

# Grip and Pinch Strength in Thai Adult

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**ABSTRACT;** The primary purpose of this study was to establish clinical norms for Thai adult on four test of hand strength. A dynamometer was used to measure grip strength and an electronic pinch meter to measure tip, key, and palmar pinch strength. A sample of 165 male and 235 female Thai adults were tested using standardized positioning and instructions. Dominant and non-dominant hand data were categorized into 6 age groups and 4 occupational groups for both sexes. This categorization provides a means of comparing the score of individual patients to that of normal subjects of the same age and sex. The ratio of dominant to non dominant grip strength was 1.05, for tip, key, and palmar pinch were 1.06, 1.05, and 1.02 respectively. Male subjects had higher scores of grip and pinch strength than female. A high correlation was seen between grip strength and age, a moderate correlation between pinch strength and age, with the highest scores occurred between the 20 to 40 age groups. Manual workers had the highest scores of grip and pinch strength, housewives had the lowest, with sedentary workers in between.

Hand is primarily a grasping or prehensile organ. The action of the shoulder, elbow and wrist joints enable the hand to be placed at almost any area of the body. The hand can be pulled toward or pushed away from the body through considerable more than a hemisphere. Hand function is the result of a unique combination of strength, coordinated mobility, stability and exquisite sensation. A complete evaluation of the hand should include measurement of range of motion of individual joints, strength of pinch and grasp, muscle testing, sensory evaluation and assessment of pain.<sup>1</sup>

Although strength is one of the important characteristics of a normal hand, this factor is not given enough attention in reconstructive surgery as compared to other parameters of motion and sensibility. Reliable and valid evaluation of hand strength is of paramount importance in determining the effectiveness of various surgical or treat-

ment procedures. In addition, normative data are needed to interpret evaluation data; to set realistic treatment goals; and to assess a patient's ability to return to employment.

Sargent first used the hand grip as a test for determining strength in 1880.<sup>2</sup> Since the time, grip strength has been correlated with hand dominance, overall "physical fitness", and normal growth.

Three basic pinch patterns: pulp pinch, key (lateral) pinch, chuck (palmar, 3 digit) pinch were generally employed in measuring hand strength.

Pulp pinch. The pulps of index and thumb are opposed with the distal interphalangeal joints extended as in gripping a sheet of paper.<sup>3,4</sup>

Key pinch. The pulp of the thumb is opposed to the radial side of the middle phalanx of the index finger, as in turning a key. The resistance exerted against the thumb is increased by (stacking up) the other fingers behind the index using the interossei.<sup>3,4</sup>

Palmar pinch. The digital pulps of index and middle fingers are brought into contact with the pulp of the thumb as in exerting longitudinal traction on a pencil. The index finger pronates and the middle finger supinates so that the three digits come to resemble the chuck of power drill.<sup>3,4</sup>

In 1981, the American Society of Hand therapists, suggesting a standardized arm positioning for hand strength test, concluded that the position of the upper extremity might influence measurements, and recommended that the patients should be seated with his shoulder adducted and neutrally rotated, elbow flexed at 90° and the forearm and wrist in neutral position.

In testing the variable of wrist position, Kraft and Detels found no significant difference with test positions at 0°, 15° and 30° dorsiflexion (0° ulnar deviation) in measuring grip strength Pryce found no significant difference in grip strength with test positions at 0° and 15° ulnar deviation, 0° and 15° dorsiflexion, or any combination of these. Both studies found grip strength to be significantly less at 15° of volar flexion.

Mathiowetz and associates used standardized

procedures (subject position and instructions) to assess the reliability and validity of grip strength and pinch evaluations. The highest test-retest reliability for each test was achieved when the mean of three trials was utilized.

The aims of the present investigation were firstly to establish clinical norms for unselected Thai men and women over a wide age range and occupations, secondly to compare the hand strength of dominant and non-dominant hands. These determinations may constitute a basis for future comparison with pathologic conditions.

## MATERIALS AND METHODS

The study included 800 hands (165 men and 235 women). These subjects were randomly selected from ambulatory patients, relatives to patients and personnels at the Faculty of Medicine Siriraj Hospital, Mahidol University. Screening criteria for subjects included no previous history of neuromuscular or orthopaedic dysfunction that would affect hand strength.

The Takei Kiki Kogyo grip dynamometer was used to test grip strength. For standardization, the handle was set at the 5 cm. position for all subjects. The dynamometer was lightly supported underneath the read out dial by the examiner to prevent inadvertent dropping.

