COMPARISON OF GRIP STRENGTH AND ISOMETRIC ENDURANCE BETWEEN THE RIGHT AND LEFT HANDS OF MEN AND THEIR RELATIONSHIP WITH AGE AND OTHER PHYSICAL PARAMETERS

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Maximum handgrip strength and endurance of fatiguing isometric handgrip muscle contraction at 40% of maximum voluntary contraction of the dominant hand were assessed separately for both right and left hands of 99 right-handed men aged 7–73 years. Subjects below 10 years (n=6) could not follow up the endurance test methods and were excluded. The relationship of handgrip strength and endurance with age and other physical parameters was also assessed. Maximum grip strength and endurance of fatiguing submaximal contraction of the right hand were significantly greater than that of the left hand for most age groups. Grip strength was positively correlated with age from 7–19 years (r=0.94 for right and r=0.89 for left) and was negatively correlated with age from 20–73 years (r=−0.74 right and r=−0.69 left). Grip strength was positively correlated with the weight (r=0.86 right and r=0.87 left), height (r=0.88 right and r=0.87 left) and body surface area (r=0.9 for both) of the subjects. Endurance of contraction of both hands did not show any relationship with age, different physical parameters or grip strength of the subjects.

Isometric strength varies with the age, size and sex of the individual (FISHER and BIRREN, 1947; ASMUSSEN and HEEBÖLL-NIELSEN, 1955, 1956, 1962; ÅSTRAND and RODAHL, 1970). Studies showing no change of strength with aging in men is also available (PETROFSKY and LIND, 1975). Isometric exercise fatigues muscles rapidly whenever the contraction tension exceeds 10–15% of the muscle’s maximal voluntary strength (MERTON, 1954; ROHMERT, 1960a, b; FUNDERBURK et al., 1974).

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It has been also reported that the endurance time is independent of the sex of the subjects (ROHMERT, 1968) and of previous dynamic training (HANSEN, 1967), as long as the subjects work at the same percentage of their own maximum strength.

The fact that age does not affect the capacity of muscle to sustain a contraction at a known fraction of maximum strength has been reported by MULLER (1961) and ROHMERT (1960a, b). PETROFSKY and LIND (1975) and PETROFSKY et al. (1975) reported that aging was associated with a significant rise in endurance in women but not in men. Although CALDWELL (1963, 1964) and START and GRAHAM (1964) suggested that no variation in the holding time among various levels of strength would occur between stronger and weaker individuals when the same relative weight load was used for each of them, TUTTLE et al. (1950) and CARLSON (1969) reported lower holding times in stronger individuals.

A comparison of grip strength and isometric endurance between the right and left hands of men is of interest. A survey of the literature indicates that there have been few studies of different age groups, particularly with regard to Indian subjects.

The present investigation has the following objectives:

1. To determine whether the difference in grip strength and isometric endurance between the right and left hands of right-handed men is significant.

2. To determine whether there is any relationship between maximum hand-grip strength and endurance contraction with age and other physical parameters.

MATERIALS AND METHODS

Ninety-nine normal healthy male subjects of six different age groups participated in the present investigation. The lowest age group (7–9 years n=6) could not take part in the endurance test procedures, and its members participated only in the strength test experiment.

The subjects were sedentary. No individual was accepted as subject if he had a history of any cardiovascular or pulmonary disorder or displayed an irregular electrocardiogram or abnormal blood pressure in the pre-exercise resting state. The subjects who were unable to continue the whole series of the experiment were also excluded. All the subjects were requested to refrain from eating and in engaging in any strenuous physical work for at least 1 hr before the experiment. The purpose of the experiment was explained to them to stimulate the participants' interest and to encourage them to perform the various tasks to their utmost ability. After an initial half-hour rest, the subjects' physical characteristics, including age, height, weight and health-oriented case history, were noted. The body surface area (BSA—m²) was estimated for each individual using the DuBois formula \( S= W^{0.425} H^{0.725} \times 0.007184 \) for the weight in kilograms and height in centimeters.

