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Normative Data on the Maximum Twisting Force for an Elderly Person's Sustainable Life

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Abstract: Most elderly people have difficulty opening a new bottle cap due to the insufficient torque to be applied. The study aims at obtaining normative data on the hand dimensions and the maximum torque that could be generated by elderly persons. This study was conducted on 30 elderly people aged 60 and over. A digital torque meter, digital caliper, and tissue tape were used to measure the maximum torque on a dummy bottle and hand dimensions. SPSS software was used for all statistical analyses. Older men have been found to have larger hand dimensions than older women. However, no significant differences in hand dimensions were found between different age groups. A statistically significant difference was observed between the age group 60–69 years vs. 80–89 years and the age group 70–79 years vs. 80–89 years in maximum torque. The correlation between hand dimensions (thumb width and index finger length) and maximum torque was highly correlated (r = 0.63 and r = 0.62, respectively). Knowledge of the relationship between hand dimensions and maximum torque can be used for future bottle cap designs to meet the needs of the elderly.

Keywords: twisting force; statistical analysis; elderly people

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1. Introduction

Around 962 million people were aged 60 and over across the world in 2017, which is about 13% of the global population [1]. The population aged 60 or above is growing at a rate of about 3% per year. Rapid aging will occur in all parts of the world, so that by 2050 all regions of the world except Africa will have nearly a quarter or more of their populations at ages 60 and above [2]. Aging appears to limit elderly people in some ways [3]. Certain challenges for elderly people, such as being unable to perform daily tasks in their daily lives, arise due to this demographic transition. The emerging demographic trends toward an aging population demand new ways and solutions to improve the quality of their lives. These include prolonged independent living, improved healthcare, and reduced social isolation [4]. Old age causes various losses of roles and functions and leads to increased dependency on others. As a result of this dependency, the need for other individuals can manifest as a decreased quality of life and dissatisfaction with it [5]. Considering the need to support elderly people in a qualitative and independent life, much research effort has been devoted to the fields of engineering, health, psychology, and many more, to improve their day-to-day activities and promote their social connections and independence [6]. This includes the involvement of the elderly in the IT society and assistive technology (technology designed to increase, maintain, or improve the functional capabilities of older adults) [7,8].

The ability to open beverage packages such as bottles, jars, and child-resistant closures has been a significant issue [9,10]. Most of the time, the seal is designed to be strong and tight to keep the drinks fresh. Therefore, the 'open ability' of such bottled packaging is becoming a concerning issue for elderly people because of muscle strength loss or other reasons [11].

Twisting strength is commonly used to open a bottle. However, most elderly consumers fail to open the bottle cap due to a lack of force to be exerted [12]. To date, the data on the maximum twisting force on opening jars is available [13]. An experiment has been conducted to investigate hand strength and the twisting force among younger and older adults [14,15]. Knowing the features of the bottle cap is essential to improving its design since it can affect the way elderly people open it with their hands. It has been established that maximum torque capacity is influenced by the diameter, material, surface texture, surface area of the bottle, and its cap. The applied torque direction and a person's grip strength also affect the maximum torque capacity needed. However, there are not enough studies related to the relationship between hand dimensions and maximum twisting force for bottle cap opening among elderly persons. This kind of study can be used as a reference for making sure the bottle cap is designed inclusively. Comprehensive hand dimensions and a maximum twisting force database contribute to product design improvements which are ergonomic-friendly in this study.

This quantitative study aims at determining the normative data on maximum twisting force as well as examining the relationship between the hand dimensions and maximum twisting force of elderly persons using statistical data analysis. The broad-ranging database of hand dimensions, as well as the maximum twisting force of the senior citizen in Malaysia, is established. It is worth mentioning that this research is not to design an alternative for opening the bottle. However, it aims at presenting information to manufacturers which will promote the use of the capacities of elderly consumers as a basis for their packaging. As such, the present study can be a reference for product design and a simpler approach to enhancing an elderly person's quality of life.

2. Methodology

The selection criteria of subjects, materials, equipment, and methods are presented in this section.