The Toyoda electronic pinch meter was used to measure tip, key and palmar pinch. Its pressure sensor was held by the examiner at the wire end to prevent dropping. The calibration of both instru-



Fig. 1

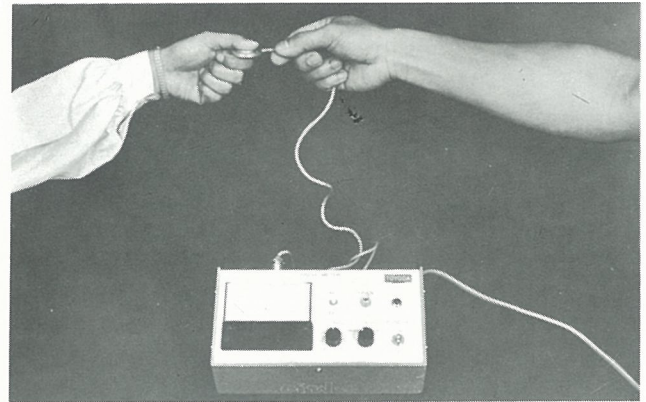


Fig. 2

ments was tested periodically during the study.

A brief interview preceded all testing. The information obtained from each subject included name, age, occupation and dominant hand. Ambidextrous persons were excluded from the study.

Grip strength was tested first (Figure 1), followed by pulp pinch, key (lateral) pinch, and palmar (chuck) pinch (Figure 2). For each of the tests of hand strength, the subjects were seated with their shoulder adducted and neutrally rotated, elbow flexed at 90° forearm in neutral position, and wrist between 0° and 30° dorsiflexion and between 0° and 15° ulnar deviation. For each strength test the scores of three successive trial were recorded for each hand.

A two-tailed, paired data t test was used to analyzed wheter there was a significant difference between each variables for grip and pinch strength scores.

## RESULTS

### 1. Dominant and Non Dominant Hand Strength

From the above study there were 365 right hand-dominant subjects (90.42%) and 35 left hand-dominant subjects (9.58%).

It was found that the average grip strength in the dominant hand was 32.72 Kgs., with a range of 13.83 to 61.33 Kgs., and a standard deviation of 9.569 Kgs. Non dominant hand grip strength averaged 30.92 Kgs, had a range of 11.5 to 57.5 Kgs, with a standard deviation of 9.156 on the average. The difference in grip strength between the dominant and non dominant hand was 1.8 Kgs. The ratio of dominant to non dominant grip strength was 1.05 for tip, key, and palmar pinch strength the average scores on dominant hand

(with standard deviation) were 6.31 ( $\pm 1.96$ ), 8.09 ( $\pm 2.50$ ), and 6.75 ( $\pm 2.26$ ) Kgs. and the average scores of 5.97 ( $\pm 1.86$ ), 7.73 ( $\pm 2.51$ ), and 6.61 ( $\pm 2.05$ ) Kgs. respectively on non dominant hand. On average, the difference in strength of tip, key, and palmar pinch between the dominant and non dominant hand were 0.34, 0.37, and 0.14 Kgs. The ratio of dominant to non dominant tip, key, and palmar pinch strength were 1.06, 1.05, and 1.02.

