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Norms for hand grip strength in children aged 6–12 years in Saudi Arabia

Mohammed Taher Ahmed Omar1,2,3, Ahmad Alghadir2,3, & Shaheerah Al Baker4

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Abstract

Objectives: There were two main objectives of this study: to establish normative values of hand grip strengths for 6–12-year-old children in Saudi Arabia and to compare results with existing Western data. Methods: Five-hundred twenty-five children from the central area of Riyadh, Saudi Arabia, were recruited. Hand grip strength was measured using a standard adjustable electronic hand dynamometer. Results: The grip strength increased with advancing age in both genders, but grip strength for boys was significantly stronger than that of girls. There was no significant difference in hand grip strength according to the type of hand dominance. The hand strength of the Saudi children appeared to be lower than that of Western children. Conclusion: The reported values of hand grip strength will allow therapists to compare scores from typical and atypical children according to the age, gender, and body measures.

Keywords
Children, hand grip strength, norms

Introduction

Hands are used in all activities of daily living, such as self-care, school, work, play, and leisure activities [1, 2]. Therefore, evaluation of hand function has become an essential part of physical/occupational therapy assessment for children with a range of disorders such as trauma, congenital, and neurological disorders. Normative data of hand grip strength are important to help identify the level of development and the degree of disability, to determine efficacy of rehabilitation, and to assess the integrity of upper limb functions [2–4].

Numerous studies have been published about hand grip strength for adults at different age groups and from diverse populations [5–12]. However, few studies have been published for norms of hand grip strength in children [13–22]. The most recent studies provided data from children in Sweden [21] and Korea [22]. Earlier studies were from children in the USA [14, 16, 18, 19] and Australia [15, 17]. The results from these studies showed that grip strength may be changed over generations. Monpetit and colleagues found that grip strength scores in a group of American children in 1964 were advanced by 1.5–2-years compared with data collected as early as 1899 [23]. Moreover, Jenue and colleagues [24] concluded that hand grip strength may differ across regions. This may be due to sociocultural differences such as nutritional status, leisure activities, technology development, and modernization [21]. Therefore, establishing norms of hand grip strength for each geographical region is important for therapists.

To our knowledge, there is no report on the normative data of hand grip strength for Saudi children. Hand grip strength is one of the basic elements to be analyzed when therapist compare typical and atypical children. Currently, the data on hand grip strength from Western countries has been used as a reference for the Saudi children. However, these data are considered inappropriate because they do not take into account the differences in physical characteristics according to race/ethnicity and region. This is the same logic as using different norms for height and weight according to race/ethnicity and region [21]. Past research suggests that Saudi children have lower values of height and weight than Western children [25, 26]. Therefore, Saudi children may also vary in hand strength when compared to existing Western demographics. The purpose of the current study is to provide normative values of hand grip strength for 6–12-year-old children in Saudi Arabia and to compare results with existing Western data.

Methods

Participants

Participants included 525 elementary school children from the urban central area of Riyadh, Saudi Arabia. All children and their parents signed a consent form describing the aims and procedures of this study. The study was approved by the Rehabilitation Research Chair of the Ethics Committee at
King Saud University in Saudi Arabia. To establish accurate norms, children with any known cognitive/neurological disorders, global delayed milestones, pain or functional limitations of the upper limbs, or inability to understand test procedures were excluded from the present study.

**Instrumentation and procedures**

Researchers collected the demographic data including age, gender, weight, and height. Body weight was measured using a portable weighing scale (Camry, Model: EF921, Camry Electronic, Co., Ltd., Zhonghan, Guangdong, China) to the nearest 0.1 kg. Height was measured with a stadiometer to the nearest 0.1 cm. Then body mass index (BMI) was computed. Hand dominance was determined by the child’s reported preference for use in activities of daily living such as writing, eating, throwing a ball, and opening and closing doors or window shutters [21, 22]. All measurements were obtained in an air-conditioned room of the health supervisor, during the school day from 8 to 11 am.

Hand grip strength was measured using a standard adjustable hand dynamometer (J-Tech 12-0259 Commander, Grip Track Dynamometer, Midvale, UT) based on the recommendation of the American Society of Hand Therapists [4].

For standardization, the dynamometer was set at the second handle position for measurement of hand grip strength. Grip strength was measured while children were in a sitting position with shoulder adducted and neutrally rotated, elbow at 90° flexion, and the forearm and wrist in neutral position [4, 27, 28]. Children were allowed to briefly practice using the dynamometer prior to assessment. Children were instructed to squeeze the handle of the dynamometer as hard as they could and to sustain the effort for 5 s. Verbal encouragement (i.e., squeeze as hard as you can) was provided to children during testing. Children performed three trials for each hand, and the mean values of these trials were recorded. Children were given one-minute to rest between trials and trials were completed with alternating hands to minimize the effects of fatigue [29]. Results were recorded in pounds. If a measurement showed a difference greater than 10% from previously obtained measurements, we did not retain that measurement and instead conducted a fourth trial [30]. These procedures have been previously well-documented as reliable [31, 32]. The calibration of instruments was tested periodically during the study, according to the manufacturer’s manual.

