

NORMAL GRIP STRENGTH

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The normal grip strength was determined with the Martin Vigorimeter in 450 men and women aged 21–65 years. The grip strength decreased steadily with increasing age. Men were stronger than women and in both sexes the dominant hand was the strongest. The ratio dominant/non-dominant hand varied only slightly with age and sex and it could thus be a useful parameter in evaluation of grip strength under pathological conditions.

Key words: grip; hand; strength

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A diminished grasping force in the hand is often seen after injury. To determine this is one way of establishing the degree of invalidity. Determinations can be made pre-operatively and postoperatively to assess the results of surgery in the arm and hand. Various methods have been developed to determine the grip strength using a number of mechanical and electrical devices (Hunsicker & Donnelly 1955, Wright 1959, Fünfgeld 1966, Hallén et al. 1966, Mannerfelt 1966, Schmidt & Toews 1970, Brewer et al. 1975, Heyward et al. 1975).

Most previous studies have involved groups isolated according to age, sex or vocation, such as college students or steel workers (Kjerland 1953, Pierson & O'Connell 1962, Anderson & Cowan 1966, Klimt 1969, Schmidt & Toews 1970, Kellor et al. 1971, Heyward et al. 1975, Nwuga 1975).

The aim of the present investigation was to determine the normal grip strength in an unselected population of adults over a wide age range. These determinations may constitute a basis for future comparison with pathologic conditions.

PATIENTS AND METHODS

The investigation included 450 probands (225 men and 225 women) aged 21–65 years. For each 5-year interval (21–25, 26–30 etc) 25 men and 25 women were investigated. They were randomly selected from among ambulatory patients, relatives to patients, and personnel at the Orthopaedic Clinic, University Hospital of Lund, without a history of trauma or pain in the upper extremity, and they thus represented various occupations. To determine the variations in grip strength on different occasions 10 men and 13 women were investigated on three different occasions at intervals of some weeks.

The Martin Vigorimeter (Gebrüder Martin, Tuttlingen, Germany), which was used, is a dynamometer with a rubber balloon which is compressed in the hand. The air-pressure within the balloon is registered in kilopond per square centimetre ($1 \text{ kp/cm}^2 = 98.1 \text{ kPa}$) on a manometer via a rubber tube connection. Three sizes of balloons are available (diameter 4, 5 and 6 cm) and in the present study the large balloon was used for men and the medium one for women.

Three consecutive determinations were performed alternating the dominant with the non-dominant hand. The proband was sitting with the elbow flexed 30° and instructed to exert maximal pressure on the balloon after having applied a comfortable grip around the balloon with the con-

nection tube coming out between the thumb and the index finger. The mean of three values for each hand was determined and the ratio dominant/non-dominant hand was calculated.

RESULTS

In general the grip strength decreased with increasing age (Figure 1, Tables 1 and 2). The values were generally higher in the dominant hand. Men were stronger than women for each age interval.

The overall ratio dominant/non-dominant hand was 1.07 ± 0.11 with little variation with age or between sexes (Tables 1 and 2).

The grip strength on different occasions showed highly significant ($P < 0.001$) differences in absolute values both in men and women (Table 3). There was no significant interaction between occasion and hand, i.e. the same hand was the strongest on the different occasions.

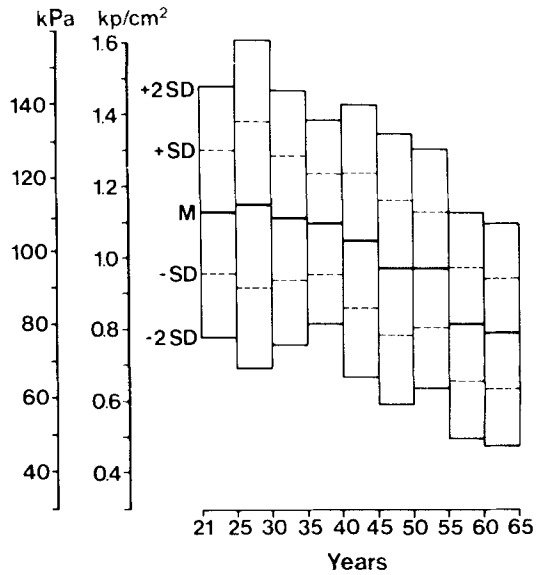


Figure 1. Grip strength of the dominant hand in normal men of various ages. $1 \text{ kp/cm}^2 = 98.1 \text{ kPa}$. M = mean value. SD = standard deviation. Each value based on 25 determinations.

Table 1. Grip strength in normal men and women of various ages for the dominant hand (DH) in kp/cm^2 and the ratio dominant hand/non-dominant hand (DH/NDH). Each value is based on 25 determinations. Statistical analysis of males vs. females (Student's t -test, one tailed). The mean value for the non-dominant hand (NDH) can be calculated from the values of DH and the ratio. The NDH showed the same sex difference and standard deviation as the DH values

