard position. The subjects were asked to take a seat and bent the elbow ahead at ninety degrees. The subjects were requested to squeeze the Hand Dynamometer by using their dominant hand for two times repetitive. Then, the grip strength of the subjects were documented. The grip strength was most frequently measured in kilograms [18, 21]. The all measurements were collected in Work System Design and Ergonomic Laboratory, Atma Jaya Catholic University of Indonesia.

2.3. Statistical Analysis

First, as a prerequisite of Pearson correlation test, the dependent variable namely grip strength was tested by using one-kolmogorov-normality test. Significance > 0.05 was probability level was used to indicate the grip strength was normal distributed. To find the hand anthropometry which had correlation toward grip strength were used the pearson correlation test. Significance < 0.05 was probability level was used to signify the variables had correlation toward grip strength. Next, to form the linear regression models of hand anthropometry toward grip strength, previously were tested by using normality residual test, multicollinearity test, heteroscedasticity test, and autocorrelation test. After that, the linear regression model were formed. The processing data was assisted by software SPSS Version 16.

3. RESULT

First, the grip strength variable in male and female were normal distributed with Kolmogorov smirnov- normality test. Next, the results showed that hand anthropometry had positive correlation toward grip strength from pearson correlation test. For hand anthropometry both males and females which related to grip strength had significance < 0.05 in pearson correlation test. The hand anthropometry which related to grip strength include finger, palm, hand circumference, hand rotation, and dynamic hand anthropometry. Table 2 presented the range of each hand anthropometry variables that related to grip strength from pearson correlation test. From the hand anthropometry variables that related to grip strength in pearson correlation, were formed the regression formulas. The regression formulas in this study divided into two main segments, first regression formula of hand anthropometry to grip strength for male and second, regression formula of hand anthropometry to grip strength for female. The table 3 showed the regression formulas of hand anthropometry toward grip strength in males. Next, table 4 showed the regression formula of hand anthropometry

toward grip strength in females. Table 5 showed that Standard Error of the Estimate (SEE) in every regression equations were less than Standard Deviation of grip strength. Standard Error of the Estimate (SEE) was a measurement that state the value of error to predict the value of grip strength [20]. From the result of table 5, the regression formulas were valid to use to predict the grip strength. The standard deviation of Grip Strength both male and female were presented in table 5. Besides, validation test also used the paired-t test to decide between the grip strength from experiments and the grip strength from the regression equations were no differ. The data were used for the paired-t test were 10 new data of male and 10 new data of female from Industrial Engineering students in Atma Jaya Catholic University of Indonesia. Based on the result, there were no differences between grip strength from regression equation and experiment.

