

Pinch Strengths in Healthy Iranian Children and Young Adult Population

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ABSTRACT

Background: Data on the physical strength capabilities are essential for designing safe and usable products and are useful in a wide range of clinical settings especially during treatment of disease affecting the function of the hand. The purpose of this study was to determine peak lateral pinch strength, key pinch strength, tip-to-tip pinch strength and three-jaw pinch strength exertions in a healthy Iranian children and young adult population.

Methods: The study was conducted among 511 participants (242 males and 269 females) aged 7-30 years. Measurements were carried out with both dominant and non-dominant hands in standard sitting posture using a B&L pinch gauge. Two repetitions of each strength measurement were recorded for each condition and the average value of the two trials was used in the subsequent analysis.

Results: The results showed significant differences in the pinch strength data in terms of the age, gender and hand dominance. The lateral pinch strength, key pinch strength, tip-to-tip pinch strength and three-jaw pinch strength exertions by females were 68.4%, 68.8%, 78.8% and 81.8% of those exerted by males, respectively. Strength exertions with the non-dominant hand were 6.4%, 5.2%, 6.6% and 5.1% lower than strength exertions of the dominant hand for the lateral pinch strength, key pinch strength, tip-to-tip pinch strength and three-jaw pinch strength exertions, respectively.

Conclusion: These findings can be used to fill the gaps in strength data for Iranian population.

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Introduction

The human hand is one of the most sophisticated and complex anatomical structures in the body. The human hand is capable of doing extremely fine and sensitive movements and must be able to perform tasks, which require considerable force. To perform such sophisticated functions, the human hand has been equipped with both mechanical and sensory capabilities.¹

The ability to grip and manipulate objects can be considered as one of the most important functions of the hand, and any deterioration in this ability can impair carrying out activities of daily living. Moreover, muscular strength is frequently needed to exert force in the form of handgrip, pinch or torque to operate equipment and controls in different occupational activities.²⁻⁴

Hand strength measurements are performed for various purposes. Hand strength measurements are useful for assessment of different hand functions and capabilities and in a wide range of clinical settings especially during treatment of disease affecting the function of the hand.^{1,5} In addition, data on the physical strength capabilities of users such as grip strength, pinch strength and torque strength are essential for designing the safe and usable products.⁶ This is particularly important since products with poor usability can lead to considerable performance decrements and to stress and frustration among consumers.^{7,8}

In the previous studies, which are, all from western countries, pinch strength differences between genders and between the dominant and non-dominant hand has been reported. However, to our knowledge, there is limited data regarding pinch strength measurements conducted among Iranian population. Therefore, the purpose of this study was to determine the different pinch strength measurements including peak lateral pinch strength, key pinch strength, tip-to-tip pinch strength and three-jaw pinch strength between the dominant and non-dominant hands, between males and females and between different age groups in a healthy children and young adult Iranian population in Iran.

Materials and Methods

The study was conducted among 511 (242 males, 269 females) healthy individuals aged between 7 to 30 years in Tabriz, the capital of the East-Azerbaijan Province, northwest of Iran. The study was conducted during a five-month period from April 2014. Recruitment locations were university buildings, schools, public and private offices and residential homes. Each participant signed a written consent form before participation in the study and was free to withdraw at any stage of the study. The participants were not paid for their participation.

Data collection in the study was based on both interviews with participants and physical pinch strength measurements. Four isometric pinch

strength measurements recorded in this study were: 1) peak lateral pinch strength, 2) key pinch strength, 3) tip-to-tip pinch strength and, 4) three-jaw pinch strength. In addition, the interview was restricted to asking for the date of birth, gender, height, weight and handedness so as not to extend testing time and encourage voluntary participation.

The pinch strength measurements were recorded by a B&L pinch gauge (B&L Engineering, Tustin, CA, USA) with a range of 0–60 lb (0–27 kg). B & L pinch gauge is one of the best products commercially available for measurement of pinch strength⁹ and has been used by a number of previous studies.¹⁰⁻¹⁴ Calibration of the pinch gauge was regularly performed during the study.

