Normal Handgrip Strength for Egyptian Children in Pre-pubertal Developmental stage

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ABSTRACT

Background and purpose: *Determination of normative data of handgrip strength of children is used in clinical assessment of hand disabilities and evaluates the response to treatment. The purpose of this study was to provide normative data of handgrip strength for Egyptian children in pre-pubertal developmental phase between six and twelve years and test the rule that the dominant hand is 10% stronger than the non-dominant hand.* ***Subjects:*** *One hundred ninety one healthy volunteers school children (88 boys and 103 girls) participated in this study they were all right handed. Methods: Handgrip strength was measured for right dominant and left non-dominant hands using calibrated hand-held dynamometer.* ***Results:*** *The results provided measurement for grip strength at different ages from six to twelve years and clarified that hand grip strength increases by age which was approximately parallel for boys and girls until age of nine years after that boys showed powerful grip strength than girls for both hands. There was also a significant difference between right dominant and left non-dominant hand for both boys and girls ($P<0.0001$). The percentage of the difference between right and left handgrip strength was ranged from 11% to 13.2% for boys and 11.1% to 14.2% for girls.* ***Conclusion:*** *Providing normal values of handgrip strength for Egyptian children in pre-pubertal developmental stage is important for providing therapist and physician with a normal baseline values to be compared with patient's disability scores.*
Key words: *Handgrip strength, normal values, pre-pubertal age children.*

INTRODUCTION

In typically developing children manipulatory actions and performance of fine motor skills develop rapidly during the first years of life with a subsequent refinement occurring throughout childhood[1,2]. Handgrip strength is an important parameter not only in evaluation of hand as a predictor of hand function, but also to explore the status of general health[3,4]. Hand is an essential organ used in activity of daily living (ADL) and grip strength plays an important role in prevention of injury and rehabilitation as it becomes a routine part of clinical evaluation and assessment. Many neurological diseases and brain lesions can cause hand function impairment. It is important that hand strength and dexterity be evaluated to determine the severity of hand dysfunction and establish an effective rehabilitation program[5,6].

Very few studies reported the measurement of hand grip strength in children. Semproli et al.,[7] investigated the relationship between hand grip and pinch strength values with basic body parameters (body height and body mass index BMI) with specific hand anthropometric parameters (finger span, lengths and perimeter) in 461 pre-pubertal children ages from 6 to 10 years. They found that the relation between anthropometry and handgrip strength is stronger in boys compared with girls and low relation between hand anthropometry and tip and key pinch strength.

Brown et al.,[8] measured hand grip strength of twenty-five children aged between

two to four years using commercially dynamometer. Their results showed that the reported grip strengths are maximum and not likely to be required every time the child holds an object. Luc and Annick[9] measured grip strength for 487 healthy children aged between 5 and 15 years. They concluded that there was a clear correlation between age and grip strength. Another study by Lindehammar[10] measured the handgrip strength and isometric muscle strength in wrist dorsiflexors to describe the changes in muscle strength in the hands of twenty children aged 7 to18 years with juvenile chronic arthritis (JCA).

Häger-Ross and Rösblad[11] measured the grip strength in 530 Swedish children ranged in age between 4-16 years to provide a recent normal data compared with data obtained in USA and Australia at 1980. However, these normative data for different population are considered inappropriate for Egyptian children because of the changes of the grip strength over different generations and the differences in nutrition type, cultural differences and environmental and physical characteristics according to race and region. This is the same logic as using different norms for height, weight, and head circumference according to race and region[5].

After surgery for trauma or correction of congenital anomaly, hand function is difficult to be evaluated in children because there is no reference about norms for Egyptian children. The aim of this study was to provide normative data of handgrip strength for Egyptian children in pre-pubertal age (6 to 12 years) and examine that the rule of dominant hand (DH) is approximately10% stronger than the non-dominant hand.

SUBJECTS AND PROCEDURES

Subjects

One hundred ninety one volunteer healthy school students (88 boys, and 103 girls) participated in the study they were selected from different primary School in Nasr City according to the following criteria:

- Their ages ranged from 6 to 12 years with the mean of their ages were 9.4±2.6 for boys and 8.8±2.3 for girls.
- They were all right handed.
- They had no history of previous hand injuries, surgeries or other functional hand limitation.
- Height and weight were measured for each child and registered to height and weight scales corresponding to their age. Height, weight for boys and girls were illustrated in table (1).

