HAND GRIP PRESSURE IN OLDER PEOPLE

BY

W. F. ANDERSON AND N. R. COWAN

Consultative Health Centre for Older People, Rutherglen, Lanarkshire

It is postulated that grip strength is of value in estimating progress after illness, that it can aid in the seeking out of early pathological processes involving the related musculature, and that it is of use in the assessment of certain generalized diseases, for example, the myopathy associated with neoplasm and thyrotoxicosis. However, there is a clear lack of information concerning "normal" grip strength in older persons and its use in geriatric practice. Grip strength has been considered in the past mainly in terms of age and zero order correlation, with inadequacy of numbers in older ages (Ruger and Stoessiger, 1927; Elderton and Moul, 1928; Fisher and Birren, 1947). Burke, Tuttle, Thompson, Janney, and Weber (1953), with only 27 subjects in the age range 60-79 years, state that the average grip strength of males at 79 years is 32.2 kg. and that this is about the same as that at age 12 to 15 years. This paper has therefore a two-fold purpose: to provide standards of hand grip pressure for healthy older people at given weight and age, and thereby to encourage the routine measurement of grip strength in geriatric practice.

METHODS

The data relate to 362 men and 394 women seen at the Rutherglen Consultative Health Centre for Older People (Anderson and Cowan, 1955). All

were considered to be in good health after a detailed clinical examination, which included ophthalmoscopic examination and where necessary electrocardiographic assessment. In particular, hand injuries, left-handedness, a haemoglobin level under 11 g. Sahli, or an apical systolic murmur louder than Grade 2 as described by Levine and Harvey (1949) excluded people from this series.

The hand grip pressure was measured with a "Meredith" dynamometer. Each individual was permitted three tries with each hand and the highest reading is the one recorded.

Body weight was measured with men and women wearing a minimum of clothing and no footwear. The weighing machine was of the Steelyard platform type reading accurately to 85 g.

RESULTS

Table I shows that men have more powerful hand grips than women. The average hand grip pressures of men and women differ significantly for both hands (*Right hand*: mean difference = 9.2 kg.; $s = 0.333912$; $t' = 27.4$; 5 per cent. level = 1.96. *Left hand*: mean difference = 9.1 kg.; $s = 0.329895$; $t' = 27.5$; 5 per cent. level = 1.96). The test of significance used for these mean differences required to take account of the significant differences between the standard

TABLE I

MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION OF THE SEVERAL VARIABLES, BY SEX

Variable		Sex	Mean $\pm$ S.E.	Standard Deviation	Coefficient of Variation
Hand Grip Pressure (kg.)	Right ..	Male	39.5 $\pm$ 0.28	5.4	13.7
		Female	30.3 $\pm$ 0.18	3.6	11.9
	Left ..	Male	37.5 $\pm$ 0.28	5.3	14.1
		Female	28.4 $\pm$ 0.18	3.6	12.6
Body weight (kg.)		Male	63.0 $\pm$ 0.49	9.4	14.9
		Female	61.6 $\pm$ 0.62	12.4	20.1
Age (completed years)		Male	72.4 $\pm$ 0.32	6.9	9.5
		Female	70.1 $\pm$ 0.35	6.9	9.8

deviations of hand grip pressures by sex. The standard deviations are greater in men than women (*Right hand*: $F=2.15$; $P<0.001$. *Left hand*: $F=2.05$; $P<0.001$).

The correlation Tables II and III show the relationship between the right hand grip pressure and log weight for men and women respectively. The corresponding correlation data for the left hand grip pressure follow a similar trend*. The distributions of hand grip pressures are not significantly skew (*Right hand*: men $t=1.26$; women $t=1.35$. *Left hand*: men $t=1.44$; women $t=0.56$) or kurtotic (*Right hand*: men $t=-0.68$; women $t=-0.37$).

Left hand: men $t=-0.48$; women $t=-0.21$). The distributions of body weight depart significantly from "normality". They are significantly skew (men $t=2.74$; women $t=3.24$) but are not significantly kurtotic (men $t=-0.65$; women $t=0.81$). However, a logarithmic transformation of body weight data shows no significant departure from "normality" with regard to skewness (men $t=0.08$; women $t=-0.97$) or kurtosis (men $t=-1.42$; women $t=-0.50$). The 0.01 level of significance is $t=2.5758$. Consequently, a logarithmic transformation of body weight data is used in this analysis.