The generic torque model presented in [16] was adopted since most bottle caps are circular. Thus, torque about the bottle cap axis is generated by a frictional force applied to the bottle cap surface so that the hand does not slip on the cap during torque loading. Thus, both normal force and frictional force can contribute directly to torque production. Figure 1 illustrates that the contact force can be resolved into normal force and frictional force components, both of which contribute to torque generation as shown in Equation (1).

$$T = \int_0^{2\pi} \vec{r} \times \vec{F}_{resultant}\, d\theta = \int_0^{2\pi} \left\{ r \left(F_f \cos\alpha + F_n \sin\alpha \right) \right\} d\theta \tag{1}$$

where T is the torque about the center of rotation, F_n is the normal force applied by the hand at a point on the bottle cap surface, F_f is the frictional force applied by the hand at that point, θ is the angle about the center of the cap, and α is the angle between $\vec{r}$ and F_n.

The dimensional measurement of the hand is defined in Figure 2b: the hand length is denoted by C, and the handbreadth is denoted by D. The grip breadth inside diameter is represented by A.

All these dimensions were measured using a caliper and fabric measuring tape. To obtain the uniformity of the gripping motion, the palm and fingers of the hand should be the location of the force distribution. The grip motions, which were found using a biodynamic hand coordinate system defined in ISO 8727 [17], are comprised in Figure 2a. The z-axis proximally passes through the 3rd metacarpal grasping gesture. The x-axis of the system is nearly normal to the palm and projects forward from the origin when the hand is open in the normal anatomical position, i.e., the palms face forward. The x and z axes were parallel to the reference x and z axis, which passed through the center of the bottle cap circle.

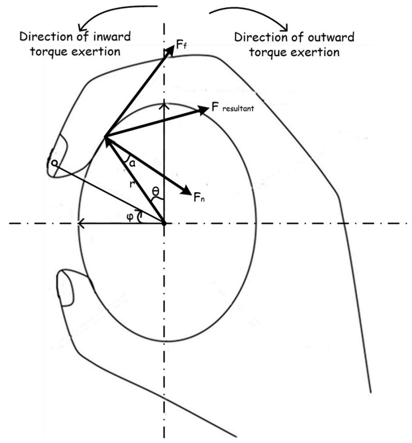


Figure 1. A cylindrical bottle cap grasped by the hand viewed from the top of the bottle.

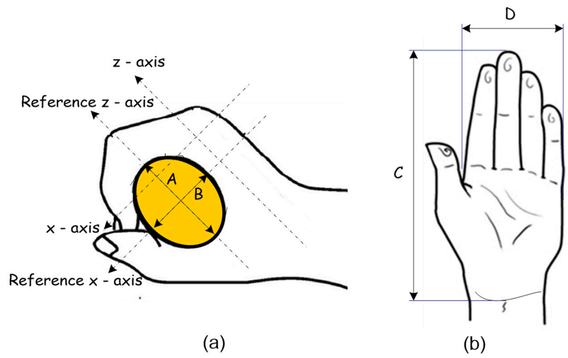


Figure 2. Dimensional measurements of hand definitions.

2.1. Subject Selection

The involvement criteria for the selection of subjects were: the subjects must be at least 60 years old; free of any history of finger and wrist problems during the experiment; participate in both measurements of hand anthropometric dimensions and maximum twisting strength; able to understand and speak basic Malay or English.

The aim and the procedure of the experiment were explained to the volunteers through an oral interview before the data collection. About 48 senior citizens (20 males and 18 females) who stay at Klang Valley, Malaysia indicated their willingness to participate in the research. Based on the stated involvement criteria, only 30 volunteers qualified for this study, and therefore a sample size of 30 was used in this study. This sample size is fairly common across statistics. It has been stated in the literature that a sample size of 30 often increases the confidence interval of the population data set and is enough to warrant assertions against the findings [18]. As such, a total of 30 (15 males and 15 females) elderly subjects were selected and involved in the case study.

2.2. Material

Four different bottles (“Cactus”, “Dasani”, “Spritzer”, and “Topvalu”), made of polyethylene terephthalate (PET) and their caps, made of polypropylene (PP), were evaluated in this study. These packages were selected because of their popularity and availability. They also have different heights, thicknesses, and diameters of the cap as shown in Table 1.

