Grip and Pinch Strength: Normative Data for Adults

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ABSTRACT. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S: Grip and pinch strength: normative data for adults. Arch Phys Med Rehabil 66:69-72, 1985.

The primary purpose of this study was to establish clinical norms for adults aged 20 to 75+ years on four tests of hand strength. A dynamometer was used to measure grip strength and a pinch gauge to measure tip, key, and palmar pinch. A sample of 310 male and 328 female adults, ages 20 to 94, from the seven-county Milwaukee area were tested using standardized positioning and instructions. Right hand and left hand data were stratified into 12 age groups for both sexes. This stratification provides a means of comparing the score of individual patients to that of normal subjects of the same age and sex. The highest grip strength scores occurred in the 25 to 39 age groups. For tip, key, and palmar pinch the average scores were relatively stable from 20 to 59 years, with a gradual decline from 60 to 79 years. A high correlation was seen between grip strength and age, but a low to moderate correlation between pinch strength and age. The newer pinch gauge used in this study appears to read higher than that used in a previous normative study. Comparison of the average hand strength of right-handed and left-handed subjects showed only minimal difference.

KEY WORDS: Exercise test; Exertion, Occupational therapy: Physical therapy

Reliable and valid evaluation of hand strength is of paramount importance in determining the effectiveness of various surgical or treatment 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.

The most common norms for grip and pinch strength used in therapy clinics were compiled by Kellor's group, [7] which sampled 250 individuals in three large age groups. Regression analysis was performed to predict the amount of right hand (RH) or left hand (LH) strength an individual of a given sex and particular age would demonstrate. Since few left-handed subjects were tested, their scores were combined with those of right-handed subjects. No standardized positioning or instructions were followed. Test-retest and interrater reliability data were not reported. The Osco pinch meter used in their study is no longer commercially available and there is some question whether data from use of the newer pinch meters can be validly compared to their norms.[17]

Another study[16] established clinical norms for grip strength, employing the Martin Vigormeter, which has a soft handle and has been used clinically with arthritic patients. However, the Jamar dynamometer has been found[3.12] to give the most accurate measure of grip strength.

Schmidt and Toews[14] used the Jamar dynamometer to test grip strength in a large sample, 1128 males (M), 80 females (F). of employee applicants at a manufacturing plant. Although the instructions and positioning were reported to be standardized, description was not sufficient for replication. Unfortunately, as the handles of the dynamometer were coated with a sand-paint mixture and the data were collected in the competitive situation of a pre-job placement interview, generalization from these results is questionable.

Recently. the American Society of Hand Therapists. suggesting a standardized arm positioning for hand strength tests, concluded that the position of the upper extremity (UE) might influence measurements, and recommended that the patient should be seated with his shoulder adducted and neutrally rotated, elbow flexed at 90° and the forearm and wrist in neutral position.[3]

Table 1: Characteristics of Subjects: Age, Sex, and Hand Dominance

	Men				Women			
			Dominance				Dominance	
Age	N	Age (x),	R	L	N	Age (X)	R	L
20-24	29	21.7	26	3	26	22.4	26	0
25-29	27	27.4	21	6	27	26.6	25	2
30-34	27	32.1	24	3	26	32.1	23	3
35-39	25	37.3	24	1	25	36.4	17	8
40-44	26	41.5	22	4	31	42.3	30	1
45-49	28	47.1	28	0	25	47.1	25	0
50-54	25	51.9	25	0	25	51.9	22	3
55-59	21	57.1	21	0	25	56.5	25	0
60-64	24	62.1	22	2	25	62.4	24	1
65-69	27	66.7	27	0	28	67.3	25	3
70-74	26	72.0	23	3	29	71.8	28	1
75+	25	78.9	25	0	26	78.8	25	1
TOTAL	310		288	22	318		295	23

In testing the variable of wrist position, Pryce[13] 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. Kraft and Detels[10] found no significant difference with test positions at 0°, 15°, and 30° dorsiflexion (0° ulnar deviation) in measuring grip strength. Both studies[10.13] found grip strength to be significantly less at 15° of volarflexion.

Mathiowetz and associates[12] 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 Jamar dynamometer and the B&L pinch gauge[b] had the highest calibration accuracy of the instruments tested.[12] No normative data based on these standardized procedures have previously been reported.