* The further correlation tables may be obtained from the authors.

TABLE II
DISTRIBUTION OF RIGHT HAND GRIP PRESSURE (kg.) AND BODY WEIGHT (log kg.) FOR MEN

Hand Grip Pressure	Log Weight										Total
	1.6000-	1.6400-	1.6800-	1.7200-	1.7600-	1.8000-	1.8400-	1.8800-	1.9200-	1.9600-1.9999	
22-				1							1
26-			2	3	3	1					9
30-	1	4	11	11	12	7	4				50
34-		2	12	10	20	18	13	1			76
38-		3	14	16	25	25	22	12			117
42-			1	6	12	13	17	8	5		62
46-				4	10	9	9	4	2	1	39
50-						1	3	2	1		7
54-57									1		1
Total	1	9	40	51	82	74	68	27	9	1	362

TABLE III
DISTRIBUTION OF RIGHT HAND GRIP PRESSURE (kg.) AND BODY WEIGHT (log kg.) FOR WOMEN

Hand Grip Pressure	Log Weight							Total
	1.5200-	1.6000-	1.6800-	1.7600-	1.8400-	1.9200-	2.0000-2.7999	
20-			2					2
22-	1	1	4	4	2			12
24-		7	8	7	4	2	1	29
26-	3	7	19	16	12	2		59
28-	2	11	24	29	20	4		90
30-	1	4	11	34	24	5		79
32-		3	9	22	17	9	2	62
34-		1	7	16	11	3		38
36-			4	7	4			15
38-			1	3	2			6
40-41				2				2
Total	7	34	89	140	96	25	3	394

The data of Table II indicate that the regression of right hand grip pressure on body weight for men is linear as follows:

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	361	10612.6	
Weights	9	2150.9	
Individuals in Weight Groups (error) ..	352	8461.7	24.04
Weights	9	2150.9	
Linear Deviation ..	1	1968.7	
Deviations from Linear Regression	8	182.2	22.77

$F=0.95$

The regression involving these two variables is linear also for the left hand of men. This linearity of regression is doubtless related to the absence of obese men in this study. None were 25 per cent. or more over ideal weight as estimated from Anderson's nomogram (1948). Of the 394 women, 108 were 25 per cent. or more over ideal weight. It may be as expected, therefore, that women show a significant departure from linear regression of hand grip pressures on body weight as shown in Table IV (below).

The regression of hand grip pressure (Y) on log weight (X_1) and age (X_2) is assumed to be for men of the form

$$\hat{Y} = a X_1 + b X_2 + c$$

and for women of the form

$$\hat{Y} = a X_1 + b X_1^2 + c X_2 + d$$

where a , b , c , and d are constants determined by the method of least squares.

The data give regressions whose equations are:

$$\begin{aligned} \text{MEN} \quad \text{Right} \quad Y &= 32.945028 X_1 - 0.32700776 X_2 + 3.953282 \\ \text{Left} \quad Y &= 33.905594 X_1 - 0.31281065 X_2 - 0.824648 \\ \text{WOMEN} \quad \text{Right} \quad Y &= 146.988935 X_1 - 39.728208 X_1^2 - 0.1990848 X_2 - 91.23304 \\ \text{Left} \quad Y &= 179.298176 X_1 - 48.448874 X_1^2 - 0.2181515 X_2 - 121.48802 \end{aligned}$$

where Y = hand grip pressure (kg.), X_1 = body weight (log kg.), and X_2 = age (completed years).