Two maximal voluntary handgrip contractions (MVC) at an interval
of 1 min and with a duration of less than 3 sec were performed by each subject at the start of each experiment. A simple handgrip dynamometer (INCO made in India) was utilized for the grip strength measurements. The sustained handgrip contraction involved as little shortening of the forearm flexor muscles as possible. Maximum strength was taken to be the stronger of the two contractions. The MVC was measured to the nearest 0.1 kg. During the test the subjects were in the sitting position with the upper arm dependent and the forearm held horizontally. The MVC of the left hand of the same individual was determined in the same way after resting at least half an hour. The dynamometer was standardized by another dynamometer (CLARKE et al., 1958) before and after the experiment. It was also standardized using the investigator's own known handgrip strength.

During the subsequent experimental phase each subject exerted a handgrip contraction on the dynamometer at a tension of 40% of the MVC of dominant hand (right) until he could no longer maintain the tension. The participants performed this static effort with their right hand on the first day and with their left hand at same tension the next time they visited the laboratory. Before and during the contraction the subjects were instructed about the importance of maintaining a steady tension and were continuously encouraged by one investigator to maintain the tension to the point of fatigue. A second observer constantly observed the subjects during the exercise and encouraged them to relax the muscles of all body parts other than the exercising forearm.

The subjects were examined in Calcutta from January, 1981 to January, 1983. The laboratory temperature was 28±1°C.

The statistical analysis primarily involved the calculation of means, standard deviations and regression lines. Comparisons were made using the F test and the unrelated t test as appropriate. The difference method was applied to determine the difference between the data achieved by the static efforts of the two hands each subject. The level indicating statistical significance was p<0.05.

**RESULTS**

The mean height, weight, body surface area (BSA), ages and grip strength of the 99 men who participated in the grip strength experiment are given in Table 1. Figure 1 shows the maximum handgrip strength of the right and left hands of the subjects.

The strength of the right handgrip was greater than that of the left hand. For age groups 7–9 years, 40–49 years and 50 and above, the difference between the two hand strengths was not statistically significant (Table 1). For the rest three age groups and for the subjects as a whole, however the difference was statistically significant.

Figure 2 shows the regression lines relating the handgrip strengths of both the
Table 1. Isometric handgrip strength of right hand and left hand of men of different age groups and their physical parameters.

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Age (yrs.) Mean±SD</th>
<th>Height (cm) Mean±SD</th>
<th>Weight (kg) Mean±SD</th>
<th>B. S. A. (m²) Mean±SD</th>
<th>MVC of right hand (kg) Mean±SD</th>
<th>MVC of left hand (kg) Mean±SD</th>
<th>Mean of strength difference (kg)</th>
<th>Level of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>10–19 years n=41</td>
<td>14.43±2.80</td>
<td>156.55±13.93</td>
<td>39.67±10.38</td>
<td>1.33±0.23</td>
<td>27.06±5.87</td>
<td>25.44±5.55</td>
<td>1.62</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>20–29 years n=25</td>
<td>24.56±2.32</td>
<td>168.38±5.73</td>
<td>53.75±6.70</td>
<td>1.60±0.01</td>
<td>34.94±2.51</td>
<td>33.42±2.68</td>
<td>1.56</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>30–39 years n=8</td>
<td>33.37±2.92</td>
<td>164.72±5.42</td>
<td>51.31±6.07</td>
<td>1.54±0.09</td>
<td>33.69±2.20</td>
<td>32.19±1.96</td>
<td>1.37</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>40–49 years n=7</td>
<td>44.57±1.98</td>
<td>163.11±6.95</td>
<td>53.35±6.75</td>
<td>1.50±0.10</td>
<td>31.36±3.31</td>
<td>30.36±2.78</td>
<td>1.00</td>
<td>NS</td>
</tr>
<tr>
<td>50 and above yrs. n=12</td>
<td>67.16±6.89</td>
<td>164.60±8.72</td>
<td>51.20±11.19</td>
<td>1.54±0.18</td>
<td>28.58±3.12</td>
<td>27.46±3.12</td>
<td>1.12</td>
<td>NS</td>
</tr>
<tr>
<td>Total subjects n=99 including 6 members of age group 7–9 years</td>
<td>26.62±18</td>
<td>159.11±16.06</td>
<td>45.23±12.78</td>
<td>1.42±0.26</td>
<td>29.09±7.17</td>
<td>27.65±6.99</td>
<td>1.44</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>

NS = not significant.