Procedures

A calibrated hand-held dynamometer was used to measure the grip strength of dominant and non-dominant hands for each child. Before beginning the measurements the dynamometer was set at zero level. The recommendations of the American Society of Hand Therapists (Richards & Palmiter 12 for standardized position and measurement procedures of hand grip strength were followed:

- The child was asked to sit comfortably on upright straight-backed chair with the feet flat on the floor, shoulder adducted and neutrally rotated, elbow flexed 90 degrees, forearm in neutral position, and the wrist was maintained between 0 and 30 degree extension and between 0 and 15 degree ulnar deviation with no arm support.
- The child was asked to hold the handgrip dynamometer vertically first in his/her

right hand with the line of the forearm maintained at the standard forearm and wrist position, then the child was asked to squeeze the dynamometer as hard as he/she could (figure 1). The same procedure was repeated for the left hand. The measurement recorded as right and left hand score The recommendations of Harkonen et al 13, Ashton 14 were followed as they recorded that the use of single measurement is accurate and time efficient and no significant difference was noted when measuring maximum grip strength between one and three trials.

Table (1): The physical characteristics of boys and girls (age, height and weight).

	Boys			Girls		
Age (Y)	number	height	Weight	Number	Height	Weight
6	15	116.2±5.1	22.1±2.7	17	112.3±4.6	20.7±5.9
7	9	121.7±2.3	27.6±4.1	14	119.6±6.7	27.1±3.7
8	10	128.9±5.8	30.3±3.4	11	124.9±4.7	29.8±6.2
9	14	135.4±3.1	33.8±4.7	14	136.1±4.5	34.6±5.2
10	11	142.2±5.4	35.8±6.2	16	139.8±5.5	33.9±7.1
11	15	148.4±6.3	38.7±5.9	15	149.9±8.6	40.2±5.8
12	13	159.5±3.5	44.1±4.6	16	153.2±6.4	48.3±8.6

Fig. (1): The standardized arm and hand position for handgrip strength measurement.

Data Analysis

Measurement of the hand grip strength for both dominant and non-dominant hands was analyzed by using SPSS (statistical Package for Social Sciences ®, version 16). A repeated measure analysis of variance (ANOVA) was used.

RESULTS

As shown in table (2) and demonstrated in figures (2) and (3) the results showed that the right and left handgrip strength for boys and girls increase by age. Right handgrip strength varied between 9.4±1.1for boys and 9.5± 0.9 for girls at age of 6 years, reached to 23.7±4.6 for boys and 21.2±4.2 for girls at age of 12 years. The left handgrip strength was 7.1±1.3 for boys, 6.7±1.4 for girls at the age of 6 years, increased to 20.7±3.7 for boys and 19.1±3.6 for girls at age of 12 years. The percentage of the difference between right and left handgrip strength (the rule of 10%) was ranged from 11% to 13.2% for boys and 11.1% to 14.2% for girls.

Table (2): Mean values and difference in percentage of handgrip strength for boys and girls from 6 to 12 year.

Boys					Girls			
Age (Y)	No	Right handgrip strength (Kg) X±SD	Left handgrip strength (Kg) X±SD	Difference of Rt and Lt %	No	Right handgrip strength (Kg) X±SD	Left handgrip strength (Kg) X±SD	Difference of Rt and Lt %
6	15	9.4±1.1	7.1±1.3	13.2	17	9.5±0.9	6.7±1.4	14.2
7	9	10.9±1.4	9.9±1.7	11.0	14	10.4±2.8	8.9±2.3	11.7
8	10	13.1±2.9	10.6±1.8	12.4	11	12.6±1.7	9.6±1.3	13.1
9	14	15.2±3.1	12.8±4.2	11.9	14	15.1±2.9	11.7±2.7	12.9
10	12	18.5±4.4	15.9±3.3	11.6	16	17.1±5.3	14.4±3.1	11.9
11	15	21.3±4.8	17.2±4.2	12.4	15	19.8±2.8	15.6±3.5	12.7
12	13	23.7±4.6	20.7±3.7	11.4	16	21.2±4.2	19.1±3.6	11.1