For the selection of the best bottle, an oral interview was carried out with only 20 elderly subjects (10 males and 10 females) aged 60 years and above. Several questions were asked during the interview. The results of each question are as follows: the majority of the interviewees were in the age group of 70–79, followed by 60–69, then 80–89; there was no one above 90 years old; all the respondents consume bottled mineral water; 30% of the respondents always have difficulty in twisting the bottle cap off, and only 10%

of them ever have any problem in doing so; all the respondents seek help rather than using a bottle opener when they have a problem in opening a bottle cap; more than half of the respondents do not support the use of bottle opener. Only 3 elderly support using bottle openers and 5 elderly have no idea.

Table 1. Diameter, thickness, and height of various brands of bottle cap.

Brands	Cactus	Dasani	Spritzer	Topvalu
Diameter (mm)	31.75	31.95	31.80	31.75
Thickness (mm)	0.45	0.20	0.50	0.60
Height (mm)	11.75	11.80	11.55	11.90

As shown in Figure 3, the "Hard" chosen by the elderly on "Topvalu" was more than double compared to the "Cactus" and "Dasani" brands. On the other hand, the "Easy" rating was assigned by almost half of the respondents for the "Cactus", "Dasani", and "Spritzer" brands. Two elderly were unable to open the "Topvalu" bottle cap.

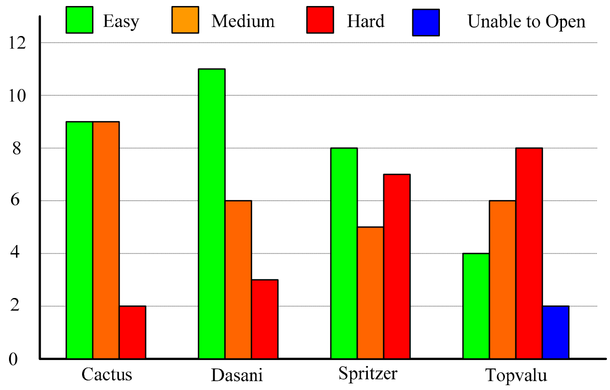


Figure 3. Easiness of bottle cap opening among various brands.

To obtain consistent data, only one brand of mineral water bottle was used in testing the hand torque strength of the elderly people, which was "Topvalu". This is because, from the data collected in oral interviews, the majority of subjects face difficulty in opening the bottle cap of the "Topvalu" brand compared to the other brands. As such, the "Topvalu" brand was chosen to provide an accurate, precise, and efficient database with broad applicability for future product designs. A mock bottle was made whereby the bottle cap was fixed with glue to test the maximum twisting force of the elderly.

2.3. Equipment

The hand dimensions were measured using a fabric measuring tape and digital caliper. An Alipio digital torque meter shown in Figure 4 was used to measure the torque strength required to open the bottle of the subjects and their maximum twisting force. The measurement range of the torque meter is from 0.04 to 10.00 N.m (from 0.5 to 100.0 kgf. cm) digitally. Its smallest reading is 0.01 N.m (0.1 kgf. cm).

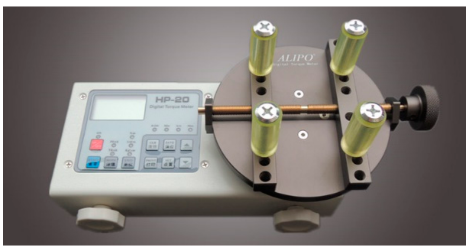
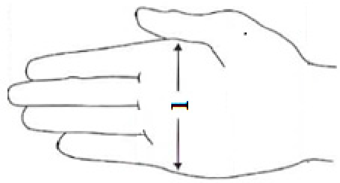
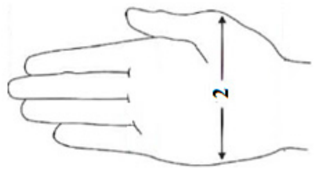
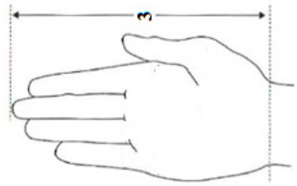
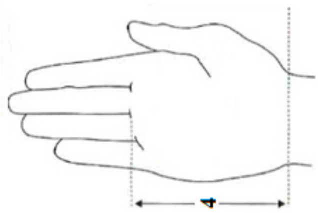
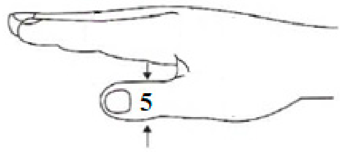
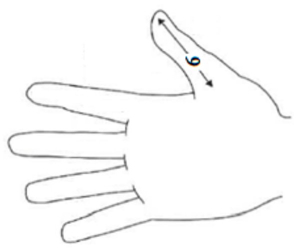
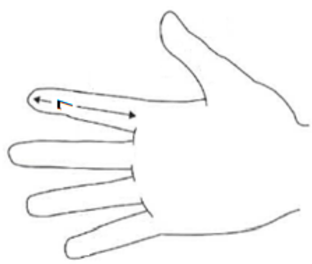