## 2. Male and Female Hand Strength

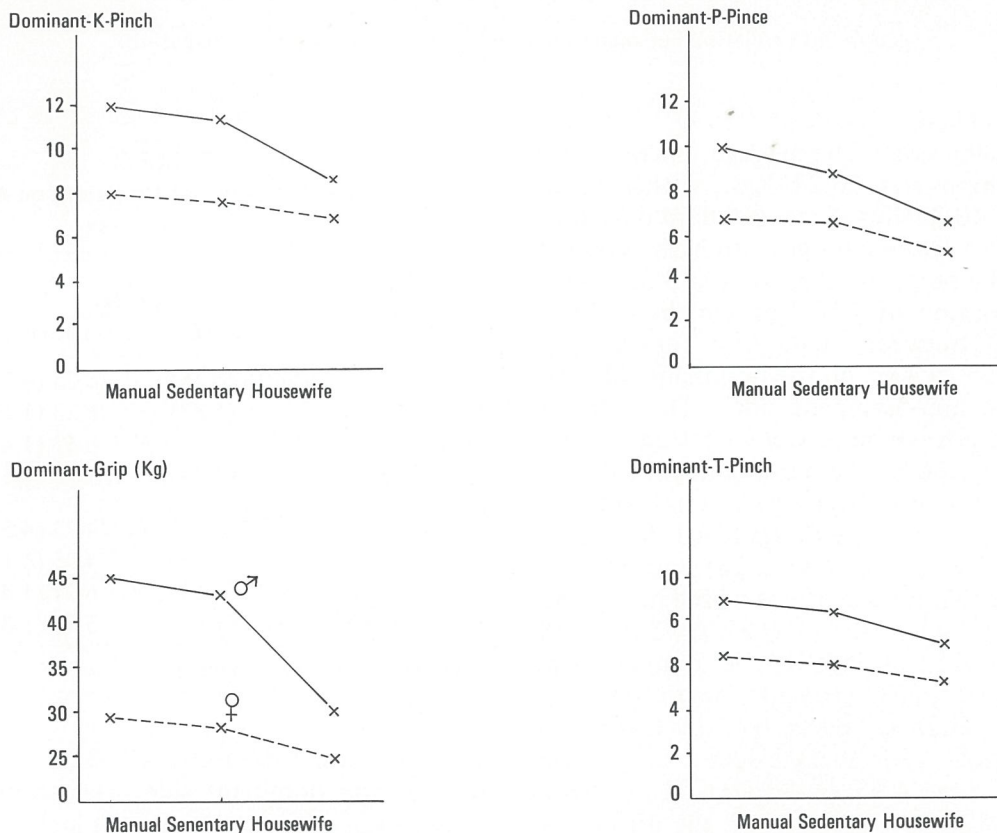
This study included 165 male (41.25%) and 235 female (58.75%) subjects.

The average grip strength of male subject were 41.95 Kgs., with a range of 15.16 to 61.33 Kgs. and a standard deviation of 6.73 Kgs. on the dominant hand and 39.76 Kgs, with a range of 12.16 to 57.5 Kgs. and standard deviation of 6.45 Kgs. on

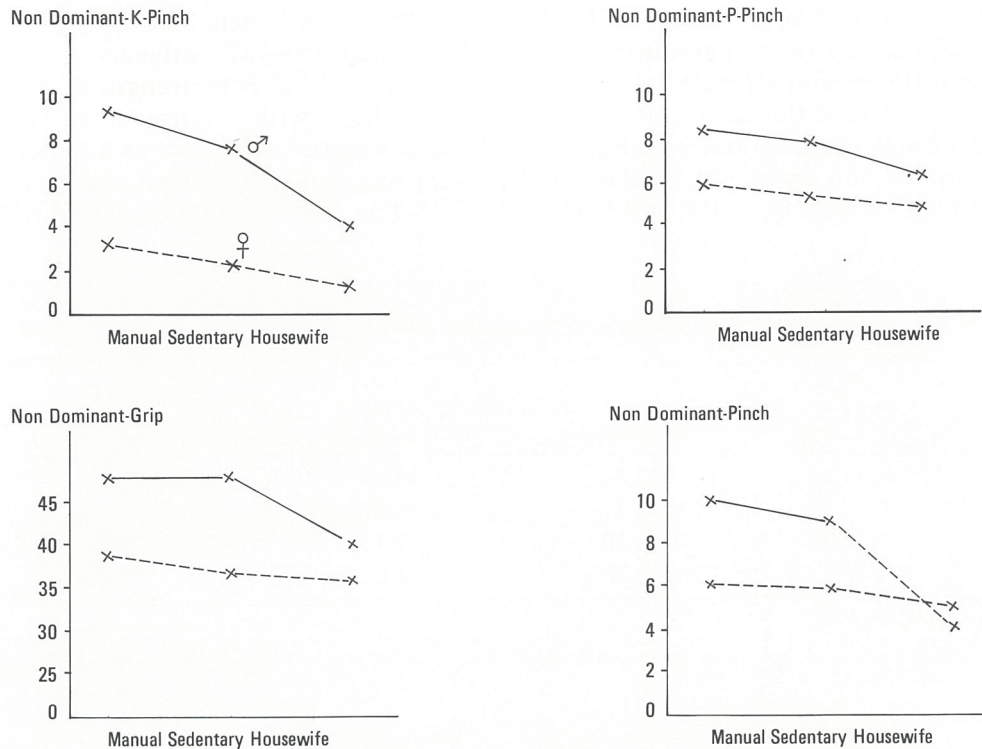
TABLE 1 Mean Values of Grip and Pinch Strength of the Dominant and Nondominant Hand.