The strength measurements were recorded instantaneously and checked visually from the display on the pinch gauge. Measurements followed the standard procedures recommended in the literature. Measurements were performed in a sitting position, with the participant's shoulder flexed forward by about 30°, the upper arm close to the trunk but slightly abducted and the elbow flexed at about 90° and the wrist was in the neutral position. The pinch gauge was held by the experimenter at the distal end to prevent dropping during the test. The participant was asked to exert his maximal voluntary strength (MVC) on the pinch gauge and to hold that force for 3 seconds. Two repetitions of the pinch strength measurement were recorded for each condition and if the two measurements were within 10% of each other, they were considered valid; otherwise, the measurement was repeated.¹⁵ Average value of the two conditions was used in the subsequent analysis. A 2-minute rest break was given between successive MVC measurements.¹⁶

Ethical Considerations

Approval for the study was obtained from the ethical review committee of the Tabriz University of Medical Sciences.

Statistical Analyses

Statistical analysis of the data including summarizing descriptive data was performed using

SPSS software version 17.0 (SPSS Inc., Chicago, IL, USA). Results were reported as mean, standard deviation (SD) and range for men and women for each age group on dominant and non-dominant hands. An independent sample *t*-test was used to evaluate the effect of gender on the pinch strength. The pinch strength comparison between the dominant and non-dominant hand was performed using paired samples *t*-test. An ANOVA test was used for evaluation of the effects of age on the pinch strength. A significance level of $P < 0.05$ was considered for all statistical analyses.

Results

Demographic characteristics of the participants are presented in Table 1. Demographic details were as follows (mean \pm SD): age, $18.4 \pm 0.6.7$ years; weight, 54.6 ± 18.0 kg; height, 157.4 ± 19.5 cm; body mass index, 21.2 ± 3.6 kg/m². Most of the participants were right-handed (93.7%).

The different pinch strength data in terms of gender, age and hand dominance are shown in Tables 2 through 5.

Table 1: Demographic characteristics of the study participants (n = 511)

Variables	
Gender (n (%))	
Male	242 (47.4)
Female	269 (52.6)
Age (years)	
Mean (SD)	18.4 (6.7)
Range	7-30
Weight (kg)	
Mean (SD)	54.6 (18.0)
Range	15-96
Height (cm)	
Mean (SD)	157.4 (19.5)
Range	103-195
BMI (kg/m ²)	
Mean (SD)	21.2 (3.6)
Range	9.9-31.6
Hand dominance (n (%))	
Right	479 (93.7)
Left	32 (6.3)

The results showed that the pinch strength exertions with the dominant hand were significantly higher than those exerted by the non-dominant hand for all types of measurements.

The mean strength values were as follows (mean \pm SD): lateral pinch strength (dominant hand = 7.9 ± 2.9 kg, non-dominant hand = 7.4 ± 2.8 kg; $P < 0.001$); key pinch strength (dominant hand = 7.8 ± 2.9 kg, non-dominant hand = 7.4 ± 2.8 kg; $P < 0.001$); tip-to-tip pinch strength (dominant hand = 4.6 ± 1.6 kg, non-dominant hand = 4.3 ± 1.4 kg; $P < 0.001$); three-jaw pinch strength (dominant hand = 5.9 ± 2.0 kg, non-dominant hand = 5.6 ± 1.9 kg; $P < 0.001$).

The results of the study showed significant differences in the pinch strength exertions between males and females for both dominant and non-dominant hands. For the dominant hand, the results indicated that the mean lateral pinch strength exerted by males (9.5 kg) were significantly higher than those exerted by females (6.5 kg) ($P < 0.001$) (Table 2). The mean key pinch strength (males = 9.3 kg, females = 6.4 kg; $P < 0.001$), tip-to-tip pinch strength (males = 5.2 kg, females = 4.1 kg; $P < 0.001$) and three-jaw pinch strength (males = 6.6 kg, females = 5.4 kg; $P < 0.001$) exertions in males were also significantly higher than in females (Tables 3, 4 and 5). Similarly for the non-dominant hand, males exerted higher lateral pinch strength (males = 9.1 kg, females = 6.1; $P < 0.001$), key pinch strength (males = 8.9 kg, females = 6.0; $P < 0.001$), tip-to-tip pinch strength (males = 4.9 kg, females = 3.8; $P < 0.001$) and three-jaw pinch strength (males = 6.2 kg, females = 5.0; $P < 0.001$) exertions than females.