**Statistical analysis**

Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS Version, 21.0, Chicago, IL). Data were described as mean, standard deviation for continuous variables and median and mode for categorical variables. Unpaired and paired t-tests were used to determine between-subjects and within-subject differences regarding hand grip differences, respectively. Pearson’s coefficient of correlation was used to evaluate the contribution of age and anthropometric measures to variability in grip strength.

A two-way ANOVA (mixed design) was used to compare sex [between-subject factor] and hand dominance (within-subject factor). The Tukey post-hoc test in separate ANOVAs was used to examine differences between specific age groups for boys and girls. Statistical significance was set at p < 0.05. The hand grip strength of Saudi children was compared with the data of Ager et al. [14] and Hager-Ross and Rsoblad [21].

**Results**

**Physical characteristics of the participants**

Table I describes the physical characteristics of the participating children. Five-hundred twenty-five children completed the test procedures, where 222 (42%) were boys, and 303 (58%) were girls. Right-hand dominance was reported in 475 children (90.5%) comprising 196 (37.3%) boys and 279 (53.2%) girls, while 50 (9.5%) reported left hand dominance, comprising 26 (4.9%) boys and 24 (4.6%) girls. None of the children reported ambidexterity. There were no differences in the weight (p > 0.05) and height (p > 0.05) between boys and girls in each age group. There was a significant and steady increase in weight (p < 0.05) and height (p < 0.05), with an advance in age chronologically. However, there were no significant differences in weight at 6–7 years old (boys; p = 0.36, and girls; p = 0.98) and 8–9 years old (boys; p = 0.97, and girls; p = 31), and height at 6–7 years old (boys; p = 0.08, and girls; p = 0.15) and 9–10 years old (boys; p = 0.11, and girls; p = 0.32).

Table I. Physical characteristics of participants, and mean hand grip strength across age range and gender.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>N</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
<th>Right</th>
<th>Left</th>
<th>Handgrip (lbs)</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td>6</td>
<td>29</td>
<td>21.04 ± 3.01</td>
<td>116.72 ± 2.80</td>
<td>18.97 ± 2.33</td>
<td>18.53 ± 2.29</td>
<td>32.85 ± 5.01*</td>
</tr>
<tr>
<td>7</td>
<td>34</td>
<td>23.46 ± 2.06</td>
<td>119.82 ± 2.92</td>
<td>21.78 ± 4.94*</td>
<td>21.33 ± 4.14*</td>
<td>38.56 ± 5.27*</td>
</tr>
<tr>
<td>8</td>
<td>30</td>
<td>27.06 ± 2.77</td>
<td>125.23 ± 2.86</td>
<td>26.18 ± 4.76*</td>
<td>26.20 ± 4.56*</td>
<td>46.24 ± 5.37*</td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>28.25 ± 2.35</td>
<td>132.40 ± 2.39</td>
<td>32.15 ± 5.39*</td>
<td>32.11 ± 6.09*</td>
<td>56.72 ± 7.05*</td>
</tr>
<tr>
<td>10</td>
<td>37</td>
<td>33.21 ± 3.47</td>
<td>135.67 ± 4.70</td>
<td>33.84 ± 6.17*</td>
<td>32.85 ± 5.01*</td>
<td>60.93 ± 6.92*</td>
</tr>
<tr>
<td>11</td>
<td>41</td>
<td>36.87 ± 4.38</td>
<td>139.29 ± 4.96</td>
<td>39.03 ± 4.84*</td>
<td>38.56 ± 5.27*</td>
<td>65.84 ± 7.22*</td>
</tr>
<tr>
<td>12</td>
<td>31</td>
<td>41.77 ± 5.99</td>
<td>146.48 ± 2.93</td>
<td>46.78 ± 5.45*</td>
<td>46.24 ± 5.37*</td>
<td>71.76 ± 7.36*</td>
</tr>
<tr>
<td>Total</td>
<td>222</td>
<td>30.72 ± 7.84</td>
<td>131.24 ± 10.6</td>
<td>31.79 ± 10.33</td>
<td>31.02 ± 10.20</td>
<td>31.02 ± 10.20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>N</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
<th>Right</th>
<th>Left</th>
<th>Handgrip (lbs)</th>
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<td></td>
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</tr>
<tr>
<td>6</td>
<td>22</td>
<td>22.13 ± 2.88</td>
<td>115.04 ± 3.04</td>
<td>17.77 ± 3.22</td>
<td>17.44 ± 3.42</td>
<td>22.13 ± 2.88</td>
</tr>
<tr>
<td>7</td>
<td>49</td>
<td>23.51 ± 2.65</td>
<td>119.12 ± 3.94</td>
<td>18.86 ± 4.26</td>
<td>18.16 ± 3.79</td>
<td>23.51 ± 2.65</td>
</tr>
<tr>
<td>8</td>
<td>56</td>
<td>27.19 ± 4.71</td>
<td>123.80 ± 5.05</td>
<td>23.21 ± 5.85</td>
<td>22.77 ± 5.57</td>
<td>27.19 ± 4.71</td>
</tr>
<tr>
<td>9</td>
<td>51</td>
<td>29.82 ± 5.76</td>
<td>130.96 ± 4.21</td>
<td>27.53 ± 5.81</td>
<td>27.06 ± 6.29</td>
<td>29.82 ± 5.76</td>
</tr>
<tr>
<td>10</td>
<td>33</td>
<td>34.18 ± 5.87</td>
<td>134.06 ± 4.70</td>
<td>29.70 ± 6.49</td>
<td>28.32 ± 7.11</td>
<td>34.18 ± 5.87</td>
</tr>
<tr>
<td>11</td>
<td>56</td>
<td>38.19 ± 6.38</td>
<td>137.07 ± 7.24</td>
<td>36.17 ± 4.01</td>
<td>34.47 ± 4.11</td>
<td>38.19 ± 6.38</td>
</tr>
<tr>
<td>12</td>
<td>36</td>
<td>42.44 ± 6.65</td>
<td>144.89 ± 5.42</td>
<td>41.86 ± 5.81</td>
<td>41.43 ± 5.68</td>
<td>42.44 ± 6.65</td>
</tr>
<tr>
<td>Total</td>
<td>303</td>
<td>31.28 ± 8.32</td>
<td>129.68 ± 10.31</td>
<td>28.16 ± 9.37</td>
<td>27.35 ± 9.29</td>
<td>31.28 ± 8.32</td>
</tr>
</tbody>
</table>