The standard deviations of the observed values of hand grip pressures from the regressions given above are:

$$\begin{aligned} \text{MEN} \quad \text{Right} \quad S_{Y,12} &= 4.354327 \text{ kg.} \\ \text{Left} \quad S_{Y,12} &= 4.176685 \text{ kg.} \end{aligned}$$

$$\begin{aligned} \text{WOMEN} \quad \text{Right} \quad S_{Y,123} &= 3.227979 \text{ kg.} \\ \text{Left} \quad S_{Y,123} &= 3.126425 \text{ kg.} \end{aligned}$$

The coefficients of X_1 and X_2 for men and of X_1 , X_1^2 , and X_2 for women are highly significantly different from zero ($P < 0.01$ for all coefficients).

Tables V to VIII show for men and women the means and first and ninety-ninth percentiles of hand grip pressure in terms of body weight and age.

The "multipliers" used in the significance tests and to calculate the confidence interval estimates on the regressions of hand grip pressures are:

$$\begin{aligned} \text{MEN} \quad c_{11} &= 0.63690338 \\ c_{22} &= 0.000057420133 \\ c_{12} &= 0.00042432324 \end{aligned}$$

$$\begin{aligned} \text{WOMEN} \quad c_{11} &= 277.431399 \\ c_{22} &= 21.7472025 \\ c_{33} &= 0.000059668217 \\ c_{12} &= -77.6105748 \\ c_{13} &= 0.0091223216 \\ c_{23} &= -0.0021262042 \end{aligned}$$

TABLE IV
FINDINGS IN WOMEN

Hand	Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Right ($F=8.37$)	Deviations from linear regression ..	392	4829.2	
	Deviations from curved regression ..	391	4728.0	12.09
	Curvilinearity of regression	1	101.2	101.20
Left ($F=12.38$)	Deviations from linear regression ..	392	4755.6	
	Deviations from curved regression ..	391	4609.6	11.79
	Curvilinearity of regression	1	146.0	146.00

TABLE V
MEANS AND PERCENTILES OF RIGHT HAND GRIP PRESSURE (kg.) FOR MEN, IN TERMS OF
BODY WEIGHT AND AGE

Body Weight (log kg.)	Percentile and Mean	Age (yrs)									
		60-	63-	66-	69-	72-	75-	78-	81-	84-	87-89
1·5800-	1st	34·4	33·5	32·6	31·7	30·8	29·8	28·7	27·7	26·6	25·5
	Mean	36·6	35·6	34·6	33·6	32·6	31·6	30·7	29·7	28·7	27·7
	99th	38·7	37·6	36·5	35·5	34·5	33·5	32·6	31·7	30·8	30·0
1·6200-	1st	36·0	35·2	34·3	33·4	32·4	31·4	30·4	29·3	28·2	27·0
	Mean	37·9	36·9	35·9	34·9	33·9	33·0	32·0	31·0	30·0	29·0
	99th	39·7	38·6	37·5	36·5	35·5	34·5	33·6	32·7	31·9	31·0
1·6600-	1st	37·6	36·8	35·9	35·0	34·1	33·0	32·0	30·9	29·7	28·6
	Mean	39·2	38·2	37·2	36·2	35·3	34·3	33·3	32·3	31·3	30·4
	99th	40·8	39·6	38·5	37·5	36·5	35·5	34·6	33·8	33·0	32·2
1·7000-	1st	39·2	38·3	37·5	36·6	35·6	34·6	33·5	32·4	31·3	30·1
	Mean	40·5	39·5	38·5	37·6	36·6	35·6	34·6	33·6	32·7	31·7
	99th	41·8	40·7	39·6	38·5	37·5	36·6	35·7	34·9	34·1	33·3
1·7400-	1st	40·6	39·8	39·0	38·2	37·2	36·1	35·0	33·9	32·7	31·5
	Mean	41·8	40·8	39·9	38·9	37·9	36·9	35·9	35·0	34·0	33·0
	99th	43·0	41·8	40·7	39·6	38·6	37·7	36·8	36·0	35·3	34·5
1·7800-	1st	42·0	41·3	40·4	39·6	38·6	37·5	36·4	35·2	34·0	32·8
	Mean	43·1	42·2	41·2	40·2	39·2	38·2	37·3	36·3	35·3	34·3
	99th	44·2	43·1	41·9	40·8	39·8	38·9	38·1	37·3	36·6	35·8
1·8200-	1st	43·3	42·5	41·7	40·8	39·8	38·8	37·6	36·5	35·3	34·1
	Mean	44·5	43·5	42·5	41·5	40·5	39·6	38·6	37·6	36·6	35·6
	99th	45·6	44·4	43·3	42·2	41·2	40·4	39·5	38·7	38·0	37·2
1·8600-	1st	44·5	43·7	42·8	41·9	40·9	39·8	38·7	37·6	36·4	35·2
	Mean	45·8	44·8	43·8	42·8	41·8	40·9	39·9	38·9	37·9	37·0
	99th	47·1	45·9	44·8	43·8	42·8	41·9	41·1	40·2	39·4	38·7
1·9000-	1st	45·6	44·7	43·8	42·9	41·9	40·9	39·8	38·7	37·5	36·4
	Mean	47·1	46·1	45·1	44·1	43·2	42·2	41·2	40·2	39·2	38·3
	99th	48·6	47·5	46·4	45·4	44·4	43·5	42·6	41·8	41·0	40·2
1·9400- -1·9799	1st	46·6	45·8	44·8	43·9	42·9	41·9	40·8	39·7	38·6	37·5
	Mean	48·4	47·4	46·4	45·5	44·5	43·5	42·5	41·6	40·6	39·6
	99th	50·2	49·1	48·1	47·1	46·1	45·1	44·2	43·4	42·5	41·7