The results showed significant differences in the mean pinch strength values in terms of the age of the participants ($P < 0.001$). For both the dominant and non-dominant hands, the mean lateral pinch, key pinch, tip-to-tip pinch and three-jaw pinch strengths exerted by the age groups from 16 to 30 years were significantly higher than those exerted by the 7–10 and 11–15 years age groups ($P < 0.001$). No significant differences were found between the age groups from 16 to 30 years.

Table 2: Lateral pinch strength (in kg) by age and gender

Age (yr)	Lateral pinch (kg)											
	Men				Women				All			
	<i>n</i>	Hand*	Mean (SD)	Min-Max	<i>n</i>	Hand*	Mean (SD)	Min-Max	<i>n</i>	Hand*	Mean (SD)	Min-Max
7-10	42	D	4.1 (0.8)	2.5-5.7	48	D	4.0 (0.7)	2.7-5.7	90	D	4.1 (0.7)	2.5-5.7
		ND	3.9 (0.9)	2.5-6.0		ND	3.9 (0.7)	2.7-6.2		ND	3.9 (0.8)	2.5-6.2
11-15	45	D	7.1 (1.1)	4.0-9.0	51	D	6.3 (1.5)	4.0-9.7	96	D	6.7 (1.4)	4.0-9.7
		ND	6.7 (1.0)	4.0-9.2		ND	6.0 (1.3)	3.7-9.0		ND	6.3 (1.2)	3.7-9.2
16-20	50	D	11.1 (1.4)	8.7-15.5	58	D	7.0 (1.1)	5.2-11.2	108	D	8.9 (2.4)	5.2-15.5
		ND	10.4 (1.3)	8.0-13.5		ND	6.6 (1.0)	4.5-8.7		ND	8.4 (2.2)	4.5-13.5
21-25	58	D	11.7 (1.5)	7.2-14.2	59	D	7.0 (1.0)	5.0-9.2	117	D	9.4 (2.6)	5.0-14.2
		ND	11.3 (1.6)	10.0-15.5		ND	6.5 (1.0)	4.7-9.0		ND	8.9 (2.8)	4.7-16.0
26-30	47	D	12.3 (0.7)	10.5-13.7	53	D	7.6 (0.9)	4.7-9.2	100	D	9.8 (2.5)	4.7-13.7
		ND	11.6 (0.9)	10.0-15.5		ND	7.0 (1.0)	3.7-8.7		ND	9.2 (2.5)	3.7-15.5
Total	242	D	9.5 (3.2)	2.5-15.5	269	D	6.5 (1.6)	2.7-11.2	511	D	7.9 (2.9)	2.5-15.5
		ND	9.1 (3.1)	2.5-15.5		ND	6.1 (1.4)	2.7-9.0		ND	7.4 (2.8)	2.5-16.0

* D= Dominant hand; ND= Non-dominant hand

Table 3: Key pinch strength (in kg) by age and gender

Age (yr)	Key pinch (kg)											
	Men				Women				All			
	<i>n</i>	Hand*	Mean (SD)	Min-Max	<i>n</i>	Hand*	Mean (SD)	Min-Max	<i>n</i>	Hand*	Mean (SD)	Min-Max
7-10	42	D	4.0 (0.8)	2.2-5.5	48	D	4.2 (0.8)	2.7-6.2	90	D	4.1 (0.8)	2.2-6.2
		ND	3.9 (0.6)	2.7-5.2		ND	4.0 (0.8)	2.7-6.2		ND	4.0 (0.7)	2.7-6.2
11-15	45	D	7.0 (1.4)	4.2-9.7	51	D	6.4 (1.3)	3.7-9.2	96	D	6.7 (1.4)	3.7-9.7
		ND	6.7 (1.3)	4.2-9.2		ND	6.0 (1.4)	3.7-9.7		ND	6.3 (1.4)	3.7-9.7
16-20	50	D	11.0 (1.3)	7.7-14.5	58	D	7.2 (1.1)	5.0-12.2	108	D	8.9 (2.3)	5.0-14.5
		ND	10.3 (1.3)	7.5-14.0		ND	6.8 (1.2)	4.7-9.7		ND	8.4 (2.1)	4.7-14.0
21-25	58	D	11.5 (1.6)	7.5-14.7	59	D	7.0 (0.9)	4.7-9.0	117	D	9.2 (2.5)	4.7-14.7
		ND	11.4 (1.6)	8.0-15.7		ND	6.6 (1.0)	4.0-9.0		ND	9.0 (2.7)	4.0-15.7
26-30	47	D	12.0 (0.9)	9.5-14.2	53	D	7.1 (0.8)	5.2-8.5	100	D	9.4 (2.6)	5.2-14.2
		ND	11.4 (1.0)	9.2-14.7		ND	6.6 (1.0)	4.2-8.2		ND	8.8 (2.6)	4.2-14.7
Total	242	D	9.3 (3.2)	2.2-14.7	269	D	6.4 (1.5)	2.7-12.2	511	D	7.8 (2.9)	2.2-14.7
		ND	8.9 (3.1)	2.7-15.7		ND	6.0 (1.5)	2.7-9.7		ND	7.4 (2.8)	2.7-15.7