Table 1: Measurement Procedures of Hand Anthropometry Dimensions

Hand Anthropometry Dimensions	Instruments	Measurement Procedures
Hand Length	Meter	The vertical distance between the wrist and the end point of middle finger
Palm Length	Meter	The vertical distance between the wrist and the base point of finger
Thumb Length	Finger Goniometer	The vertical distance between the base point of thumb and the end point of thumb
Forefinger Length	Finger Goniometer	The vertical distance between the base point of forefinger and the end point of forefinger
Middle Finger Length	Finger Goniometer	The vertical distance between the base point of middle finger and the end point of middle finger
Ring Finger Length	Finger Goniometer	The vertical distance between the base point of ring finger and the end point of ring finger
Little Finger Length	Finger Goniometer	The vertical distance between the base point of little finger and the end point of little finger
Thumb Width	Finger Goniometer	The flat distance in bone joints of thumb
Thumb Thick	Finger Goniometer	The depth in bone joints of thumb
Forefinger Width	Finger Goniometer	The flat distance in bone joints of forefinger which leaded to the body
Forefinger Thick	Finger Goniometer	The depth in bone joints of forefinger which leaded to the body
Palm Width	Meter	The horizontal distance between the outer edge of palm and the inner edge of palm
Palm to Thumb Width	Meter	The horizontal distance between the outer edge of thumb and the inner edge of palm
Palm to Thumb Thick	Large Anthropometer	The vertical distance between the bottom of thumb and the back of the palm
Palm Thick	Large Anthropometer	The vertical distance between the bottom of palm and the back of palm
Hand Width Maximum	Meter	The furthest horizontal distance between the little finger and the thumb
Upper Arm Length	Anthropometry Chair	The vertical distance between the top of shoulder and the bottom of elbow
Forearm Length	Anthropometry Chair	The horizontal distance between the end point of middle finger and the elbow
Vertical Arm Length	Anthropometry Chair	The vertical distance between the end point of middle finger and the top of shoulder
Maximum Hand Circumference	Body Tape	The distance between the outer edge of thumb and the inner edge of palm in circular position
Hand Circumference	Body Tape	The distance between the outer edge of palm and the inner edge of palm in circular position
Wrist Circumference	Body Tape	The distance from the top to the bottom of wrist in circular position
Forearm Circumference	Body Tape	The distance from the top to the bottom of forearm in circular position between 1.5 and 2 inches from elbow
Arm Rotation	Modified Anthropometer	First, the bottom of arm gripped the middle rod of arc. Next, the bottom of arm rotated the arc to the left as far as possible, then rotated the arc to the right as far as possible.
Palm Rotation	Modified Anthropometer	First, the fingers gripped the middle rod of arc and arm and wrist in static condition. Next, the fingers rotated the arc to the left as far as possible Then, rotated the arc to the right as far as possible.
Grip Diameter	Meter	The starting position was hand gripped the conical tube, then we measured the diameter which was gripped

Hand Span	Meter	The furthest diagonal distance between the little finger and the thumb
Handling distance	Meter	The vertical distance when gripped the hand dynamometer to the bottom line of hand dynamometer

Table 2: Range of Hand Anthropometry Variables that Related to Grip Strength in Male and Female

Male		**Female**	
Hand Anthropometry Variables	Min-Max	Hand Anthropometry Variables	Min-Max
Forefinger width	1.3 cm - 2.2 cm	Hand length	14.2 cm - 18.3 cm
Forefinger thick	1.2 cm - 1.8 cm	Thumb width	6.4 cm - 8.3 cm
Maximum Hand Circumference	21.9 cm - 26.8 cm	Palm width	1.2 cm - 2.4 cm
Hand Circumference	22.1 cm - 30.6 cm	Palm to thumb width	7.6 cm - 9.7 cm
Wrist Circumference	17.9 cm - 23.6 cm	Maximum Hand Circumference	18.3 cm - 24.1 cm
Forearm Circumference	15.3 cm - 19.2 cm	Hand Circumference	18.3 cm - 28.2 cm
Arm Rotation	32^{O}- 75^{O}	Wrist Circumference	15.5 cm - 20 cm
Palm Rotation	20^{O}- 57^{O}	Forearm Circumference	13.3 cm - 18.1 cm
Grip Diameter	4.3 cm - 6 cm	Arm Rotation	38^{O} - 78^{O}
Handling Distance	3.9 cm - 5.7 cm	Palm Rotation	17^{O} - 50^{O}
		Grip Diameter	4.1 cm - 6.2 cm
		Hand span	15.8 cm - 20.5 cm
		Maximum hand width	13.5 cm - 18.5 cm
		Handling Distance	3.3 cm - 5.5 cm

Table 3: Regression Formula for Grip Strength to Hand Anthropometry in Male Subjects

	Regression Formula	Information
(FFW & FFT) TO GS	Y = 4.566 + 2.322 X1 + 18.849 X2	X1 = FFW (cm), X2 = FFT (cm)
(MHC & FAC) TO GS	Y = -20.053 + 1.183 X1 + 1.061 X2	X1 = MHC (cm), X2 = FAC (cm)
(HC & WC) TO GS	Y = -11.826 + 1.606 X1 + 0.884 X2	X1 = HC (cm), X2 = WC (cm)
(AR & PR) TO GS	Y = 18.202 + 0.289 X1 + 0.03 X2	X1 = AR (^{O}), X2 = PR (^{O})
(GD & HD) TO GS	Y = -38.324 + 6.821 X1 + 7.979 X2	X1 = GD (cm), X2 = HD (cm)