TABLE VI
MEANS AND PERCENTILES OF LEFT HAND GRIP PRESSURE (kg.) FOR MEN, IN TERMS OF
BODY WEIGHT AND AGE

Body Weight (log kg.)	Percentile and Mean	Age (yrs)									
		60-	63-	66-	69-	72-	75-	78-	81-	84-	87-89
1·5800-	1st	32·1	31·3	30·4	29·5	28·6	27·7	26·7	25·7	24·6	23·6
	Mean	34·2	33·3	32·3	31·4	30·4	29·5	28·6	27·6	26·7	25·7
	99th	36·3	35·2	34·2	33·2	32·2	31·3	30·4	29·5	28·7	27·9
1·6200-	1st	33·8	33·0	32·1	31·2	30·3	29·3	28·4	27·3	26·3	25·2
	Mean	35·5	34·6	33·7	32·7	31·8	30·8	29·9	29·0	28·0	27·1
	99th	37·3	36·2	35·2	34·2	33·3	32·3	31·5	30·6	29·8	29·0
1·6600-	1st	35·4	34·6	33·7	32·9	32·0	31·0	30·0	29·0	27·9	26·7
	Mean	36·9	36·0	35·0	34·1	33·1	32·2	31·3	30·3	29·4	28·4
	99th	38·4	37·4	36·3	35·3	34·3	33·4	32·6	31·7	30·9	30·2
1·7000-	1st	37·0	36·2	35·4	34·5	33·6	32·6	31·6	30·5	29·4	28·2
	Mean	38·3	37·3	36·4	35·4	34·5	33·6	32·6	31·7	30·7	29·8
	99th	39·6	38·4	37·4	36·3	35·4	34·5	33·6	32·9	32·1	31·4
1·7400-	1st	38·5	37·7	36·9	36·1	35·2	34·2	33·1	32·0	30·9	29·7
	Mean	39·6	38·7	37·7	36·8	35·9	34·9	34·0	33·0	32·1	31·2
	99th	40·7	39·6	38·5	37·5	36·5	35·7	34·9	34·1	33·3	32·6