	X		SE (difference)	p-value*
	Dominant	Non-dominant		
Grip	32.73	30.93	0.123	0.000
T-pinch	6.31	5.97	0.053	0.000
K-pinch	8.10	7.73	0.057	0.000
P-pinch	6.75	6.61	0.077	0.067

\*paired *t* - test (two-tailed, n = 400)



Graph 1 Correlation between dominant hand strength and occupation.



Graph 2 Correlation between non-dominat hand strength and occupation.

the non dominant side. The average female dominant grip strength was 26.24 Kgs., with a range from 13.83 to 40.33 Kgs. and a standard deviation of 4.713 Kgs. Non dominant grip strength averaged 24.72 Kgs, had a range of 13.83 to 40.33 Kgs. with a standard deviation of 4.50 Kgs. On the average, the difference between male and female grip strength were 15.71 Kgs. on the dominant side and 15.49 Kgs. on non-dominant side. The ratio of male to female grip strength were 1.59 on the dominant side and 1.60 on the non dominant side.

The average scores from male dominant tip, key, and palmar pinch (with standard deviation) were 7.85 ( $\pm$  1.81), 10.19 ( $\pm$  2.16) and 8.19 ( $\pm$  2.28) Kgs. and the average scores of the non dominant side were 7.42 ( $\pm$  1.71), 9.89 ( $\pm$  2.12), and 8.08 ( $\pm$  1.91). The average female dominant tip, key, and palmar pinch strengths (with standard deviation) were 5.23 ( $\pm$  1.18), 6.62 ( $\pm$  1.44), and 5.73 ( $\pm$  1.61) Kgs. The average scores of the non dominant side were 4.95 ( $\pm$  1.15), 6.21 ( $\pm$  1.41), and 5.57 ( $\pm$  1.39). On the average, the difference between male and female tip, key, and palmar pinch strength were 1.54, 2.09 and 1.44 Kgs. On

TABLE 2  
Mean Scores and Standard Deviations on All Test as a function of sex

	X (SD)		p-value*
	Male (n=165)	Female (n=235)	
D-grip	41.96 (6.75)	26.25 (4.72)	0.000
D-T-pinch	7.85 (1.82)	5.23 (1.18)	0.000
D-K-pinch	10.20 (2.17)	6.62 (1.44)	0.000
D-P-pinch	8.19 (2.29)	5.73 (1.61)	0.000
ND-grip	39.76 (6.47)	24.73 (4.51)	0.000
ND-T-pinch	7.42 (1.71)	4.95 (1.15)	0.000
ND-K-pinch	9.89 (2.13)	6.21 (1.41)	0.000
ND-P-pinch	8.08 (1.92)	5.57 (1.39)	0.000

\*unpaired t - test (two - tailed)

the dominant side and 2.47, 3.68 and 2.51 Kgs., on the non dominant side. The ratio of male to female tip, key, and palmar pinch strength were 1.50, 1.54, and 1.43 on the dominant side and 1.24, 1.28 and 1.22 on the non dominant side.

TABLE 3  
Mean Scores and Standard Deviations on all test items as a Function of Sex and Age with Analysis of Variance on Means of test Items.

	10 - 19 (n=19)	20 - 29 (n=66)	X (SD) 30 - 39 (n=44)	40 - 49 (n=14)	50 - 80 (n=22)	p-value*
Male						
D-grip	40.72 (9.84)	42.47 (5.80)	44.28 (5.90)	43.08 (3.29)	36.09 (6.37)	0.0001
D-T-pinch	7.78 (1.97)	7.84 (1.71)	8.11 (1.84)	8.11 (1.54)	7.23 (2.10)	0.4430
D-K-pinch	10.97 (2.69)	10.47 (2.11)	10.39 (1.87)	9.23 (1.32)	8.94 (2.33)	0.0063
D-P-pinch	8.36 (2.21)	8.49 (2.57)	8.25 (2.09)	7.87 (1.48)	7.21 (2.15)	0.2313
ND-grip	38.24 (9.32)	41.18 (5.24)	41.07 (5.63)	40.19 (4.20)	33.94 (6.63)	0.0000
ND-T-pinch	6.82 (1.73)	7.62 (1.59)	7.57 (1.92)	7.71 (1.54)	6.88 (1.62)	0.1863
ND-K-pinch	10.24 (2.54)	10.16 (2.15)	9.99 (1.99)	9.25 (1.67)	8.97 (2.03)	0.1279
ND-P-pinch	8.11 (1.98)	8.34 (1.91)	8.07 (1.91)	8.20 (2.05)	7.25 (1.77)	0.2563

TABLE 4  
Mean Scores and Standard Deviations on all test items as a Function of Sex and Age with Analysis of Variance on Means of test Items.