X: Mean SD: Standard Deviation

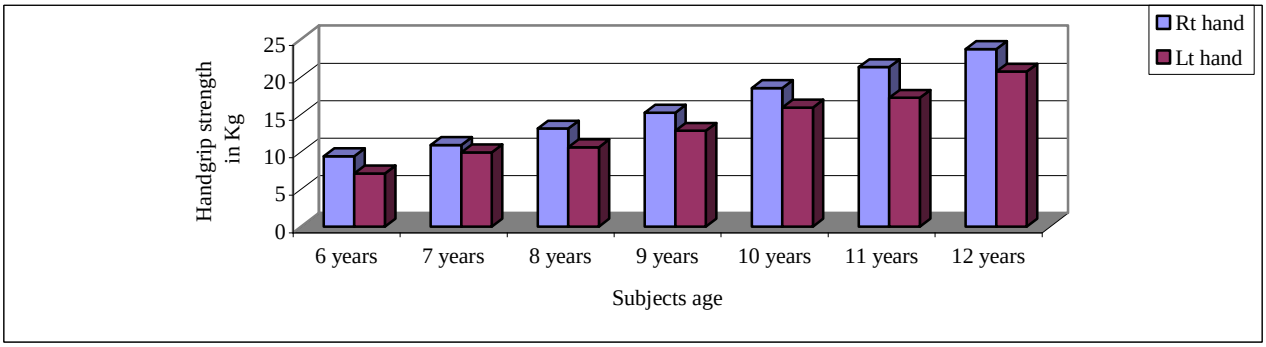

Fig. (2): Mean values of handgrip strength for boys.

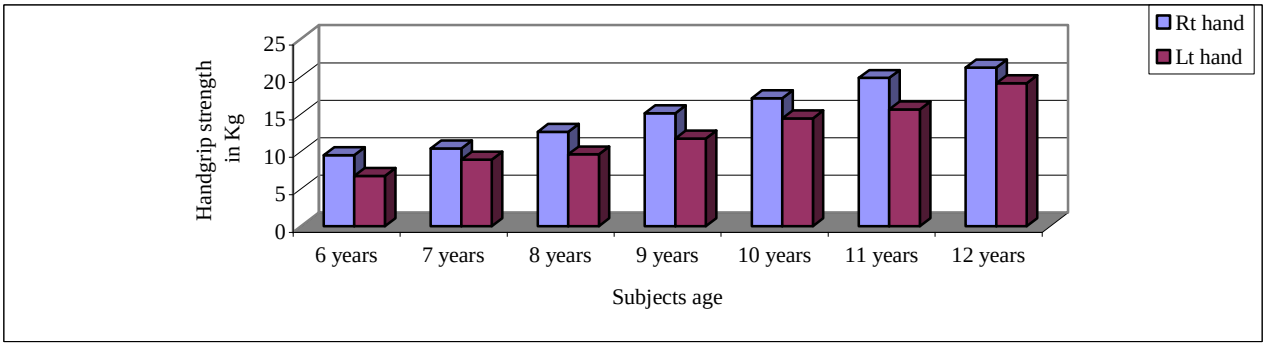

Fig. (3): Mean values of handgrip strength for girls.

Table (3), summarize the differences in mean values of hand grip strength between boys and girls. It was illustrated that there was a statistically highly significant difference of handgrip strength between right and left hands for both boys, and girls (P<0.0001). The difference between boys and girls for right handgrip strength was considered significant (P<0.01), and for left hand showed high significant difference (P<0.0001), as illustrated in figures (4) and (5).

Table (3): The difference of mean values of handgrip strength between boys and girls.

	Handgrip	Number	Mean ± SD	Difference	t-value	P-value
Boys	Right Left	88	16.014±5.358 13.314±4.866	2.7	10.383	<0.0001**
Girls	Right Left	103	15.1±4.528 12.11± 4.021	2.99	9.593	<0.0001**
Boys Girls	Right	88 103	16.014±5.358 15.1±4.528	0.9143	2.616	<0.01*
Boys Girls	Left	88 103	13.314±5.102 12.11±4.437	1.204	6.476	<0.0001**