FFW = forefinger width, FFT = forefinger thick, MHC = maximum hand circumference, FAC = forearm circumference, HC = hand circumference, WC = wrist circumference, AR = arm rotation, PR = palm rotation, GD = grip diameter, HD = handling distance, GS = grip strength, Y = dependent variable (GS), X = independent variables (Hand anthropometry)

Table 4: Regression Formula for Grip Strength to Hand Anthropometry in Female Subjects

	Regression Formula	Information
(HL & PW) TO GS	Y = -33.543 + 0.624 X1 + 6.16 X2	X1 =HL (cm), X2 = PW (cm)
(TW & PTW) TO GS	Y = -23.392 + 9.191 X1 + 3.316 X2	X1 = TW (cm), X2 = PTW (cm)
(MHC & FAC) TO GS	Y = -21.786 + 1.802 X1 + 0.256 X2	X1 = MHC (cm), X2 = FAC (cm)
(HC & WC) TO GS	Y = -26.113 + 2.231 X1 + 0.534 X2	X1 = HC (cm), X2 = WC (cm)
(AR & PR) TO GS	Y = 12.542 + 0.038 X1 + 0.213 X2	X1 = AR (^{O}), X2 = PR (^{O})
(GD, HS, MHW, & HD) TO GS	Y = -18.985 + 1.315 X1 + 0.245 X2 + 1.024 X3 + 2.9 X4	X1 = GD (cm), X2 = HS (cm), X3 = MHW (cm), X4 = HD (cm)

HL = hand length, PW = palm width, TW = thumb width, PTW = palm to thumb width, MHC = maximum hand circumference, FAC = forearm circumference, HC = hand circumference, WC = wrist circumference, AR = arm rotation, PR = palm rotation, GD = grip diameter, HS = hand span, MHW = maximum hand width, HD = handling distance, GS = grip strength, Y = dependent variable (GS), X = independent variables (Hand anthropometry)

Table 5: Comparison of Standard Deviation on Grip Strength and Standard Error of the Estimate in each Regression Formula

Male			Female		
Regression Formula	Standard Error of the Estimate	Standard Deviation of Grip Strength	Regression Formula	Standard Error of the Estimate	Standard Deviation of Grip Strength
(FFW & FFT) TO GS	5.52571		(HL & TW) TO GS	4.16435	
(MHC & FAC) TO GS	5.43725		(PW & PTW) TO GS	3.69605	
(HC & WC) TO GS	5.96848	**6.37364**	(MHC & FAC) TO GS	4.36388	**4.89645**
(AR & PR) TO GS	5.58037		(HC & WC) TO GS	4.35391	
(GD & HD) TO GS	5.14597		(AR & PR) TO GS	4.46077	
			(GD, HS, MHW, & HD) TO GS	4.22702	

FFW = forefinger width, FFT = forefinger thick, HL = hand length, PW = palm width, TW = thumb width, PTW = palm to thumb width, MHC = maximum hand circumference, FAC = forearm circumference, HC = hand circumference, WC = wrist circumference, AR = arm rotation, PR = palm rotation, GD = grip diameter, HS = hand span, MHW = maximum hand width, HD = handling distance, GS = grip strength.

4. DISCUSSION

This study wished to examine the correlation of hand anthropometry toward grip strength in sedentary Industrial Engineering students aged 18-21 years old in Atma Jaya Catholic University of Indonesia. Nowadays, college student lifestyle were sedentary. Recently, college student also prefer used the elevator than stairs to classroom. College student also spent their daily routine for study, did their assignments, or university organization activities so they mostly did low physical activity in their daily routine. Based on the data in this study, college student also were sedentary because they did the assignment around 5 hours in a day, used the mobile application around 7 hours in a day. Therefore, college students did not have time to perform the exercise and workout in their daily routine. The lifestyle indicate college students were sedentary.