	10 - 19 (n = 14)	20 - 29 (n = 87)	X (SD) 30 - 39 (n = 51)	40 - 49 (n = 50)	50 - 80 (n = 33)	p-value*
Female						
D-grip	25.04 (4.24)	27.33 (4.36)	27.27 (4.80)	25.98 (5.00)	22.71 (3.47)	0.0000
D-T-pinch	5.37 (0.82)	5.34 (1.06)	5.53 (1.27)	5.17 (1.29)	4.56 (1.10)	0.0041
D-K-pinch	6.15 (0.87)	6.66 (1.47)	6.92 (1.41)	6.91 (1.41)	5.86 (1.42)	0.0042
D-P-pinch	5.83 (1.44)	6.01 (1.57)	6.12 (1.70)	5.71 (1.46)	4.41 (1.21)	0.0000
ND-grip	23.14 (4.08)	25.41 (4.44)	25.61 (4.01)	24.97 (4.93)	21.86 (3.80)	0.0006
ND-T-pinch	4.82 (0.94)	5.03 (1.07)	5.12 (1.18)	5.06 (1.22)	4.39 (1.20)	0.0417
ND-K-pinch	5.78 (0.89)	6.20 (1.43)	6.53 (1.38)	6.40 (1.47)	5.66 (1.38)	0.0407
ND-P-pinch	5.27 (1.10)	5.73 (1.43)	5.85 (1.35)	5.58 (1.37)	4.82 (1.31)	0.0085

### 3. Hand Strength as A Function of Age

In this study, average dominant grip strength of male subject increased from 40.72 Kgs. at 10-19 years age group to a maximum of 44.28 Kgs. at 30-39 years age group and decreased as age increased to a minimum of 33.39 Kgs. at more than 60 years age group. The average non-dominant grip strength in men increased from 38.23 Kgs. at 10-19 years age group to a maximum of 41.17 Kgs. at 20-29 years age group and decreased to a minimum of 31.74 Kgs. at over 60 years age group. Similar results were found in female grip strength analysis, with minimum scores at both extremes and maximum scores within 20-29 and 30-39 years age group.

For tip, key and palmar pinch in both male and female subjects, the same pattern of strength still persisted but there were no significant difference in average strength between each age groups in male subject.

### 4. Hand Strength as A Function of Occupation

Of 400 subjects in this study, there were 127 manual worker, 180 sedentary worker, and 67 housewife.

The average grip and pinch strength of both dominant and nondominant hand in both male and

female subject were unanimously highest among manual worker and lowest among housewife with sedentary worker in between.

## DISCUSSION

The primary purpose of this study is to present clinical norms for Thai adults on four test of hand strength. The literature available on grip and pinch strength statistics in ASEAN is meager and non in Thai population. The data shown here are meant to be used as a reference in evaluation of grip and pinch strength in disabled as caused by disease or trauma.

Awareing that shoulder, elbow, wrist and body position affect hand strength scores. The instruction on joints and body position of the American society of Hand therapists was strictly followed.<sup>5</sup>

Previous studies<sup>1,2,6-10</sup> have established that many factors including handedness, sex, age, height, weight, and occupation influence the hand strength.

Since similar testing devices have not been used a comparison of the absolute values from this investigation with those of others is not possible.

Analysis of the data on the difference between grip and pinch strengths of the dominant and non dominant hands revealed that, on the average the

TABLE 5  
Analysis of Variance on Means of Hand Strength of Different Occupation.