The primary purpose of this study was to establish clinical

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Fig 1-Grip strength measurement: This standardized arm and hand positioning was used for all hand strength measurements.

norms for men and women aged 20 to 75+ years for hand strength evaluations based on standardized procedures and instructions.[12] A second purpose was to compare the hand strength of dominant and non-dominant hands.

METHOD

Subjects. The study included 628 volunteers (310 men, 318 women) aged 20 to 94 years. Subjects were interviewed at shopping centers, fairs, senior citizen centers, a rehabilitation center (staff), and a university. All subjects were from the seven-county Milwaukee region, which includes urban, suburban, and rural area. Therefore it was assumed that a broad range of socioeconomic and occupational groups was obtained. Subjects were divided into 12 age groups (table 1) of five-year intervals, except for the 75+ age group. All subjects in the 20 to 59 year groups were free from disease or injury that could affect their UE strength. Subjects 60 years and above had the following less stringent criteria: a) no acute pain in their arms and hands, b) at least 6 months post- hospitalization (heart attack or any surgery), c) subjects continued to carry on a normal lifestyle without restriction in their activity level because of a health problem.[6]

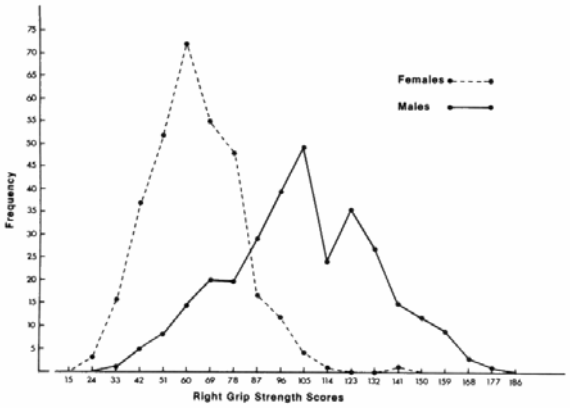

Fig 3--Frequency polygons for male and female, right-grip strength scores.

Procedures. A brief interview preceded all testing, to determine if subjects met the above criteria. This study was part of a larger study which included two dexterity tests: the Nine Hole Peg Test and the Box and Block Test (unpublished data). The hand strength testing followed the dexterity tests.

Grip strength was tested first (fig 1), followed by tip (two-point) pinch, key (lateral) pinch, and palmar (three-jaw chuck) pinch (fig 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,[3] and wrist between 0° and 30° dorsiflexion and between 0° and 15° ulnar deviation.[10.13] For each strength test the scores of three successive trials were recorded for each hand.

Equipment. The standard, adjustable-handle Jamar dynamometer, reported as the most accurate for measuring grip strength,[8.12] was used. For standardization, it was set at the second handle position for all subjects. The dynamometer was lightly held around the readout dial by the examiner to prevent inadvertent dropping.

The B&L pinch gauge, used to measure tip, key, and palmar pinch, was held by the examiner at the distal end to prevent dropping. Scores were read on the needle side of the red readout marker. The calibration of both instruments was tested periodically during the study.

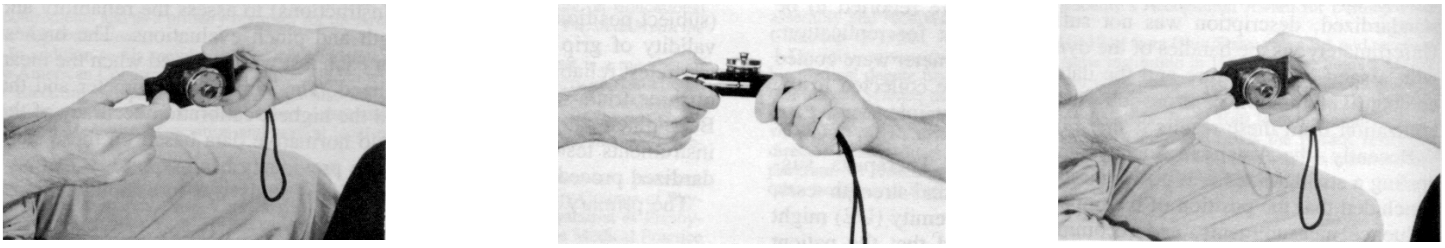

Fig 2 - Tip pinch (left) is thumb tip to index fingertip. Key pinch (center) is thumb pad to lateral aspect of middle phalanx of index finger. Palmar pinch (right) is thumb pad to pads of index and middle fingers.