Age	Men		Women	
	DH	DH/NDH	DH	DH/NDH
21 – 25	1.13 ± 0.18	1.07 ± 0.08	$1.03 \pm 0.16^*$	$1.10 \pm 0.12 \text{ NS}$
26 – 30	1.16 ± 0.23	1.05 ± 0.08	$0.96 \pm 0.16^{***}$	$1.10 \pm 0.08^*$
31 – 35	1.12 ± 0.17	1.06 ± 0.08	$0.95 \pm 0.17^{***}$	$1.07 \pm 0.14 \text{ NS}$
36 – 40	1.10 ± 0.18	1.07 ± 0.10	$0.95 \pm 0.19^{**}$	$1.06 \pm 0.15 \text{ NS}$
41 – 45	1.06 ± 0.14	1.05 ± 0.10	$0.90 \pm 0.19^{***}$	$1.09 \pm 0.12 \text{ NS}$
46 – 50	0.97 ± 0.19	1.03 ± 0.08	$0.82 \pm 0.22^{**}$	$1.06 \pm 0.17 \text{ NS}$
51 – 55	0.97 ± 0.17	1.05 ± 0.10	$0.79 \pm 0.18^{***}$	$1.12 \pm 0.11^*$
56 – 60	0.81 ± 0.16	1.09 ± 0.13	$0.74 \pm 0.17 \text{ NS}$	$1.05 \pm 0.14 \text{ NS}$
61 – 65	0.79 ± 0.16	1.06 ± 0.16	$0.66 \pm 0.18^{**}$	$1.09 \pm 0.13 \text{ NS}$

Values = means \pm standard deviations

*** $P < 0.001$

** $0.001 < P < 0.01$

* $0.01 < P < 0.05$

NS $P > 0.05$

Table 2. Regression analysis of grip strength in normal men and women. Grip strength in kp/cm^2 (y) for various ages (x) of dominant hand (DH), non-dominant hand (NDH) and ratio DH/NDH. Correlation coefficient (r) and its significance

Men	DH	$y = -9.5 \cdot 10^{-3} x + 1.43$	$r = -0.571^{***}$
	NDH	$y = -9.1 \cdot 10^{-3} x + 1.35$	$r = -0.547^{***}$
	DH/NDH	$y = 1.6 \cdot 10^{-4} x + 1.05$	$r = 0.020^{\text{NS}}$
Women	DH	$y = -8.9 \cdot 10^{-3} x + 1.25$	$r = -0.549^{***}$
	NDH	$y = -8.0 \cdot 10^{-3} x + 1.16$	$r = -0.507^{***}$
	DH/NDH	$y = -4.5 \cdot 10^{-4} x + 1.10$	$r = -0.045^{\text{NS}}$

*** $P < 0.001$

NS $P > 0.05$

Table 3. Analysis of variance for values of grip strength ($100 \text{ kp}/\text{cm}^2$) determined in normal men on different occasions. (Similar significance of F was found in the tested women)

Source of variation		Sum of squares	DF	Men square	F
Main effects					
Occasion		690	2	345.4	38.65***
Hand		1126	1	1126.6	126.09***
Proband		6125	9	680.5	76.16***
2-way interactions					
Occasion	hand	5	2	2.9	0.32 ^{NS}
Occasion	proband	2792	18	155.1	17.36***
Hand	proband	656	9	72.9	8.16***
Residual		160	18	8.9	
Total		11,558	59	195.9	

*** $P < 0.001$

NS $P > 0.05$

Table 4. Analysis of variance for the ratio of values in per cent (dominant hand/non-dominant hand) of grip strength determined in normal men on different occasions. (Similar significance of F was found in the tested women)

Source of variation		Sum of squares	DF	Men square	F
Main effects					
Occasion		3	2	1.6	0.10 ^{NS}
Proband		1164	9	129.3	8.42***
Residual		276	18	15.3	
Total		1444	29	49.7	

*** $P < 0.001$

NS $P > 0.05$

The ratio dominant/non-dominant hand did not show any significant difference when tested sequentially with an interval of some weeks (Table 4).

DISCUSSION

The data shown here are meant to be used as a reference in evaluation of grip strength disabled because of disease or trauma.

It is well known that the grip strength decreases with increasing age (Kjerland 1953, Anderson & Cowan 1966, Schmidt & Toews 1970, Kellor et al. 1971), and that it is correlated with body weight and height (Pierson & O'Connell 1962, Anderson & Cowan 1966, Schmidt & Toews 1970, Petrofsky & Lind 1975).

This investigation showed age-correlated values for both men and women drawn from the general population, with the determinations performed as is usual in everyday clinical practice.

Since similar testing devices have not been used, a comparison of the absolute values from this investigation with those of others (Kjerland 1953, Wright 1959, Pierson & O'Connell 1962, Anderson & Cowan 1966, Schmidt & Toews 1970, Kellor et al. 1971, Heyward et al. 1975, Nwuga 1975) is not possible.

Most previous investigators have found a sex difference in grip strength; men have more powerful handgrips than women (Kjerland 1953, Anderson & Cowan 1966, Kellor et al. 1971, Nwuga 1975). This was confirmed in the present investigation. The difference is actually even greater than registered due to the difference in balloon size used for the two sexes. A small balloon, such as that used in testing women, gives higher values (Fünfgeld 1966).

In agreement with Schmidt & Toews (1970), who tested men, the dominant hand was generally found to be the strongest. They found the dominant hand to be stronger by a factor dominant/non-dominant hand of 1.03,

which is in accordance with the ratio 1.07 ± 0.11 observed in the present investigation.

Diurnal and day-to-day variations which influence the grip strength have previously been reported by Cousins (1955), Wright (1959), Lee et al. (1974), Rikli (1974). Such variations, however, are diminished when the ratio of the value for the two hands is calculated.

The ratio value was thus found to be a stable parameter, showing little difference for the various age groups both in men and women. Also when tested on various occasions no significant differences were found. Thus the ratio of the dominant hand over the non-dominant hand is an accurate means of evaluating grip strength.

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