Figure 4. Alipo HP100 digital torque meter.

2.4. Procedure

A description of each hand's anthropometric dimensions is given in the measurement adapted from a Malaysian Standard, MS ISO 7250-1:2008 (Malaysian Standard, 2008) shown in Table 2.

Table 2. Description and illustration of hand anthropometric dimensions.

No.	Segment/Description	Figures
1	Handbreadth (at metacarpal) Maximum breadth of the hand between the metacarpal II and the metacarpal V	
2	Handbreadth (across thumb) The breadth of the hand as measured across the distance of the metacarpal bones	
3	Hand length Length of the hand between the stylion landmark on the wrist and the tip of the middle finger	
4	Palm length Distance between the stylion on the wrist and the root of a middle finger	
5	Thumb breadth Maximum breadth of the thumb perpendicular to its long axis.	
6	Thumb length Distance between the root and the tip of the thumb	
7	Index finger length Distance from the tip of the second finger to the proximal finger crease on the palm	

The anthropometric measurements such as handbreadth with the thumb, hand breadth at metacarpal, hand length, palm length, thumb length, thumb breadth, and index finger length were recorded with the help of fabric measuring tape. The parameters were measured manually in centimeters and recorded by reading the number where the end of the fabric tape measure overlaps the remaining length. The measurement, performed in sitting positions, was taken three times to obtain the average.

In this paper, the right hand of the subject was measured because all the volunteers were right-handed. Furthermore, the right hand usually tends to be slightly bigger than the left hand [19].

Maximum twisting force is the maximum force exertion by the subjects [20]. It is hypothetically expected to be lower than the torque required to open a new bottle cap. This is because a normal bottle cap designed in the market should not require an individual's maximum strength to open it.

Regarding the maximum twisting force measurement, two participants were tested during each session. The recording was taken on alternate participants to prevent fatigue development. In the beginning, the aim of the experiment and the procedure were explained to each subject. In addition, the subjects were advised to wipe their hands thoroughly before exerting their maximum force to prevent sweat from their hands affecting their maximum twisting force on the bottle cap. The test pieces and equipment were demonstrated to the participants. The participants were allowed to take some trials with the test pieces before the experiment. In each trial, the torque exertion was repeated three times in between a rest period of 2 min. Moreover, between two consecutive trials, a rest of 3 min was given to the elderly person to avoid fatigue. The test was not repeated to prevent the subjects from losing their energy after several trials. As such, their twisting force was generated at a maximum level. However, when any of the elderly persons experienced pain or discomfort, the subject was asked to stop the task immediately [21]. The subjects were in the seated position for testing their maximum twisting force on a mock bottle, which had the same cap diameter and cap thickness. The twisting action was demonstrated on the bottle cap before the subjects were asked to twist the bottle cap in an anti-clockwise direction using their preferred hands to create the torque and the non-preferred hand to hold the circular base of the bottle (see Figure 5). The readings were recorded with the digital torque meter.

Figure 5. Position of both hands while opening the bottle cap.

Data collection for the hand dimensions and maximum twisting force were analyzed in terms of the maximum, minimum, mean, and standard deviation (SD). IBM SPSS (Statistical Package for the Social Sciences) statistical software (Version 23) was used. The irregular and outlier anthropometric data were eliminated to ensure the accuracy of the data. The statistical significance level was accepted for $p < 0.05$ in this study [22].

Parametric tests were used in the present research. The four main assumptions of parametric tests (i.e., normality, equal variance, independence, and no outliers) were confirmed before analysis. Since our sample size was small, a Shapiro–Wilk test was used for the normality test; side-by-side boxplots were used to satisfy the condition for equal variance; Grubbs' test was used to confirm that there were no outliers. Since random sampling was used for sample selection, the independency condition was assured.