Table 2: Performance of All Subjects an Grip Strength (pounds)

		Men					Women				
	Hand	Mean	SID	SE	Low	mm	Mean	SID	SE	Low	High
20-24	R	121.0	20.6	3.8	91	167	70.4	14.5	2.8	46	95
	L	104.5	21.8	4.0	71	150	61.0	13.1	2.6	33	88
25-29	R	120.8	23.0	4.4	78	158	74.5	13.9	2.7	48	97
	L	110.5	16.2	3.1	77	139	63.5	12.2	2.4	48	97
30-34	R	121.8	22.4	4.3	70	170	78.7	19.2	3.8	46	137
	L	110.4	21.7	4.2	64	145	68.0	17.7	3.5	36	115
35-39	R	119.7	24.0	4.8	76	176	74.1	10.8	2.2	50	99
	L	112.9	21.7	4.4	73	157	66.3	11.7	2.3	49	91
40-44	R	116.8	20.7	4.1	84	165	70.4	13.5	2.4	38	103
	L	112.8	18.7	3.7	73	157	62.3	13.8	2.5	35	94
45-49	R	109.9	23.0	4.3	65	155	62.2	15.1	3.0	39	100
	L	100.8	22.8	4.3	58	160	56.0	12.7	2.5	37	83
50-54	R	113.6	18.1	3.6	79	151	65.8	11.6	2.3	38	87
	L	101.9	17.0	3.4	70	143	57.3	10.7	2.1	35	76
55-59	R	101.1	26.7	5.8	59	154	57.3	12.5	2.5	33	86
	L	83.2	23.4	5.1	43	128	47.3	11.9	2.4	31	76
60-64	R	89.7	20.4	4.2	51	137	55.1	10.1	2.0	37	77
	L	76.8	20.3	4.1	27	116	45.7	10.1	2.0	29	66
65-69	R	91.1	20.6	4.0	56	131	49.6	9.7	1.8	35	74
	L	76.8	19.8	3.8	43	117	41.0	8.2	1.5	29	63
70-74	R	75.3	21.5	4.2	32	108	49.6	11.7	2.2	33	78
	L	64.8	18.1	3.7	32	93	41.5	10.2	1.9	23	67
75+	R	65.7	21.0	4.2	40	135	42.6	11.0	2.2	25	65
	L	55.0	17.0	3.4	31	119	37.6	8.9	1.7	24	61
All	R	104.3	28.3	1.6	32	176	62.8	17.0	0.96	25	137
Subjects	L	93.1	27.6	1.6	27	160	53.9	15.7	0.88	23	115

Instructions. Standardized instructions described by Mathiowetz and associates[12] were used.

RESULTS

In general, grip strength peaked within the 25 to 39 age group for both men and woman subjects (table 2) and gradually declined thereafter. For tip, key, and palmar pinch (tables 35) the average scores were relatively stable to 55 to 59 years before the gradual decline began. Thus it was not surprising that the inverse relationship between age and hand strength was higher for grip strength than for pinch strength (tables 6,7). In general the highest correlations were achieved between the right and left hand scores for each hand strength test (eg, right grip and left grip).

Data for both sexes (tables 2-5) demonstrated that the right

Table 3: Average Performance of All Subjects on Tip Pinch (pounds)

		Men					Women				
Age	Hand	Mean	SD	SE	Low	High	Mean	SD	SE	Low	High
20-24	R	18.0	3.0	. 57	11	23	11.1	2.1	. 42	8	16
	L	17.0	2.3	. 43	12	33	10.5	1.7	. 34	8	14
25-29	R	18.3	4.4	. 84	10	34	11.9	1.8	. 35	8	16
	L	17.5	5.2	. 99	12	36	11.3	1.8	. 35	9	18
30-34	R	17.6	6.7	. 71	12	25	12.6	3.0	. 58	8	20
	L	17.6	4.8	. 93	10	27	11.7	2.8	. 54	7	17
35-39	R	18.0	3.6	. 73	12	27	11.6	2.5	. 50	8	19
	L	17.7	3.8	. 76	10	24	11.9	2.4	. 47	8	16
40-44	R	17.8	4.0	. 78	11	25	11.5	2.7	. 49	5	15
	L	17.7	3.5	. 68	12	25	11.1	3.0	. 54	6	17
45-49	R	18.7	4.9	. 92	12	30	13.2	3.0	. 60	9	19
	L	17.6	4.1	. 77	12	28	12.1	2.7	. 55	7	18
50-54	R	18.3	4.0	. 80	11	24	12.5	2.2	. 44	9	18
	L	17.8	3.9	. 77	12	26	11.4	2.4	. 49	7	16
55-59	R	16.6	3.3	. 73	11	24	11.7	1.7	. 34	9	16
	L	15.0	3.7	. 81	10	26	10.4	1.4	. 29	8	13
60-64	R	15.8	3.9	. 80	9	22	10.1	2.1	. 43	7	17
	L	15.3	3.7	. 76	9	23	9.9	2.0	. 39	6	15
65-69	R	17.0	4.2	. 81	11	27	10.6	2.0	. 39	7	15
	L	15.4	2.9	. 55	10	21	10.5	2.4	. 45	7	17
70-74	R	13.8	2.6	. 52	11	21	10.1	2.6	. 48	7	15
	L	13.3	2.6	. 51	10	21	9.8	2.3	. 43	6	17
75+	R	14.0	3.4	. 68	7	21	9.6	2.8	. 54	4	16
	L	13.9	3.7	. 75	8	25	9.3	2.4	. 47	4	13
All	R	17.0	4.1	. 23	7	34	11.3	2.6	. 15	4	20
Subjects	L	16.4	4.0	. 23	8	36	10.8	2.4	. 14	4	18