From table 2, it showed that the value of hand size in males were higher than females. This study correlated hand anthropometry, weight, height, and BMI to grip strength in sedentary undergraduate students. Based on the results, hand anthropometry had positive correlation toward grip strength in males and females. Then the higher the value of hand anthropometry, then the higher the value of grip strength for both males and females and conversely. The results from this research also gave the same result with the previous research that explained the grip strength also a variable was affected by few factors like anthropometry [2, 1].

Separation between regression formulas for grip strength in males and females because the grip strength of male and female were different. The previous study had been reported that grip strength of hand dominant (right hand or left hand) in male was stronger than female for all people [18, 16, 17, 15]. The grip strength of male was stronger than female because in the daily routine, male more often did the activities that required the grip strength than female. For example, male often did physical activities like sports that required the grip strength in their daily routine than female such as, basketball, tennis, baseball, billiard, badminton, etc. Besides, female rarely did the physical activities like sports in their routine. So, the grip strength of male was stronger than female although the standard of grip strength between male and female were different. Therefore, in this study the regression formulas of grip strength in male and female were separated. The mean of the grip strength in male was presented in table 8 and for female was presented in table 9.

Besides, the all regression equations in this study were decent to use to predict the grip strength in undergraduate students aged 18-21 years old. The regression formulas were worthy because it passed the prerequisite test of linear regression model building include, normality residual test, multicollinearity test, heteroscedasticity test, and autocorrelation test. A regression formula was appropriate if the formula passed few assumptions include, residual were normal distributed, no correlation among independent variables, the variance of residual among observations were homogeneous, and residual between the current and previous observations did not have a correlation. Regression equation can be used as a good predictor if the regression equation had passed the requirements of BLUE (Best Linear Unbiased Estimator*)*, that means the regression formula had passed the prerequisite test of linear regression model building include, normality residual test, multicollinearity test, heteroscedasticity test, and autocorrelation test [22]. Besides, the regression equation was decent if it passed the validation test. The validation was tested with paired-t test. In this study, Paired t-test compared the grip strength that obtained from experiments and regression formulas. Based on the validation results, the grip strength that collected from all regression formulas and grip strength that obtained from experiments were not differ significantly. Therefore, the all regression equations in this study were worthy to predict the grip strength. But the regression formulas in this study had some limitations. The limitations were the regression formulas could only predict the grip strength in sedentary Industrial Engineering in Atma Jaya Catholic University of Indonesia aged 18-21 years old.

Based on the result of the previous research, it showed that hand anthropometry also had positive correlation toward grip strength [7]. All the regression equations had positive correlation to grip strength. The previous study also reported that the higher the measurement of hand anthropometry, then the higher the value of grip strength in male and female. The subjects of the previous study were Secondary School Students aged 14-18 years old in Kano, Nigeria. Therefore in this previous study, it reported that hand anthropometry variables, height, weight, and BMI positively correlated with grip strength in secondary school students. Another previous researches, it reported that the anthropometry variables significantly correlated with grip strength [3, 10, 11, 12, 13]. Besides, body dimensions correlated to grip strength for both right and left hand [4].

Based on the previous study, it reported that the hand anthropometry variables were positively correlated toward grip strength in university softball players [9]. So, the higher of the hand anthropometry, then the higher the grip strength in softball players. Therefore, the anthropometry variables were the key to establish the success in softball players. Based on the previous study, it described that hand anthropometry showed positive correlation to grip strength in handball players [5]. So, the similarity between the study in sedentary and active was the hand anthropometry variables were positively correlated toward grip strength.

Standardized coefficient were the value that stated the level of relation of independent variables toward dependent variable. The scale of standardized coefficient was from minus one to one [6]. If the value was closer to one that means the relation of independent variable to dependent variable was stronger in each regression equation. Table 6 showed the

Standardized coefficient of each hand anthropometry variables in each regression formulas. Therefore, from the table 6, we could know what hand anthropometry variables that had the highest relation toward grip strength in each regression formulas. The higher the value of Standardized coefficient, then the higher the relation of hand anthropometry variable toward grip strength in each regression formulas. Generally, in the table 6 the hand anthropometry that had highest relation toward grip strength was handling distance variable on regression formula of Grip Strength TO (Grip Diameter and Handling Distance) in male and the variable that had lowest relation was palm rotation on regression formula of Grip Strength TO (Arm Rotation and Palm Rotation) in male. Besides, the hand anthropometry variable that had highest relation toward grip strength was thumb width on regression formula of Grip Strength TO (Hand Length and Thumb Width) in female and the variable that had lowest relation toward grip strength was hand span on regression formula of Grip Strength TO (Grip Diameter, Hand Span, Maximum Hand Width, and Handling Distance) in female.