An independent *t*-test was used to examine the significant difference in the mean maximum twisting force across gender. The level of significance (alpha level) is commonly used as 0.05. In this study, a 2-tailed test for the possibility of the relationship in both directions was used, whereby each tail of the distribution was 0.025 of the tests. There are some assumptions for the *t*-test as follows [23]: the samples are randomly drawn from the populations; the dependent variable fits a normal distribution; the scores in the populations have the same variance (s1 = s2) [24].

For further analysis, one-way ANOVA (analysis of variance) analysis was carried out to determine whether there was a significant difference(s) in the age group from 7 hand dimensions and maximum twisting force. The inter-interaction between independent variables affecting the values of the dependent variable has been studied as well using the post-hoc test. The assumption of a two-way ANOVA should be fulfilled as follows [25,26]: the dependent variable is measured at a continuous level; homogeneity of population variance; the independent variables should consist of two or more categorical, independent groups; the samples are drawn from the normal distribution of the population; independence of observations; no significant outliers exist.

Then, the post-hoc test (Scheffe test) was used to confirm where the differences occurred between groups when there was a statistically significant difference in group means.

Pearson product-moment correlation (PPMC) was used to measure the direction and strength of the correlation that exists between two variables measured on one or more interval scales. In this study, all variables were involved in the PPMC test to find out where the significant correlations were. For example, gender, age group, 7 hand dimensions, and maximum twisting force were included in the PPMC test. The Pearson correlation coefficient denoted as r indicates how far away these data are from the best-fit line. The nearer the value of r is to zero, the better the variation around the best-fit line. There are some assumptions with regards to PPMC as follows [27]: the variables must be approximately normally distributed; the two variables should be measured at the interval or ratio level; there is a linear relationship between the two variables; there should be no significant outliers.

3. Results and Discussion

The results for demographic data and descriptive analyses (including data for hand dimensions, hand torque strength, maximum twisting force, and boxplot) are presented in this section. This includes the inferential analyses discussion, Pearson correlation test, one-way ANOVA test, independent *t*-test, and Scheffe test. The discussion on the relationship between hand dimensions and the maximum twisting force of elderly persons is also presented, including the comparisons with previous studies.

3.1. Demographic Data

A total of 30 elderly subjects (15 males, and 15 females) were invited to take part in a health interview before measuring their hand dimensions and maximum twisting force. There were 12 young old (60 to 69 years, mean: 63, SD: 2.31), 9 middle old (70 to 79 years, mean: 73, SD: 2.08), and 9 very old (80 to 89 years, mean: 82, SD: 1.73).

The demographic data were collected according to the Health Interview Guide to make sure the elderly person was qualified for the following tests. The demographic data are presented in Table 3.

3.2. Descriptive Analyses

Tables 4 and 5 show the mean, standard deviation, range, minimum, maximum 10th percentile, and 95th percentile of the seven measured hand dimensions for elderly male and female participants, respectively. Hand dimension data are collected from 15 elderly males and 15 elderly females.

Table 3. Subject demographics.

Characteristic	Subject	
Hand dominance	All 30 subjects are right-handed	
Fingers or wrist joint problems	None of the subjects have finger or wrist joint problems	
Diagnosed Disease/Impairment	Arthritis	0
	Heart Problems	4
	Alzheimer's	0
	High Blood Pressure	8
	Stroke	1
	Muscle Disorders	0
	Arm Injuries/Disorders	0
	Physical Disability	6

Table 4. Descriptive statistics of hand dimensions for older men.

	Handbreadth at Metacarpal (cm)	Handbreadth across Thumb (cm)	Hand Length (cm)	Palm Length (cm)	Thumb Breadth (cm)	Thumb Length (cm)	Index Finger Length (cm)
Mean	8.9	11.0	19.3	11.2	2.9	6.3	7.5
Std. Deviation	0.4	0.4	1.0	0.6	0.2	0.5	0.4
Range	1.4	1.3	3.1	1.6	0.7	1.6	1.3
Minimum	8.2	10.2	17.8	10.5	2.5	5.4	6.7
Maximum	9.6	11.5	20.9	12.1	3.2	7.0	8.0
Percentiles 10	8.2	10.4	17.8	10.5	2.6	5.5	6.8
Percentiles 90	9.6	11.5	20.7	12.0	3.2	6.9	7.9

Table 5. Descriptive statistics of hand dimensions for elderly females.