Table 4: Average Performance Of All Subjects and Key Pinch (pounds)

		Mean					Women				
Age	Hand	Mean	SD	SE	Low	High	Mean	SD	SE	Low	High
20-24	R	26.0	3.5	.65	21	34	17.6	2.0	.39	14	23
	L	24.8	3.4	.64	19	31	16.2	2.1	.41	13	23
25-29	R	26.7	4.9	.94	19	41	17.7	2.1	.41	14	22
	L	25.0	4.4	.85	19	39	16.6	2.1	.41	13	22
30-34	R	26.4	4.8	.93	20	36	18.7	3.0	.60	13	25
	L	26.2	5.1	.98	17	36	17.8	3.6	.70	12	26
35-39	R	26.1	3.2	.65	21	32	16.6	2.0	.40	12	21
	L	25.6	3.9	.77	18	32	16.0	2.7	.53	12	22
40--44	R	25.6	2.6	.50	21	31	16.7	3.1	.56	10	24
	L	25.1	4.0	.79	19	31	15.8	3.1	.55	8	22
45-49	R	25.8	3.9	.73	19	35	17.6	3.2	.65	13	24
	L	24.8	4.4	.84	18	42	16.6	2.9	.58	12	24
50-54	R	26.7.	4.4	.88	20	34	16.7	2.5	.50	12	22
	L	26.1	4.2	.84	20	37	16.1	2.7	.53	12	22
55-59	R	24.2	4.2	.92	18	34	15.7	2.5	.50	11	21
	L	23.0	4.7	1.02	13	31	14.7	2.2	.44	12	19
60-64	R	23.2	5.4	1.13	14	37	15.5	2.7	.55	10	20
	L	22.2	4.1	.84	16	33	14.1	2.5	.50	10	19
65--69	R	23.4	3.9	.75	17	32	15.0	2.6	.49	10	21
	L	22.0	3.6	.70	17	28	14.3	2.8	.53	10	20
70-74	R	19.3	2.4	.47	16	25	14.5	2.9	.54	8	22
	L	19.2	3.0	.59	13	28	13.8	3.0	.56	9	22
75+	R	20.5	4.6	.91	9	31	12.6	2.3	.45	8	17
	L	19.1	3.0	.59	13	24	11.4	2.6	.50	7	16
All	R	24.5	4.6	.26	9	41	16.2	3.0	.17	8	25
Subjects	L	23.6	4.6	.26	11	42	15.3	3.1	.18	7	26

hand was stronger than the left hand. However, within specific age groups there were a few exceptions to this. Men were stronger than women on all hand strength tests. For example, figure 3 shows this difference in grip strength; the figure also demonstrates a relatively normal distribution of scores.

Data for right and left hand-dominant subjects analyzed separately (table 7), show little functional difference between the mean scores of right hand-dominant and left hand-dominant subjects. In all cases except for tip and palmar pinch of left hand-dominant women, the mean right hand scores were larger than the mean left hand scores. For these reasons and due to the small percentage (7%) of left hand-dominant subjects the normative data presented in tables 2-6 are the combined scores of right and left hand-dominant subjects.