*Significant **Highly Significant

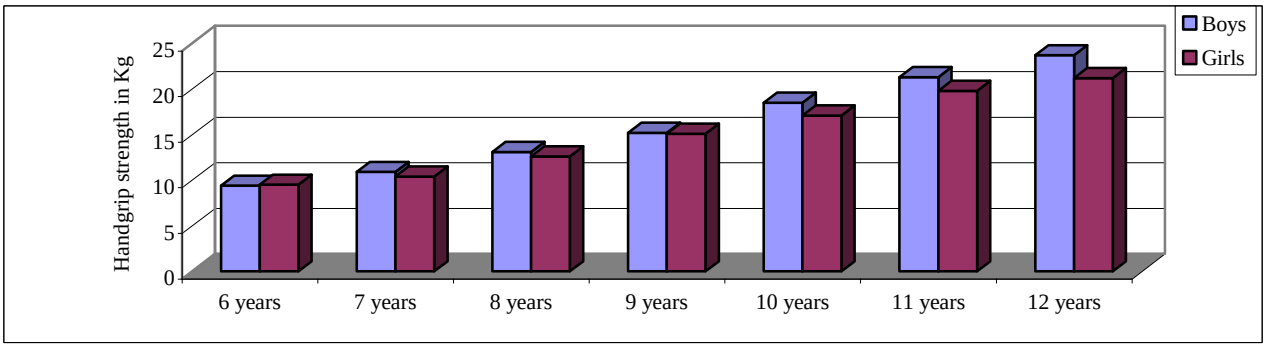

Fig. (4): Difference of mean values of right handgrip strength for boys and girls.

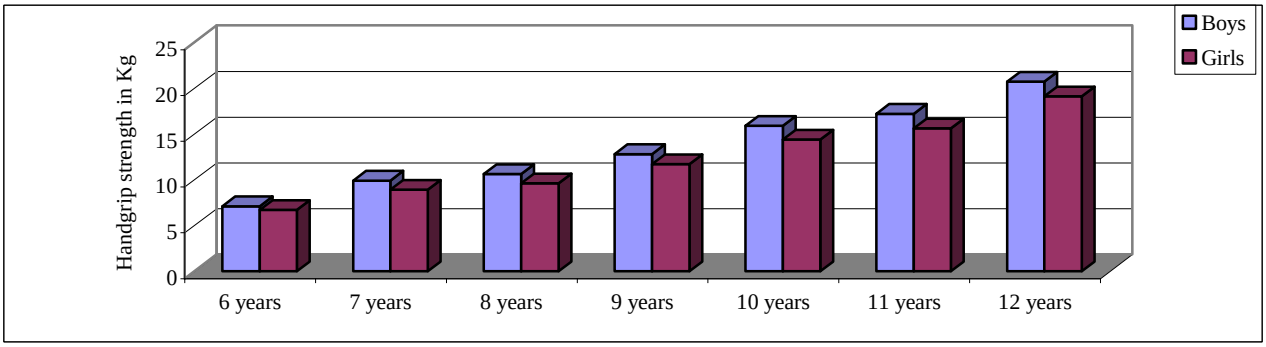

Fig. (5): Difference of mean values of left handgrip strength for boys and girls.

DISCUSSION

Measurement of handgrip strength is an essential part in evaluation of hand problems, general health and fitness status. This study was conducted to provide a normative data of handgrip strength for Egyptian children in pre-pubertal developmental stage and examine that the rule that dominant hand is approximately 10% stronger than the non-dominant hand.

The results of this study recorded the values of development of handgrip strength at different ages from six to twelve years and showed that handgrip strength progressively increase with age for both boys and girls and this increase is nearly closer in both boys and girls till the age of 9 years. As shown from the

obtained results the mean values of handgrip strength for right dominant-hand for boys and girls were (9.4, 9.5Kg at age of six years, 10.9, 10.4Kg at age of 7 years, 13.1, 12.6Kg at age of 8 years, and 15.2, 15.1Kg at age of 9 years) respectively.

In spite of the use of different procedure and instruments in the previous studies from Australia[15,16], USA[6,14,17], and Canada[18], the results of this study reported the development of handgrip strength with age similar to those studies.

The results of the current study come in agreement with Beunenet al., and Carmelli[19,20], who reported that although the growth in muscle cross sectional area was clearly greater in boys, grip strength increased similarly in the two genders till age of nine years and the similarity of the increase in grip strength in both genders suggests that this effect is independent of the hormonal changes occurring during puberty.

The obtained results also clarified that after the age of 9 years boys tended to produce higher handgrip strength than girls in both dominant and non-dominant hands. The mean values of hand grip strength for both boys and girls were 16.014±5.358 and 15.1±4.528 respectively. Right dominant hand showed a statistically significant difference ($P<0.01$) while mean values of left non-dominant hand recorded highly significant difference ($P<0.0001$) as the mean values were 13.314 ± 4.866 and 12.11±4.021 for boys and girls respectively.

These results are supported by the work of Smith et al.,[21] who suggested that the increase in maximal isometric grip strength during childhood and in preadolescence stages has two components. The first is muscle growth, which takes a gender-specific course during puberty, indicating that it is influenced by hormonal changes. The second is an increase in grip strength per muscle cross sectional area (CSA).