By difference method was applied to compare the difference between the strength of right hand and left hand of individual persons. The lower age group 7–9 years is too small (n=6) to support significance in difference between the strength of the two hands and is excluded from determining the statistical significance separately.
Fig. 1. Maximum handgrip strength of each of 99 men. It shows clearly that on the whole MVC (right) is somewhat greater than MVC (left) of same person.

Fig. 2. Regression lines representing the relationship between grip strength of both hands and ages of 99 men. ●, MVC (right) below 20 yrs. \((y = -3.4373 + 2.0982x)\); □, MVC (left) below 20 yrs. \((y = -3.5026 + 1.9892x)\); ○, MVC (right) 20 yrs. and above \((y = 38.8412 - 0.1572x)\); △, MVC (left) 20 yrs. and above \((y = 36.9857 - 0.1442x)\)
Table 2. Relationship of MVC with age, weight, height and body surface area of 99 men.

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Regression equations</th>
<th>r-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVC (right) with age</td>
<td>( y = -3.4373 + 2.0982x ) (below 20 years)</td>
<td>+0.94</td>
</tr>
<tr>
<td></td>
<td>( y = 38.8912 - 0.1572x ) (20 years and above)</td>
<td>-0.74</td>
</tr>
<tr>
<td>MVC (left) with age</td>
<td>( y = -3.5026 + 1.9892x ) (below 20 years)</td>
<td>+0.89</td>
</tr>
<tr>
<td></td>
<td>( y = 36.9857 - 0.1442x ) (20 years and above)</td>
<td>-0.69</td>
</tr>
<tr>
<td>MVC (right) with weight</td>
<td>( y = 7.249 + 0.483x )</td>
<td>+0.86</td>
</tr>
<tr>
<td>MVC (left) with weight</td>
<td>( y = 6.031 + 0.478x )</td>
<td>+0.87</td>
</tr>
<tr>
<td>MVC (right) with height</td>
<td>( y = -32.958 + 0.39x )</td>
<td>+0.88</td>
</tr>
<tr>
<td>MVC (left) with height</td>
<td>( y = 32.652 + 0.379x )</td>
<td>+0.87</td>
</tr>
<tr>
<td>MVC (right) with B. S. A.</td>
<td>( y = -4.976 + 23.891x )</td>
<td>+0.9</td>
</tr>
<tr>
<td>MVC (left) with B. S. A.</td>
<td>( y = -5.735 + 23.41x )</td>
<td>+0.9</td>
</tr>
</tbody>
</table>

Note: for all r-values \( p < 0.001 \).

Table 3. Endurance of isometric handgrip muscle contraction of right hand and left hand of 93 men at tension of 40% of MVC of dominant hand (right).

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Endurance (sec) of right hand Mean±S D</th>
<th>Endurance (sec) of left hand Mean±S D</th>
<th>Mean of differences in endurances (sec) of two hands</th>
<th>Level of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>10–19 years</td>
<td>162.8±38.2</td>
<td>148.8±29.3</td>
<td>13.9</td>
<td>( p &lt; 0.001 )</td>
</tr>
<tr>
<td>n=41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–29 years</td>
<td>156.2±53.0</td>
<td>139.6±40.2</td>
<td>16.6</td>
<td>( p &lt; 0.01 )</td>
</tr>
<tr>
<td>n=25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30–39 years</td>
<td>164.1±42.2</td>
<td>154.5±46.4</td>
<td>9.6</td>
<td>( p &lt; 0.05 )</td>
</tr>
<tr>
<td>n=8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40–49 years</td>
<td>161.0±41.6</td>
<td>131.0±33.3</td>
<td>30.0</td>
<td>( p &lt; 0.001 )</td>
</tr>
<tr>
<td>n=7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 and above ages</td>
<td>162.5±42.3</td>
<td>144.5±41.9</td>
<td>18.0</td>
<td>( p &lt; 0.001 )</td>
</tr>
<tr>
<td>n=12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*All ages</td>
<td>161.0±42.9</td>
<td>144.9±35.8</td>
<td>16.0</td>
<td>( p &lt; 0.001 )</td>
</tr>
</tbody>
</table>

By difference method is applied to signify the difference between the endurance of two hands of individual persons.

right and left hands to the age of the subjects. Strength was positively correlated with age up to the age of 19 years and was negatively correlated with age from 20–73 years.