Table 5: Average Performance of All Subjects on Palmar Pinch (pound)

		Males					Females				
Age	Hand	Mean	SD	SE	Low	High	Mean	SD	SE	Low	High
20-24	R	26.6	5.3	1.03	18	45	17.2	2.3	.45	14	23
	L	25.7	5.8	1.08	15	42	16.3	2.8	.56	11	24
25-29	R	26.0	4.3	.84	19	35	17.7	3.2	.62	13	29
	L	25.1	4.2	.82	19	36	17.0	3.0	.58	13	26
30-34	R	24.7	4.7	.91	16	34	19.3	5.0	.99	12	34
	L	25.4	5.7	1.10	15	37	18.1	4.8	.94	12	32
35-39	R	26.2	4.1	.83	19	36	17.5	4.2	.85	13	29
	L	25.9	5.4	1.17	14	40	17.1	3.4	.69	12	24
40-44	It	24.5	4.3	.85	17	37	17.0	3.1	.56	10	23
	L	24.8	4.9	.96	15	37	16.6	3.5	.63	10	25
45-49	R	24.0	3.3	.63	19	33	17.9	3.0	.60	12	27
	L	23.7	3.8	.71	18	33	17.5	2.8	.57	12	24
50-54	R	23.8	5.4	1.08	15	36	17.3	3.1	.63	12	23
	L	24.0	5.8	1.16	16	36	16.4	2.9	.59	12	22
55-59	R	23.7	4.8	1.06	16	34	16.0	3.1	.63	11	26
	L	21.3	4.5	.99	12	8	15.4	3.0	.61	11	21
60-64	R	21.8	3.3	.67	16	28	14.8	3.1	.61	10	20
	L	21.2	3.2	.65	15	27	14.3	2.7	.54	10	20
65-69	R	21.4	3.0	.58	15	25	14.2	3.1	.59	8	20
	L	21.2	4.1	.80	14	30	13.7	3.4	.64	8	22
70-74	R	18.1	3.4	.67	14	27	14.4	2.6	.48	9	19
	L	18.8	3.3	.65	13	27	14.0	1.9	.35	10	17
75+	R	18.7	4.2	.84	9	26	12.0	2.6	.51	8	17
	L	18.3	3.8	.77	10	26	11.5	2.6	.52	6	16
All	R	23.4	5.0	.28	9	45	16.3	3.8	.21	8	34
subjects	L	23.0	5.3	.30	10	42	15.7	3.6	.20	6	32

Table 6: Correlation Coefficients for All Subjects

Variables	Age	R-grip	L-Grip	R-Tip	L-Tip	R-Key	L-Key	R-Palmar	L-Palmar
Males									
Age	1.00	-.62	-.64	-.32	-.33	-.44	-.45	-.51	-.47
R-Grip		1.00	.89	.49	.47	.58	.59	.57	.56
L-Grip			1.00	.49	.50	.56	.62	.57	.60
R-Tip				1.00	.76	.64	.60	.58	.52
L-Tip					1.00	.66	.71	.48	.58
R-Key						1.00	.85	.65	.61
L-Key							1.00	.57	.68
R-Palmar								1.00	.77
L-Palmar									1.00
Females									
Age	1.00	-.62	-.61	-.27	-.25	-.48	-.46	-.45	-.44
R-Grip		1.00	.90	.47	.44	.63	.63	.57	.55
L-Grip			1.00	.44	.46	.57	.61	.55	.56
R-Tip				1.00	.75	.65	.63	.56	.53
L-Tip					1.00	.58	.66	.50	.60
R-Key						1.00	.83	.68	.63
L-Key							1.00	.63	.69
R-Palmar								1.00	.81
L-Palmar									1.00

DISCUSSION

When the results of this study are compared to those of a similar study by Kellor's group,[7] several observations can be made. Grip strength (right and left hands) of males improved in 14/24 age groups while grip strength of women improved in 21/24 age groups. Overall the male scores are similar to those in Kellor's study but female scores have improved especially in the 20 to 54-year group. It might be speculated that the hand strength of women may have increased as a result of changing sex roles in our society. However, further investigation is needed to resolve this question.

The scores for tip, key, and palmar pinch improved in this study at all M and F age groups when compared to Kellor's report. It may be speculated that both M and F pinch strength has increased since 1971; yet if this were true, a similar increase in grip strength would also be expected. Since this did not occur, Trombly's speculation[17] that the newer pinch gauge used in this study reads higher than the Osco pinch meter used in Kellor's study, appears to be supported. It is speculated that the improved M and F pinch strength scores of this study are more related to test instrument differences than to actual improved pinch strength scores. If this is true, therapists using the newer pinch gauge should not use Kellor's normative data to interpret test results.