Based on the validation result, the best regression formula in male that could predict the grip strength was regression equation of Grip Strength TO (Forefinger Width and Forefinger thick). The reason was forefinger dimensions were the parts of the hand that corresponded directly when subjects squeezed the hand dynamometer. The best regression formula in female that could predict the grip strength was regression equation of Grip Strength TO (Arm Rotation and Palm Rotation). The reason was that dimensions also were dynamic hand anthropometry dimensions that required the grasp activity in its measurement. The validation of each regression formula was processing by using 10 new data of male and 10 new data of female Industrial Engineering students. Based on the table 7, we could know the differences between grip strength from experiment and grip strength from each regression formula in male and female. The lower the differences between grip strength from experiment and grip strength from regression formula, then the regression formula was better.

Refer to table 8 and table 9, Industrial Engineering Student in this study were sedentary. From table 8, can be said that male sedentary students had weak grip strength. Refer to table 9, can be said female students had normal grip strength. Based on the Camry Electronic Hand Dynamometer Instruction manual and Lafayette Instrument Owner's Manual, it also classified the male sedentary Industrial Engineering in Atma Jaya Catholic University of Indonesia had weak grip strength and the female sedentary Industrial Engineering in Atma Jaya Catholic University of Indonesia had normal grip strength. The exercise can be done by referring the value of independent variables and the 75th Percentile of data, if the value of independent variable below its 75th Percentile, so the male student could train their hand till the maximum value in table 2. Based on the previous research, it said that the grip strength can be used as an indicator to detect a dangerous diseases [24]. Grip strength was considered better than systolic blood pressure. The Weak Grip strength can be used to detect some dangerous diseases like Coronary Heart and Stroke. Therefore, exercise like, fitness, playing basketball, tennis, baseball could be an option for male sedentary student to increase their grip strength until reach the normal category. The 75th Percentile which used in this study were 75% of the subjects' data in this study. By using the 75% of data that were taken, the actual hand anthropometry can be shown.

Table 6: Standardized Coefficients of the Hand Anthropometry Variable in Each Regression Formulas

Male			Female		
Regression Formulas	Independent Variables	Standardized Coefficients	Regression Formulas	Independent Variables	Standardized Coefficients
(FFW & FFT) TO GS	Forefinger width	0.068	(HL & TW) TO GS	Hand length	0.108
	Forefinger thick	0.492		Thumb width	0.506
(MHC & FAC) TO GS	Maximum Hand Circumference	0.24	(PW & PTW) TO GS	Palm width	0.447
	Forearm Circumference	0.366		Palm to thumb width	0.32
(HC & WC) TO GS	Hand Circumference	0.318	(MHC & FAC) TO GS	Maximum Hand Circumference	0.394
	Wrist Circumference	0.135		Forearm Circumference	0.122
(AR & PR) TO GS	Arm Rotation	0.489	(HC & WC) TO GS	Hand Circumference	0.414
	Palm Rotation	0.042		Wrist Circumference	0.104
(GD & HD) TO GS	Grip Diameter	0.423	(AR & PR) TO GS	Arm Rotation	0.077
	Handling Distance	0.511		Palm Rotation	0.403
			(GD, HS, MHW, & HD) TO GS	Grip Diameter	0.138
				Hand span	0.054
				Maximum hand width	0.214
				Handling Distance	0.325

FFW = forefinger width, FFT = forefinger thick, HL = hand length, PW = palm width, TW = thumb width, PTW = palm to thumb width, MHC = maximum hand circumference, FAC = forearm circumference, HC = hand circumference, WC = wrist

circumference, AR = arm rotation, PR = palm rotation, GD = grip diameter, HS = hand span, MHW = maximum hand width, HD = handling distance, GS = grip strength.