	Handbreadth at Metacarpal (cm)	Handbreadth across Thumb (cm)	Hand Length (cm)	Palm Length (cm)	Thumb Breadth (cm)	Thumb Length (cm)	Index Finger Length (cm)
Mean	7.7	9.5	16.5	9.5	2.2	5.6	6.7
Std. Deviation	0.3	0.4	0.6	0.3	0.2	0.3	0.4
Range	0.9	1.1	1.9	1.2	0.9	0.8	1.3
Minimum	7.4	9.0	15.5	8.8	1.8	5.2	6.0
Maximum	8.3	10.1	17.4	10.0	2.7	6.0	7.3
Percentiles 10	7.4	9.0	15.6	8.9	1.9	5.3	6.1
Percentiles 90	8.2	10.0	17.3	9.0	2.6	5.9	7.2

It can be observed that the older men have larger hand dimensions in comparison to the elderly females, i.e., handbreadth at metacarpal (+1.2 cm), handbreadth across thumb (+1.5 cm), hand length (+2.8 cm), palm length (+1.7 cm), thumb breadth (+0.7 cm), thumb length (+0.7 cm), and index finger length (+0.8 cm). A 90th percentile means that 90% of the elderly people were below that value while 10% of them were above that value. In general, elderly males have much higher 10th and 90th percentiles in hand dimensions compared to that elderly females.

3.3. Maximum Twisting Force Data

Table 6 demonstrates the essential information about the gender comparisons, including the sample size (N), mean, standard deviation, and standard error mean for maximum twisting force. It can be found that the elderly males (1.08 ± 0.35) N.m exerted more significant maximum twisting force than those of elderly females (0.79 ± 0.30) N.m, with a difference of 0.29 N.m. A low standard deviation of both genders indicates that the maximum twisting force tends to be very close to the mean. Furthermore, the results revealed a low standard error mean which means there is relatively less spread in the sampling distribution. In general, the maximum twisting force of the elderly was (0.94 ± 0.35) N.m. Overall, the 5th percentile and 95th percentile of maximum twisting force were 0.35 N.m and 1.54 N.m.

Table 6. Group statistics of maximum twisting force based on gender.

Gender		N	Mean	Std. Deviation	Std. Error Mean	5th Pct	95th Pct
Maximum Twisting Force (N.m)	Male	15	1.08	0.35	0.09	0.66	1.57
	Female	15	0.79	0.30	0.08	0.37	1.32
Combination		30	0.94	0.35	0.06	0.35	1.54

Table 7 presents the descriptive statistics of maximum twisting force for both genders with different age groups. In general, the average maximum twisting force that could be generated by elderly males was higher than that of females in the age group of 60–69 years and 70–79 years. On the other hand, for both males and females aged 80–89 years, the average maximum twisting force was quite similar. Moreover, it was observed that in the 80–89 age group, the minimum and maximum value of the maximum twisting force of males was slightly lower than females by 0.05 N.m, which was supposed to be higher than females. This may be due to changes in muscle strength with age [9,28].

Table 7. Descriptive statistics of maximum twisting force for both genders with different age groups.

Age Group	Gender	Maximum Twisting Force (N.m)							
		N	Mean	SD	Range	Min	Max	5th Pct	95th Pct
60–69	Male	6	1.33	0.20	0.53	1.04	1.57	1.04	1.57
	Female	6	1.01	0.25	0.65	0.84	1.49	0.84	1.49
70–79	Male	5	1.19	0.14	0.35	1.02	1.37	1.02	1.37
	Female	4	0.70	0.22	0.50	0.37	0.87	0.37	0.87
80–89	Male	4	0.59	0.18	0.41	0.33	0.74	0.33	0.74
	Female	5	0.61	0.28	0.69	0.38	1.07	0.38	1.07

It was also found that the maximum twisting force decreased with age. The maximum twisting force of the elderly persons ranged from 0.33 to 1.57 N.m. From the results, a variation in maximum torque was observed in each of the older age groups. The 5th percentile and 95th percentile of peak torsional strength are summarized in Table 7. Overall, it was found that the maximum torque exerted by older men is significantly higher than that of older women.