Table 2 illustrates the regression lines relating maximum grip strength (right and left) to the age, weight, height and body surface area of the subjects. The
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MVC was positively correlated with the weight, height and body surface area of the subjects.

The mean endurance times of the both the right and left hand contractions at 40\% of the MVC of the dominant hand (right) for 93 men belonging to five different age groups are illustrated in Table 3. There was no significant difference ($p>0.05$) in endurance for different age groups. Figure 3 represents the endurance of the right and left hands of 93 subjects. For all age groups and for the subjects as a whole the mean endurance time of the right hand contraction was significantly greater than that of the left hand contraction. For all subjects, the mean dif-
ference in the endurance of the contraction between the two hands of the individual subjects was 16 sec ($p < 0.001$).

No relationship was found between the endurance of isometric contraction and the age, weight, height, body surface area or MVC of the individual subjects.

DISCUSSION

The earlier reports on the relationship between age and the maximum voluntary handgrip strength are almost unanimous that from about the age of 20 until 60 years there is a gradual decline in strength (ASMUSSEN and HEEBÖLL-NIELSEN, 1955, 1956, 1962). Our findings agree with those results. PETROFSKY and LIND (1975) reported no change in muscle strength with age in male homogenous subjects. Individual variations in MVC may be attributed to the wide differences in the mechanical advantage achieved by different hand sizes on the fixed dimension of the dynamometer. Progressive lack of training (RICHARDSON, 1953), reduced urinary excretion of testosterone (HETTINGER, 1961; SIMONSON, 1971), cell death in the brain and loss of nerve cell in the spinal cord (CRITCHLEY, 1942) and a reduction of total number of muscle fibres with aging (GUTMAN and HANZLEKOVA, 1972) could account for the reduction of muscle strength with age.

In the present study, the weight, height and body surface area of the subjects show a positive correlation with MVC. In this respect our findings agree with the findings of ASMUSSEN and HEEBÖLL-NIELSEN (1962).

In our findings the MVC values achieved by subject’s right hand were significantly greater than those of the left hand. For age groups 7–9 years, 40–49 years and 50 and above, the above differences were not statistically significant. This is probably due to the small number of subjects in those groups. Because all our subjects were right handers, their right hand should be stronger than the left. The same idea also has been proposed by LIND and McNICOL (1968). Greater utilization of the right hand in the performance of daily activities and the subsequent training effect has led to the dominance of the right hand muscles over the left hand in right-handed individuals.

The endurance of handgrip contractions in our investigation are in agreement with the results obtained by other authors (ROHMERT, 1960a, b; LIND et al., 1964; BRUCE et al., 1968; WILEY and LIND, 1971; FUNDERBURK et al., 1974; PETROFSKY et al., 1975). The balance of the evidence favors the theory that fatigue is metabolic in origin (MERTON, 1954; SIMONSON, 1971). The fact that age does not affect the capacity of muscles to sustain a contraction at a known fraction of maximum strength has been reported by MULLER (1961) and ROHMERT (1960a, b). Those findings are supported by the results of the present investigation. Reasons for the absence of any relationship between the endurance of handgrip contraction and different physical parameters and MVC should be the same as those discussed with regard to age effects.
In our findings, the endurance of right hands was greater than that of left hands. The dominance of right hand endurance over left hand endurance was statistically significant for all ages and for all age groups. As the absolute load was same for each arm, the muscles of the left arm would have to contract at a greater proportional tension in comparison with the dominant right hand. Thus the contraction at greater tension by the weaker arm caused the lower endurance during left-hand contraction in the right-handed subjects.

REFERENCES


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