	$\bar{X}$ (SD)			p-value*
	Manual (n = 127)	Sedentary (n = 180)	Housewife (n = 67)	
D-grip	37.18 (9.51)	32.24 (9.16)	24.97 (4.64)	0.000
D-T-pinch	7.18 (2.03)	6.09 (1.76)	4.93 (1.30)	0.000
D-K-pinch	9.08 (2.43)	7.94 (2.40)	6.34 (1.54)	0.000
D-P-pinch	7.60 (2.51)	6.63 (1.91)	5.13 (1.47)	0.000
ND-grip	35.48 (8.78)	30.03 (8.83)	23.89 (4.76)	0.000
ND-T-pinch	6.87 (1.82)	5.78 (1.80)	4.64 (1.13)	0.000
ND-K-pinch	8.82 (2.34)	7.51 (2.48)	5.97 (1.48)	0.000
KD-P-pinch	7.50 (2.04)	6.41 (1.90)	5.15 (1.38)	0.000

\*Analysis of Variance

dominant grip is 5.8 per cent greater than the non dominant and the dominant tip, key and palmar pinch is 5.38, 4.57, 2.07 per cent stronger than the non dominant side. The ratio of dominant to non dominant grip and pinch (tip, key and palmar) strength were 1.05, 1.06, 1.05 and 1.02 respectively.

From a survey of the Canadian Army in World War I it was found that the dominant grip strength was 10 per cent greater than the non dominant. This premise seemed to be different comparing to several other studies<sup>1,2,7</sup> done in caucasian subjects which showed that most of the grip strength different range from 3.2 per cent to 7 per cent (5.8% in our study). The average dominant/non dominant grip strength ratio from those studies were between 1.03 to 1.14 (1.05 in our study). Toews and Patterson had found that in evaluation grip strength and grip loss, the actual reading of the dynamometer was not of first importance. Rather, they agreed that it was the ratio of the dominant hand to the non dominant hand that was the key factor in the evaluation of grip strength or grip loss. In addition, they had found that this ratio probably remained constant, in the absence of injury, over a period of years regardless of a person's occupation.

As would be expected, most previous investigators<sup>5,7,9</sup> had found a sex difference in hand strength; men have more powerful hand strength than women. This was also confirmed in the present investigation. The ratio of male to female grip strength in our study were 1.59 on the dominant and 1.60 on the non dominant side, the average ratio of male to female pinch strength were 1.49 on the dominant and 1.25 on the non dominant side.

TABLE 6

Correlation Coefficient between Hand Strength and Age.

	Correlation coefficient (r) Age (n = 400)	
D-Grip	4 = -0.22	(p = 0.0000)
D-T-Pinch	r = -0.15	(p = 0.0020)
D-K-Pinch	r = -0.19	(p = 0.0001)
D-P-Pinch	r = -0.24	(p = 0.0000)
ND-grip	r = -0.21	(p = 0.0000)
ND-T-pinch	r = -0.12	(p = 0.0132)
ND-K-pinch	r = -0.16	(p = 0.0011)
ND-P-pinch	r = -0.19	(p = 0.0002)

Previous studies<sup>6,7,9</sup> established that there was a relationship between pinch strength and age, and a highly significant correlation between grip strength and age.

Kellor developed normative data based on a linear inverse relationship that is maximal hand strength was achieved at 20 years and decreased with increasing age. The data from our study and others would support a curvilinear relationship, with hand strength peaking somewhere between 20 and 40 years of age and decreasing thereafter. Therefore, use of a linear regression to predict adult hand strength scores needs to be questioned.

In the comparison of hand strength between different occupations, the highest scores of grip and pinch in either hand of both male and female were among manual worker and the lowest scores were among housewife. This finding was quite similar to the study done by Hunter et al.<sup>1</sup>

Some factors that may have effects on the result have been noted in the analysis of the present study. It is not known whether a sample of hand strength of a Siriraj Hospital-Area population (though many of the subjects were from other provinces) is representative of the whole country. Since many of the subjects were volunteers, there is a chance that some who thought they might do well would be more likely to participate than any who thought they might do poorly. This could cause a biased sample in favour of higher hand strength scores. To decrease the chance of this happening, there was an attempt to avoid a competitive atmosphere at the testing sites.

## CONCLUSION

From the study of grip and pinch strength in 400 Thai adults, there was a 5.8 per cent difference in grip strength and 5.38, 4.57, and 2.07 per cent difference in tip, key, and palmar pinch strength between the dominant and non-dominant hand. Male subjects had higher scores of grip and pinch strength than female ones. There was a significant correlation between hand strength and age with the highest strength between 20 and 40 years age group and decreasing thereafter. Manual worker had the highest hand strength and housewife had the lowest with sedentary worker in between.

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