continued

Table VI, continued

Body Weight (log kg.)	Percentile and Mean	Age (yrs)									
		60-	63-	66-	69-	72-	75-	78-	81-	84-	87-89
1·7800-	1st Mean 99th	39·9	39·2	38·4	37·5	36·6	35·6	34·5	33·4	32·2	31·0
		41·0	40·0	39·1	38·1	37·2	36·3	35·3	34·4	33·5	32·5
		42·0	40·9	39·8	38·7	37·8	36·9	36·1	35·4	34·7	34·1
1·8200-	1st Mean 99th	41·2	40·5	39·7	38·8	37·9	36·9	35·8	34·7	33·5	32·3
		42·3	41·4	40·4	39·5	38·6	37·6	36·7	35·7	34·8	33·9
		43·4	42·3	41·2	40·2	39·3	38·4	37·6	36·8	36·1	35·4
1·8600-	1st Mean 99th	42·5	41·7	40·8	40·0	39·0	38·0	37·0	35·9	34·7	33·6
		43·7	42·7	41·8	40·9	39·9	39·0	38·0	37·1	36·2	35·2
		44·9	43·8	42·8	41·8	40·8	40·0	39·1	38·4	37·6	36·9
1·9000-	1st Mean 99th	43·6	42·8	41·9	41·0	40·1	39·1	38·1	37·0	35·9	34·8
		45·0	44·1	43·2	42·2	41·3	40·3	39·4	38·5	37·5	36·6
		46·5	45·4	44·4	43·4	42·5	41·6	40·8	40·0	39·2	38·4
1·9400 -1·9799	1st Mean 99th	44·7	43·8	43·0	42·1	41·1	40·1	39·1	38·1	37·0	35·9
		46·4	45·5	44·5	43·6	42·6	41·7	40·8	39·8	38·9	37·9
		48·1	47·1	46·1	45·1	44·1	43·3	42·4	41·6	40·8	40·0

TABLE VII

MEANS AND PERCENTILES OF RIGHT HAND GRIP PRESSURE (kg.) FOR WOMEN, IN TERMS OF BODY WEIGHT AND AGE

Body Weight (log kg.)	Percentile and Mean	Age (yrs)									
		60-	63-	66-	69-	72-	75-	78-	81-	84-	87-89
1·5400-	1st Mean 99th	26·8	26·3	25·8	25·2	24·7	24·1	23·5	22·9	22·2	21·6
		29·1	28·5	27·9	27·3	26·7	26·2	25·6	25·0	24·4	23·8
		31·5	30·8	30·1	29·5	28·8	28·2	27·6	27·0	26·5	26·0
1·5800-	1st Mean 99th	28·2	27·7	27·2	26·7	26·1	25·5	24·9	24·3	23·6	22·9
		30·0	29·4	28·8	28·2	27·6	27·0	26·4	25·8	25·2	24·6
		31·7	31·1	30·4	29·7	29·1	28·5	27·9	27·4	26·8	26·3
1·6200-	1st Mean 99th	29·4	28·9	28·4	27·9	27·3	26·7	26·1	25·4	24·7	24·0
		30·7	30·1	29·5	28·9	28·3	27·7	27·1	26·6	25·9	25·4
		32·1	31·3	30·7	30·0	29·4	28·8	28·2	27·7	27·2	26·7
1·6600-	1st Mean 99th	30·3	29·8	29·3	28·8	28·2	27·6	26·9	26·2	25·5	24·7
		31·3	30·7	30·1	29·5	28·9	28·3	27·7	27·1	26·6	26·0
		32·4	31·6	30·9	30·3	29·7	29·1	28·6	28·1	27·6	27·2
1·7000-	1st Mean 99th	30·9	30·5	30·0	29·4	28·8	28·2	27·5	26·7	26·0	25·2
		31·8	31·2	30·6	30·0	29·4	28·8	28·2	27·6	27·0	26·4
		32·7	32·0	31·3	30·6	30·0	29·5	29·0	28·5	28·1	27·7
1·7400-	1st Mean 99th	31·4	30·9	30·4	29·8	29·2	28·5	27·8	27·0	26·3	25·5
		32·2	31·6	31·0	30·4	29·8	29·2	28·6	28·0	27·4	26·8
		32·9	32·2	31·5	30·9	30·4	29·8	29·4	28·9	28·5	28·1
1·7800-	1st Mean 99th	31·6	31·2	30·7	30·1	29·4	28·7	28·0	27·2	26·5	25·7
		32·4	31·8	31·2	30·6	30·0	29·4	28·8	28·2	27·6	27·0
		33·1	32·4	31·7	31·1	30·6	30·1	29·6	29·2	28·7	28·3
1·8200-	1st Mean 99th	31·8	31·3	30·8	30·1	29·5	28·8	28·0	27·3	26·5	25·7
		32·5	31·9	31·3	30·7	30·1	29·5	28·9	28·3	27·7	27·1
		33·2	32·5	31·8	31·2	30·7	30·2	29·8	29·3	28·9	28·5
1·8600-	1st Mean 99th	31·7	31·2	30·6	30·0	29·3	28·6	27·9	27·1	26·4	25·6
		32·5	31·8	31·2	30·6	30·1	29·5	28·9	28·3	27·7	27·1
		33·2	32·5	31·9	31·3	30·8	30·3	29·9	29·4	29·0	28·6
1·9000-	1st Mean 99th	31·3	30·8	30·2	29·6	28·9	28·2	27·5	26·8	26·0	25·3
		32·3	31·7	31·1	30·5	29·9	29·3	28·7	28·1	27·5	26·9
		33·3	32·6	32·0	31·4	30·9	30·4	29·9	29·4	29·0	28·6
1·9400 -1·9799	1st Mean 99th	30·6	30·0	29·4	28·8	28·2	27·5	26·8	26·1	25·4	24·7
		32·0	31·4	30·8	30·2	29·6	29·0	28·4	27·8	27·2	26·6
		33·4	32·8	32·2	31·6	31·0	30·5	30·0	29·5	29·0	28·6