3.4. Inferential Analyses

3.4.1. Pearson Product-Moment Correlation Analysis

Pearson product-moment correlation was employed to understand if there was an association concerning two variables measured on at least one interval scale. The null hypothesis (H0) and alternative hypothesis (H1) of the *p*-value significance test for the correlation can be expressed as follows [29]:

Lena and Margara [30] indicated that the correlation between the dependent and independent variables ranged from +1.00 (positive relationship) to −1.00 (negative relationship). A correlation close to 0 indicates that there is no relationship between the two variables. A positive relationship means the two variables tend to increase together, while a negative relationship means one variable increases but another variable decreases.

3.4.2. Relationship between Gender and Maximum Twisting Force

The correlation between gender and maximum twisting force was statistically significant ($p < 0.05$), rejecting the null hypothesis. The Pearson correlation coefficient (r) was found to be equal to −0.42. This indicates a moderate correlation where the coefficient is significantly different from 0. A negative correlation means that elderly males can exert more maximum twisting force than elderly females.

3.4.3. Relationship between Age Group and Maximum Twisting Force

A high correlation between age group and maximum twisting force was found (r = −0.67). A negative correlation indicates that the maximum twisting force decreased with increasing age.

3.4.4. Relationship between Seven Hand Dimensions and Maximum Twisting Force of Elderly Persons

Pearson's correlation analysis was used to examine the relationship between seven hand dimensions (i.e., hand width at the metacarpal, hand width across the thumb, hand length, palm length, thumb width, thumb length, and index finger length) and maximum torque in elderly individuals. The results of Pearson's product-moment correlation analysis are tabulated in Table 8.

Table 8. Correlations between seven hand dimensions and maximum twisting force of elderly persons.

Hand Dimensions	Maximum Twisting Force (N.m)	
	p	**r**
Handbreadth at the metacarpal	0.01	0.51 **
Handbreadth across the thumb	0.03	0.41 *
Hand length	0.01	0.45 *
Palm length	0.59	0.35
Thumb breadth	0.01	0.63 **
Thumb length	0.01	0.46 *
Index finger length	0.01	0.62 **

** Correlation is significant at the 0.01 level (2-tailed); * correlation is significant at the 0.05 level (2-tailed); '*p*' is the significant 2-tailed value; 'r' is the Pearson correlation coefficient.

It was observed that handbreadth at the metacarpal, thumb breadth, and index finger length have a positive correlation with maximum twisting force at 0.01 significant level (2-tailed). A moderate correlation was found between handbreadth at the metacarpal and maximum twisting force (r = 0.51) of elderly persons. On the other hand, both thumb breadth and index finger length were highly correlated with maximum twisting force, with a Pearson correlation coefficient of r = 0.63 and r = 0.62, respectively.

There was a positive, moderate correlation between handbreadth across the thumb and maximum twisting force, r = 0.41. Similarly, hand length and thumb length were moderately correlated with maximum twisting force ($0.41 < |r| < 0.6$). Only palm length was not significantly correlated with maximum twisting force, as the *p*-value is 0.59, which is more than 0.05.

Overall, there was a strong, positive correlation between hand dimensions and maximum twisting force; this means that increases in hand dimensions were correlated with increases in maximum twisting force.

3.5. Independent t-Test

An independent samples test displays the results in two parts that provide different information, and is shown in Table 9. Part 1 is a Levene's test for equal variances and Part 2 is the *t*-test for equal means. Levene's test for equal variances tests the assumption of homogeneity. Referring to the Levene's test, the value of Sig 0.48 > 0.05 is referred to as the assumed equal variances, and only the first line of the *t*-test results was reported. A value greater than 0.05 means that the spread in the two states is about the same.

Table 9. Independent samples test of maximum twisting force across genders.