The results of the current study was also supported by the findings of Round et al., and Kanehisa et al.,[22,23] who showed that there are at least three effects of gender-specific prepubertal development, which all contribute to higher forearm muscle mass and strength in boys compared with girls. First, boys on average become taller than girls. This by itself should lead to generally greater force, since greater body height means greater bone length, which is an important determinant of muscle mass and force. Second, the gender difference in forearm length is even more pronounced than would be expected from the difference in height. This is because, during puberty, the forearm length-to-body height ratio increases in boys but not in girls. Third, even when the differences in forearm length are accounted for, forearm muscles grow wider in boys than in girls.

Beunen and Thomis[24] reported that gender difference in grip strength is entirely due to the higher muscle CSA in boys. Possible explanations include changes in muscle enzyme activity, an increasing proportion of type II fibers, changes in the recruitment of muscle fibers, or decreased negative feedback from Golgi tendon organs.

The results of the current study are supported by the findings of Lunde et al., Jarit, and Crosby et al.,[25,26,27] who found a consistent difference of about 10% between right and left handgrip strength in right dominant individuals (rule of 10%). In this study the rule of 10% is ranged from 11% to 13.2% for boys and 11.1% to 14.2% for girls. Petersen et al.,[28], were not holding this rule for left-dominant individuals, where strength is approximately the same in both hands. Several studies[16,29] did not report any effect of hand dominance on grip strength, while Newman et al.,[15] found a

difference in grip strength between the dominant and non-dominant hand. Häger-Ross and Rösblad[12] reported that right handed children were stronger in their right hand while no significant difference between the hands was observed for the left-hand children. This conflict of the results from different studies may be due to the lack of consistency and homogeneity which makes it difficult to draw a conclusion on the effect of hand dominance on the handgrip strength. Further studies are needed with regard to the relation between grip strength and general body strength or fatigue status for children and adults.

Conclusion

This study of the normative data of grip strength for Egyptian children in pre-pubertal developmental stage showed increase in grip strength with age. The handgrip strength was approximately parallel for boys and girls until age of 9 years after that boys showed greater grip strength than girls for right dominant and left non-dominant hand. A significant difference between right dominant and left non-dominant hand was observed for both boys and girls. The study showed the importance of the evaluation of the handgrip strength as a normative record to be used as determent of the effect of treatment strategies and is accepted that handgrip strength provide an objective index for the functional integrity of upper extremity.

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الملخص العربي

قوة قبضة اليد الطبيعية للأطفال المصريين قبل سن البلوغ

الخلفية والغرض : تستعمل البيانات المعيارية الطبيعية لقوة قبضة يد الأطفال لتقييم حالات العجز ف ي اليد وتقييم استجابة العلاج . كان الغرض من الدراسة هو إمدادنا بالبيانات المعيارية الطبيعية لقوة قبضة يد الأطفال المصريين في مرحلة ما قبل البلوغ من عمر 6 إلى 12 سنة واختبار قاعدة ال10%. الأشخاص . 191 من أطفال المدارس الأصحاء (88 ولد و103 بنت) . **الطريقة :** قياس قوة قبضة اليد اليمنى السائدة واليد اليسرى الغير سائدة باستخدام جهاز الديناموميتر اليدوي المعاير . **النتائج :** أظهرت النتائج زيادة في قوة قبضة اليد اليمنى السائدة واليد اليسرى الغير سائدة مع زيادة العمر بالتوازي لكل من الأولاد والبنات حتى عمر 9 سنوات. بعد ذلك يظهر الأولاد زيادة كبيرة فى قوة قبضة اليد اليمنى السائدة واليسرى غير السائدة أكثر من البنات. أتضح أن هناك اختلاف ذو دلالة هامة بين اليد اليمنى واليد اليسرى لكل من الأولاد والبنات (<0.0001) النسبة المئوية للفرق بين قوة قبضة اليد اليمنى واليد اليسرى كانت بين 11% إلى 13.% للأولاد و 11.1 إلى 14.2 للبنات. الخلاصة. تعتبر البيانات الطبيعية لقوة قبضة اليد للأطفال المصريين قبل سن البلوغ مهمة لإمداد كل من المعالج والطبيب بقاعدة تقييم أساسية لمقارنة درجة إعاقة المريض.

الكلمات الدالة : قوة قبضة اليد – القيم الطبيعية – الأطفال .