* D= Dominant hand; ND= Non-dominant hand

Table 4: Tip-to-tip pinch strength (in kg) by age and gender

Age (yr)	Tip-to-tip pinch (kg)											
	Men				Women				All			
	<i>n</i>	Hand*	Mean (SD)	Min-Max	<i>n</i>	Hand*	Mean (SD)	Min-Max	<i>n</i>	Hand*	Mean (SD)	Min-Max
7-10	42	D	2.4 (0.5)	1.5-3.7	48	D	2.5 (0.6)	1.2-4.0	90	D	2.5 (0.6)	1.2-4.0
		ND	2.3 (0.5)	1.2-3.7		ND	2.4 (0.6)	1.2-4.2		ND	2.4 (0.6)	1.2-4.2
11-15	45	D	4.9 (1.4)	2.2-7.2	51	D	4.0 (1.1)	2.0-6.2	96	D	4.5 (1.3)	2.0-7.2
		ND	4.8 (1.3)	2.5-7.2		ND	3.8 (1.0)	1.7-6.7		ND	4.2 (1.2)	1.7-7.2
16-20	50	D	5.6 (1.0)	3.5-7.2	58	D	4.7 (1.0)	2.7-6.7	108	D	5.1 (1.1)	2.7-7.2
		ND	5.2 (0.9)	3.5-7.0		ND	4.4 (1.0)	2.7-6.7		ND	4.8 (1.0)	2.7-7.0
21-25	58	D	5.8 (1.2)	3.5-8.2	59	D	4.5 (0.8)	3.0-7.2	117	D	5.1 (1.2)	3.0-8.2
		ND	5.6 (1.2)	3.5-8.0		ND	4.2 (0.7)	2.7-7.0		ND	4.9 (1.2)	2.7-8.0
26-30	47	D	6.7 (1.1)	4.5-8.7	53	D	4.5 (0.7)	2.7-6.5	100	D	5.5 (1.4)	2.7-8.7
		ND	6.2 (1.2)	3.2-9.0		ND	4.2 (0.7)	2.7-6.7		ND	5.1 (1.3)	2.7-9.0
Total	242	D	5.2 (1.7)	1.5-8.7	269	D	4.1 (1.1)	1.2-7.2	511	D	4.6 (1.6)	1.2-8.7
		ND	4.9 (1.6)	1.2-9.0		ND	3.8 (1.1)	1.2-7.0		ND	4.3 (1.4)	1.2-9.0