N = Number of participants.

*Significant differences between boys and girls in respect to age group (p < 0.05).

| Significant differences in respect to age group (p < 0.05).
Hand grip strength

Age- and gender-specific hand grip strength is presented in Table I regardless of hand dominance. The grip strength varied between 17.44 lbs in 6 years old girls to 46.78 lbs in 12 years old boys. There was a gradual and significant increase in the grip strength with advancing age chronologically. However, 6–7 years and 9–10 years old children did not show significant differences in grip strength in boys ($p > 0.05$) and girls ($p > 0.05$). Similarly, comparison of grip strength between the right and left hand of the children showed no significant differences ($p > 0.05$), except for two: 7-year and 11-year-old girls ($p < 0.05$).

Figure 1 shows the mean grip strength according to genders across different age ranges. The grip strength of the boys was significantly ($p < 0.05$) greater than that of the girls, except for 6-year-olds, there were no difference ($p > 0.05$) in the grip strength between boys and girls. The differences in grip strength were not homogenous across age groups. When we compared 6-year-old boys to 6-year-old girls, we found that boys’ grip strength was 6.5% stronger than the grip strength of girls. For the group of 7–9-year olds the boys were 14–18% stronger than girls; for the group of 10–12-year olds, the boys were 10–15% stronger than girls. The greatest increase of grip strength was observed between 11 and 12 years of age (8 and 6.3 lbs for boys and girls, respectively).

Tables II and III present the data for grip strength according to dominant hand. Comparison of hand grip strength for the dominant hand versus non-dominant hand indicated non-significant differences for the boys ($p > 0.05$) and girls ($p > 0.05$). There were no significant ($p > 0.05$) difference in the grip strength of the left hand between different dominant hand groups and genders. Similarly, there were no significant differences between right-hand grip strength and left-hand grip strength among right-hand dominance of each age group and gender.

Figure 2 shows a comparison of hand grip strength of Saudi children with the Western data of Agar et al. (US) [14] and Hager-Ross and Rosblad (Sweden) [21]. In general, hand grip strength tends to be similar for Saudi boys under 9 years old and it tends to be lower for age groups 10–12 in comparison with data from the US [14] and Sweden [21]. For Saudi girls, hand grip strength tends to be lower than Western reference values, especially when compared to the US [14] data for 6–10-year-old girls. However, for 10- and 12-year-old Saudi girls, hand grip strength seems to be higher than reference values from Sweden [21].

Discussion

To our knowledge, this is the first published normative data of hand grip strength in Saudi children. The main objective of this study was to establish age and sex reference values of hand grip strength among Saudi children 6–12 years old, and to compare these data with existing Western data. Our data confirm progressive linear increases in hand grip strength for the dominant hand versus non-dominant hand for the boys and girls ($p > 0.05$). The greatest increase of grip strength was observed between 11 and 12 years of age (8 and 6.3 lbs for boys and girls, respectively).