Previous studies[5.7.9.14] have established that there is a relationship between hand strength and age. This was confirmed in our present study, especially for grip strength. 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[1.2.4.5.9] would support a curvilinear relationship, with hand strength peaking somewhere between 25 and 50 years of age and decreasing thereafter. Therefore. use of a linear regression to predict adult hand strength scores needs to be questioned.

Some previous studies[11.15.16] presented their data on hand dominance as major/minor hand or dominant/non-dominant hand. Other studies[4.7] ignored the issue of hand dominance, due to the small percentage (less that 10% of their sample) of LH subjects and combined their data with RH subjects. Our present study would appear to support the latter approach because in 6/8 tests (table 7) the mean RH strength score of LH-dominant subjects was higher than their left. With these hand strength tests and with the method used to determine hand dominance

Table 7: Comparison of Right Hand-Dominant and Left Hand Dominant Subjects: Four Tests of Hand Strength, pounds

Males

Right band Dominant (n = 288), Left band dominant (n = 22)

Hand	Ted	Dominance	Mean	SD	SE
R	Grip	R	104.4	28.4	1.67
		L	103.3	28.6	6.09
L	Grip	R	92.5	27.3	1.61
		L	99.9	31.2	6.65
R	Tip pinch	R	17.0	4.1	.24
		L	17.1	3.3	.70
L	Tip pinch	R	16.3	4.0	.24
		L	16.8	3.9	.94
R	Key pinch	R	24.6	4.7	.28
		L	23.8	3.7	.78
L	Key pinch	R	23.7	4.7	.27
		L	22.9	4.1	.88
R	Palmar pinch	R	23.4	5.1	.30
		L	22.9	4.0	.95
L	Palmar pinch	R	23.1	5.3	.31
		L	22.4	4.2	.91

Females

Right band dominant (a 2"). Left band dominant (a = 23)

Hand	Ted	Dominance	Maw	SD	SE
R	Grip	R	62.7	17.1	1.00
		L	63.3	16.4	3.43
L	Grip	R	53.8	15.6	.91
		L	55.8	17.4	3.63
P.	Tip pinch	R	11.4	2.6	.15
		L	11.2	2.5	.52
L	Tip pinch	R	10.7	2.5	.14
		L	11.7	1.9	.38
R	Key pinch	R	16.3	3.1	.19
		L	15.8	3.2	45
L	Key pinch	R	15.)	3.2	.19
		L	15.1	2.5	.52
R	Palmar pinch	R	16.3	3.8	.22
		L	15.7	3.5	.73
L	Palmar pinch	R	15.7	3.6	.21
		L	15.7	3.1	.65

in this study, the approach of combining scares of RH and LH subjects would appear justified. The relatively small difference between RH and LH scores suggests that some subjects will do better with their LH, even when reported to be right-handed.

Some limitations have been noted in the analysis of the present report It is not known whether a sample of hand strength of a Milwaukee-area population is representative of the whole country. Due to time and money constraints, our subjects were not selected randomly. Since all were volunteers, there is a chance that sonic 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 favor of higher hand strength scores. There was an attempt to avoid a competitive atmosphere at the testing sites, to decrease the chance of this happening. While testing tip pinch for this study, some subjects with long fingernails had difficulty assuming the recommended positioning (fig 2). while others had difficulty maintaining the position as they were pinching (index finger or thumb would hyperextend and/or slip off the meter). When these problems were encountered, subjects were tested as close to the recommended positioning as possible. Recently the standard Jamar dynamometer has been slightly modified (calibration screw moved to the center of the readout dial). Although not anticipated to affect scores, this needs to be verified by further research.

CONCLUSIONS

To improve the reliability and validity of hand strength evaluations the following recommendations are made: (1) Standardized positioning and instruction should be followed; (2) the average of three trials should be used. (3) the dynamometer and pinch gauge described should be used for data collection; (4) scores obtained should be compared to the appropriate age and sex categories for interpretation; (5) the calibration of the dynamometer and pinch gauges should be checked regularly; (6) the same test instrument should be used for pre- and post-testing.

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Suppliers

a. Jamar dynamometer. Asimov Engineering Co.. Los Angeles. CA 90024

b. B&L pinch gauge. B&L Engineering, Tustin. CA 92780 (714) 505-9492