* D= Dominant hand; ND= Non-dominant hand

Table 5: Three-jaw pinch strength (in kg) by age and gender

Age (yr)	Three-jaw pinch (kg)											
	Men				Women				All			
	<i>n</i>	Hand*	Mean (SD)	Min-Max	<i>n</i>	Hand*	Mean (SD)	Min-Max	<i>n</i>	Hand*	Mean (SD)	Min-Max
7-10	42	D	2.7 (0.6)	1.7-4.2	48	D	3.4 (0.8)	1.7-5.2	90	D	3.1 (0.8)	1.7-5.2
		ND	2.6 (0.6)	1.5-4.0		ND	3.1 (0.7)	1.5-4.7		ND	2.9 (0.7)	1.5-4.7
11-15	45	D	5.5 (1.2)	2.7-8.2	51	D	5.6 (1.6)	3.0-9.7	96	D	5.6 (1.4)	2.7-9.7
		ND	5.3 (1.1)	3.0-7.5		ND	5.2 (1.5)	2.7-9.7		ND	5.2 (1.3)	2.7-9.7
16-20	50	D	7.5 (1.5)	5.0-14.7	58	D	6.0 (1.2)	3.7-9.7	108	D	6.7 (1.6)	3.7-14.7
		ND	7.1 (0.8)	4.7-10.0		ND	5.6 (1.2)	3.5-9.7		ND	6.3 (1.3)	3.5-10.0
21-25	58	D	8.2 (1.7)	4.2-11.5	59	D	6.0 (1.0)	3.5-9.2	117	D	7.1 (1.8)	3.5-11.5
		ND	7.8 (1.4)	4.5-11.0		ND	5.7 (1.0)	4.0-8.2		ND	6.7 (1.6)	4.0-11.0
26-30	47	D	8.2 (1.1)	5.5-11.0	53	D	5.7 (0.7)	4.0-7.0	100	D	6.8 (1.5)	4.0-11.0
		ND	7.4 (1.2)	3.5-10.0		ND	5.1 (0.7)	3.2-7.2		ND	6.2 (1.5)	3.2-10.0
Total	242	D	6.6 (2.4)	1.7-14.7	269	D	5.4 (1.4)	1.7-9.7	511	D	5.9 (2.0)	1.7-14.7
		ND	6.2 (2.1)	1.5-11.0		ND	5.0 (1.4)	1.5-9.7		ND	5.6 (1.9)	1.5-11.0

D= Dominant hand; ND= Non-dominant hand

Discussion

The present study was conducted to determine the effects of gender and handedness on four isometric pinch strength measurements including peak lateral pinch strength, key pinch strength, tip-to-tip pinch strength and three-jaw pinch strength among healthy children and young adults in Tabriz, Iran. The main findings were that for all the strength measurements, the pinch strength exertions by males was significantly higher than those exertions by females and also the strength exertions with the dominant hand was higher than those exerted by the non-dominant hand. Significant differences were also found in terms of the age of the participants so that for both the dominant and non-dominant hands, the pinch strengths exerted by the age groups from 16 to 30 years were significantly higher than those exerted by the 7–10 and 11–15 years age groups.

The results of the present study indicated that for all types of pinch strength measures evaluated in the study, males were significantly stronger than females, which is generally consistent with the findings of previous research.⁶ The lateral pinch strength, key pinch strength, tip-to-tip pinch strength and three-jaw pinch strength exertions by females were 68.4%, 68.8%, 78.8% and 81.8% of those exerted by males, respectively. The muscular strength differences between males and females may be attributed to different factors such as genetic differences in muscle mass or neuromuscular function, culturally related behavioral differences and motivation to perform such trials.¹⁷

With regard to the hand dominance, the difference between the strength capabilities of the dominant and non-dominant hand in this study varied from 5.1% to 6.6%. Pinch strength exertions with the non-dominant hand were 6.4%, 5.2%, 6.6% and 5.1% lower than strength exertions of the dominant hand for the lateral pinch strength, key pinch strength, tip-to-tip pinch strength and three-jaw pinch strength exertions, respectively. This finding is in agreement with previous reports that the strength of the dominant hand is stronger than that of the non-dominant hand.^{18,19}

To our knowledge, this study is one of the first attempts to characterize various pinch strength exertions among the children and young adult population in the northwest of Iran. However, care should be given when applying the findings of this study as the participants in this study may not be the representative of the Iranian population, and thus the findings may not be generalizable to other ethnic groups in Iran. Therefore, further studies considering various ethnic groups in the country are recommended. In addition, further studies testing other strength measurements such as handgrip or torque strength among Iranian population are worth investigating. As there are limited data on strength capabilities of Iranian population, further research in this area can fill the gaps in strength data for Iranian population and can provide valuable information for designers to design the safe and usable products for the community.

Conclusion

The findings of this study provide an insight into the different pinch strength measures and individual strength differences among the population in the northwest of Iran. The pinch strength exertions by males were significantly higher than those exertions by females and the strength exertions with the dominant hand were significantly higher than those exerted by the non-dominant hand for all types of strength measurements. The mean pinch strength exertions by females were between 68.4% and 81.8% of those exerted by males. The mean strength exertions with the non-dominant hand were 5.1% to 6.6% lower than strength exertion of the dominant hand. The pinch strengths exerted by the age groups from 16 to 30 years were also higher than those exerted by the 7–10 and 11–15 years age groups. These additional findings on the pinch strength of the Iranian population can fill the gap in the strength data for Iranians, or used by health and safety practitioners in the field.

Competing interests

The authors declare that there is no conflict of interests.

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