TABLE VIII

MEANS AND PERCENTILES OF LEFT HAND GRIP PRESSURE (kg.) FOR WOMEN, IN TERMS OF BODY WEIGHT AND AGE

Body Weight (log kg.)	Percentile and Mean	Age (yrs)									
		60-	63-	66-	69-	72-	75-	78-	81-	84-	87-89
1·5400-	1st Mean 99th	24·6 26·9 29·1	24·1 26·2 28·4	23·5 25·6 27·7	22·9 24·9 27·0	22·3 24·3 26·3	21·6 23·6 25·6	21·0 23·0 25·0	20·3 22·3 24·3	19·6 21·7 23·7	18·9 21·0 23·1
		26·2 27·9 29·6	25·7 27·3 28·9	25·1 26·6 28·2	24·5 26·0 27·5	23·9 25·3 26·8	23·2 24·7 26·1	22·6 24·0 25·5	21·9 23·4 24·9	21·1 22·7 24·3	20·4 22·1 23·7
		27·5 28·8 30·1	27·0 28·2 29·4	26·4 27·5 28·6	25·8 26·9 27·9	25·2 26·2 27·2	24·6 25·6 26·6	23·9 24·9 26·0	23·1 24·2 25·4	22·4 23·6 24·8	21·6 22·9 24·3
1·6200-	1st Mean 99th	28·6 29·6 30·6	28·0 29·0 30·0	27·5 28·3 29·1	26·9 27·6 28·3	26·2 27·0 27·7	25·6 26·3 27·0	24·8 25·6 26·5	24·1 25·0 25·9	23·3 24·3 25·4	22·5 23·7 24·9
		29·3 30·2 31·0	28·8 29·5 30·2	28·2 28·8 29·5	27·6 28·2 28·8	27·0 27·5 28·1	26·2 26·9 27·5	25·5 26·2 27·0	24·7 25·6 26·5	23·9 24·9 25·9	23·1 24·3 25·5
		29·8 30·6 31·4	29·3 29·9 30·6	28·7 29·3 29·8	28·1 28·6 29·1	27·4 28·0 28·5	26·7 27·3 27·9	25·9 26·7 27·4	25·1 26·0 26·9	24·3 25·3 26·4	23·5 24·7 25·9
1·7400-	1st Mean 99th	30·2 30·9 31·6	29·6 30·2 30·8	29·0 29·5 30·1	28·4 28·9 29·4	27·7 28·2 28·8	26·9 27·6 28·2	26·1 26·9 27·7	25·3 26·3 27·2	24·5 25·6 26·7	23·7 25·0 26·3
		30·3 31·0 31·7	29·7 30·3 30·9	29·2 29·7 30·2	28·5 29·0 29·5	27·8 28·4 29·0	27·0 27·7 28·4	26·2 27·1 27·9	25·4 26·4 27·4	24·6 25·7 26·9	23·7 25·1 26·4
		30·2 30·9 31·7	29·6 30·3 31·0	29·0 29·6 30·2	28·3 29·0 29·6	27·6 28·3 29·0	26·8 27·7 28·5	26·1 27·0 28·0	25·2 26·4 27·5	24·4 25·7 27·0	23·6 25·0 26·5
1·8200-	1st Mean 99th	29·8 30·7 31·7	29·2 30·1 31·0	28·5 29·4 30·3	27·9 28·8 29·7	27·2 28·1 29·1	26·4 27·5 28·5	25·6 26·8 28·0	24·9 26·2 27·5	24·1 25·5 27·0	23·3 24·9 26·5
		29·0 30·4 31·8	28·4 29·7 31·1	27·8 29·1 30·4	27·1 28·4 29·8	26·5 27·8 29·1	25·7 27·1 28·6	24·9 26·5 28·0	24·2 25·8 27·4	23·4 25·2 27·0	22·6 24·5 26·4
		29·0 30·4 31·8	28·4 29·7 31·1	27·8 29·1 30·4	27·1 28·4 29·8	26·5 27·8 29·1	25·7 27·1 28·6	24·9 26·5 28·0	24·2 25·8 27·4	23·4 25·2 27·0	22·6 24·5 26·4