Z		Levene's Test for Equality of Variances		*t*-Test for Equality of Means			
		F	Sig.	t	df	Sig. (2-Tailed)	Mean Difference
Maximum Twisting Force (N.m)	Equal variances assumed	0.53	0.48	2.43	28	0.02	0.29
	Equal variances not assumed			2.43	27.28	0.02	0.29

Next, by referring to the *t*-test, the table shows the difference in means between genders is 0.29 N.m. The significant value of 2-tailed for both genders is 0.02 N.m. Since the *p*-value is less than 0.05, it was enough for rejection of the null hypothesis. It can be concluded that there was a significant difference between the elderly males and elderly females for the maximum twisting force. The *t*-test results show that males had significantly higher maximum twisting force than females ($t = 2.43$, $df = 28$, $p < 0.05$).

3.6. One-Way ANOVA Tests

One-way ANOVA (analysis of variance) compares the means of two or more independent groups to determine whether there is statistical evidence that the associated population means are significantly different [31].

3.6.1. Any Significant Differences among the Elderly Persons of Different Age Groups on the Seven Hand Dimensions

Table 10 presents the results of the ANOVA analysis and whether there was a statistically significant difference between the group means. It can be observed that the significance value for each hand dimension is greater than 0.05; therefore, there was no statistically significant difference between older people of different age groups and each of the hand dimensions. The null hypotheses were accepted [32].

Table 10. ANOVA test among the elderly of different age groups on the seven hand dimensions.

		df	F	Sig.
Handbreadth at Metacarpal (cm)	Between Groups	2	0.3	0.7
	Within Groups	27		
	Total	29		
Handbreadth across Thumb (cm)	Between Groups	2	0.4	0.7
	Within Groups	27		
	Total	29		
Hand Length (cm)	Between Groups	2	1.2	0.3
	Within Groups	27		
	Total	29		
Palm Length (cm)	Between Groups	2	0.3	0.7
	Within Groups	27		
	Total	29		
Thumb Breadth (cm)	Between Groups	2	0.4	0.7
	Within Groups	27		
	Total	29		
Thumb Length (cm)	Between Groups	2	0.2	0.8
	Within Groups	27		
	Total	29		
Index Finger Length (cm)	Between Groups	2	2.0	0.2
	Within Groups	27		
	Total	29		

3.6.2. Any Significant Differences among the Elderly Persons of Different Age Groups on Maximum Twisting Force

The ANOVA tests among the elderly persons of different age groups on the maximum twisting force is presented in Table 11.

Table 11. ANOVA tests among the elderly persons of different age groups on the maximum twisting force.

		df	F	Sig.
Maximum Twisting Force (N.m)	Between Groups	2	11.53	0.00
	Within Groups	27		
	Total	29		

It can be observed that in the maximum twisting force comparison for age groups 60–69 years and 80–89 years, the results indicated a statistically significant difference (Sig. = 0.00 which is less than 0.05), with a mean difference of 0.57 N.m. Similarly, a statistically significant difference was found between the age groups 70–79 years and 80–89 years in the maximum twisting force, $p = 0.03$ which is less than 0.05, with a mean difference of 0.37 N.m. On the contrary, no significant difference had been observed between the age groups 60–69 years and 70–79 years for the maximum twisting force exerted by the elderly person. The result for multiple comparisons using the Scheffe post-hoc test is shown in Table 12.

Table 12. Multiple comparisons using the Scheffe post-hoc test.

Dependent Variable	(I) Age Group	(J) Age Group	Mean Difference (I–J)	Sig.
Maximum Twisting Force (N.m)	60–69	70–79	0.20	0.26
		80–89	0.57 *	0.00
	70–79	60–69	−0.20	0.26
		80–89	0.37 *	0.03
	80–89	60–69	−0.57 *	0.00
		70–79	−0.37 *	0.03

* The mean difference is significant at the 0.05 level.

4. Conclusions

The range of elderly people's hand dimensions were measured and compared. It has been observed that older men have larger hand dimensions compared to older women.

The range of maximum twisting force of elderly persons was determined. The relationship between hand dimensions and the maximum torque of older individuals was identified. A statistically significant difference was observed between the age group 60–69 years vs. 80–89 years and the age group 70–79 years vs. 80–89 years in maximum torque. The correlation between hand dimensions (thumb width and index finger length) and maximum torque was highly correlated ($r = 0.63$ and $r = 0.62$, respectively).

This research is limited to only the maximum twisting force for an elderly person. The torque strength was not included. For future research, it would be interesting to correlate maximum twisting strength with anthropometric indicators (e.g., BMI, percentage of fat mass, percentage of muscle mass, etc.).

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