Table 7: The Difference of Average Grip Strength from Experiment and Regression Formula

Male				Female			
Regression Formula	Average Grip Strength From Experiment (kg)	Average Grip Strength from Regression Formula (kg)	Difference	Regression Formula	Average Grip Strength From Experiment (kg)	Average Grip Strength from Regression Formula (kg)	Difference
(FFW & FFT) TO GS	**38.42**	38.31	0.11	(HL & TW) TO GS	**23.46**	22.16	1.30
(MHC & FAC) TO GS		37.17	1.25	(PW & PTW) TO GS		22.64	0.81
(HC & WC) TO GS		38.18	0.24	(MHC & FAC) TO GS		22.37	1.08
(AR & PR) TO GS		37.89	0.52	(HC & WC) TO GS		22.18	1.27
(GD & HD) TO GS		37.11	1.31	(AR & PR) TO GS		22.83	0.62
				(GD, HS, MHW, & HD) TO GS		22.53	0.92

FFW = forefinger width, FFT = forefinger thick, HL = hand length, PW = palm width, TW = thumb width, PTW = palm to thumb width, MHC = maximum hand circumference, FAC = forearm circumference, HC = hand circumference, WC = wrist circumference, AR = arm rotation, PR = palm rotation, GD = grip diameter, HS = hand span, MHW = maximum hand width, HD = handling distance, GS = grip strength.

Table 8: Average and 75th Percentile Value of Independent Variables in Male

Independent Variables	Mean	75th Percentile	Standard Deviation
Forefinger width	1.84	2	0.19
Forefinger thick	1.44	1.5	0.17
Maximum Hand Circumference	23.86	24.7	1.29
Hand Circumference	20.52	28.1	1.26
Wrist Circumference	16.82	21.4	0.97
Forearm Circumference	26.23	17.3	2.20
Arm Rotation	57.51	66	10.77
Palm Rotation	38.53	45	9.05
Grip Diameter	5.17	5.5	0.40
Handling Distance	4.90	5.1	0.41
Average Grip Strength		**35.99**	

Table 9: Average and 75th Percentile Value of Independent Variables in Female

Independent Variables	Mean	75th Percentile	Standard Deviation
Hand length	16.94	17.3	1.12
Thumb width	1.86	7.6	0.22
Palm width	7.47	2	0.57
Palm to thumb width	8.84	9.2	0.63
Maximum Hand Circumference	21.03	21.6	1.07
Hand Circumference	17.93	23.4	0.89
Wrist Circumference	14.78	18.5	0.97
Forearm Circumference	22.44	15.1	2.34
Arm Rotation	54.95	63	9.86
Palm Rotation	35.23	42	9.41
Grip Diameter	4.83	5.1	0.46
Hand span	18.33	19	1.09
Maximum hand width	16.56	17.4	1.02
Handling Distance	4.55	4.9	0.50
Average Grip Strength		**21.89**	

5. CONCLUSION OF THE STUDY

Based on the result of this study, it seemed that the hand anthropometry variables toward grip strength positively correlated. The result of the previous studies gave the same result with this study. The result of the previous researches was the hand anthropometry toward grip strength positively correlated in active people [7, 9, 5]. Besides, the regression equations in male and female also valid to use. Therefore, the regression formulas also can be used to predict the grip strength in male and female sedentary Industrial Engineering students of Atma Jaya Catholic University of Indonesia aged 18-21 years old. Then, if the higher the value of hand anthropometry, then the higher the value of grip strength and conversely. Based on the results, the best regression formula in all equations of male that could predict the grip strength was regression equation of Grip Strength TO (Forefinger Width and Forefinger thick) and the best regression formula in all equations of female that could predict the grip strength was regression equation of Grip Strength TO (Arm Rotation and Palm Rotation). Besides, male and female sedentary college students could increase their grip strength by doing workout and training on their hand with sports that required the grip strength.

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