The product moment zero order correlation coefficients between each pair of variates where the relationship is linear are as shown in Table IX.

TABLE IX
CORRELATION COEFFICIENTS

Variates	Men		Women	
	Right	Left	Right	Left
Hand grip pressure and log weight	+0·4307	+0·4541		
Hand grip pressure and age	-0·4776	-0·4429	-0·4334	-0·4663
Log weight and age	-0·0765		-0·3177	

These correlation coefficients, except log weight and age for men, are highly significantly different from zero ($P < 0.01$). The sex contrast between the significant correlation coefficient of -0.3177 for log weight and age in women and the non-significant value of -0.0765 in men may reflect the absence of obese men in this series.

The coefficients of multiple correlation are as follows:

Hand	Men	Women
Right	0.6003	0.4615
Left	0.6132	0.5177

These values though significantly different from zero are somewhat small. They indicate that, while body weight and age are of value in assessing hand grip pressure, it is desirable to seek additional effective correlatives.

SUMMARY

- (1) The hand grip pressure of 362 men and 394 women considered to be healthy and aged 60 to 89 years is assessed with reference to body weight and age.
- (2) In both sexes hand grip pressure is significantly related to body weight and age. The important equations are:

MEN	Right	$Y = 32.945028X_1 - 0.32700776X_2 + 3.953282$
	Left	$Y = 33.905594X_1 - 0.31281065X_2 - 0.824648$

WOMEN	Right	$Y = 146.988935X_1 - 39.728208X_2 - 0.1990848X_2 - 91.23304$
	Left	$Y = 179.298176X_1 - 48.448874X_2 - 0.2181515X_2 - 121.48802$

where Y = hand grip pressure (kg.), X_1 = body weight (log kg.), and X_2 = age (completed years).

- (3) The means, first and ninety-ninth percentiles of hand grip pressure in terms of body weight and age are presented.

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REFERENCES

- Anderson, A. B. (1948). *Cited in "The Practice of Endocrinology"*, p. 319. Eyre & Spottiswoode, London.
- Anderson, W. F., and Cowan, N. R. (1955). *Lancet*, **2**, 239.
- Burke, W. E., Tuttle, W. W., Thompson, C. W., Janney, C. D., and Weber, R. J. (1953). *J. appl. Physiol.*, **5**, 628.
- Elderton, E. M., and Moul, M. (1928). *Ann. Eugen. (Lond.)*, **3**, 277.
- Fisher, M. B., and Birren, J. E. (1947). *J. appl. Psychol.*, **31**, 490.
- Levine, S. A., and Harvey, W. P. (1949). "Clinical Auscultation of the Heart", p. 145. Saunders, Philadelphia.
- Ruger, H. A., and Stoessiger, B. (1927). *Ann. Eugen. (Lond.)*, **2**, 76.