Table II. Mean hand grip strength of the boys, according to hand dominance.

<table>
<thead>
<tr>
<th>Age-groups (years)</th>
<th>R-hand dominant</th>
<th>L-hand dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right hand*</td>
<td>Left hand</td>
</tr>
<tr>
<td></td>
<td>$N = 27$</td>
<td>$N = 2$</td>
</tr>
<tr>
<td>6</td>
<td>19.14 ± 2.29</td>
<td>16.00 ± 1.88</td>
</tr>
<tr>
<td>7</td>
<td>21.83 ± 5.10</td>
<td>21.00 ± 0.46</td>
</tr>
<tr>
<td>8</td>
<td>26.55 ± 5.01</td>
<td>25.00 ± 3.92</td>
</tr>
<tr>
<td>9</td>
<td>32.29 ± 5.37</td>
<td>31.33 ± 6.67</td>
</tr>
<tr>
<td>10</td>
<td>34.14 ± 6.31</td>
<td>30.45 ± 2.79</td>
</tr>
<tr>
<td>11</td>
<td>39.10 ± 4.49</td>
<td>39.035 ± 3.13</td>
</tr>
<tr>
<td>12</td>
<td>46.84 ± 5.72</td>
<td>46.49 ± 4.20</td>
</tr>
</tbody>
</table>

N = Number of participants, R = Right, L = Left.
*No significant differences ($p > 0.05$) of right hand compared to left hand in respect to right and left hand dominant.
both genders with advancing age. These findings were supported by studies previously published findings from other countries [14–22, 33] that established a positive relationship between hand grip strength and age. In this investigation, we observed that a significant increase in grip strength occurred around 10–12 years of age, which was consistent with the results of Hager-Ross and Rosblad [21]. This apparently concurs with physical growth associated with the onset of puberty [21, 34, 35]. In addition, biological maturity is known to have a strong impact on strength measures, especially for boys [34, 35].

Regarding the difference in hand grip strength by gender, in our study, the grip strength of the boys was significantly stronger than that of the girls at 6–12 years of age. This finding is similar to that reported in previous studies [14–22]. In the present study, 6-year-old boys and girls had similar grip strength, but older boys tended to demonstrate higher grip strength than same age girls. The non-significant difference in grip strength reported at 6 years of age between boys and girls aligns with the prior research of Reberston and Deitz [19], Smet and Vereammen [20], Hager-Ross and Rosblad [21], as they found no differences in grip strength under the age of 7 years. The gender-specific differences we observed might be attributed to lack of physical activity and limited opportunities for girls to engage in it inside and outside school. For cultural reasons families may not encourage girls...
to take part in physical activity. Elsewhere, boys were found more likely than girls to participate in sports and physical activity [36]. So, it is noteworthy that physical-activity levels of girls have been reported to be much lower than those of males irrespective of the region [36, 37]. Moreover, data from a limited number of studies indicate that 60% of Saudi children and 71% of young people do not engage in physical activity of sufficient duration and frequency [38, 39].

With regard to the difference between dominant and non-dominant hands in our study, there was no significant difference in grip strength according to the type of hand dominance in the boys and girls. These results were consistent with the findings from several studies [14, 18, 22]. However, these findings contradict the findings of Hager-Ross and Rosblad [21], and early findings of Newman et al. [15]. These two studies found that right-handed children showed increased strength in their right hand when compared to their left hand, but left-handed children did not differ in hand grip strength between their left and right hands. That is, reported hand dominance was associated with varying hand strength for right-handed, but not left-handed children. These inconsistent results might be partially explained by methodological differences and small numbers of left-handed children in these studies.

Differences in hand strength for Saudi children in our sample to children in previously obtained Western samples may be attributable to the racial differences between Arabic, American and European populations. Jeune et al. [24] stated that comparison of hand grip strength across regions may provide some insight as to the historical regional differences in genetic factors, nutritional deficiencies, and sociocultural environment. Additionally, variations in grip strength norms from different regions and population are believed to be due largely to anthropometric differences [12, 24, 40, 41]. Our data suggest that grip strength norms from the Western population may not accurately represent the local population; hence local reference values are needed.

This study has some limitations. The children were from the urban central area of Riyadh. Therefore, a broad range of the sociocultural and economic aspects was not representative in this study. So, further study using the same standardized procedures in another area within the country is required. Another limitation was the small number of left-hand dominant subjects (n=50). Therefore, future studies should recruit more left-handed subjects to ensure greater confidence in estimates of normal values and better predictability of the grip strength pattern across different age-groups and genders are required.

**Declaration of interest**

The authors report no conflicts of interest, financial or otherwise. The authors alone are responsible for the content and writing of the paper.

**References**


