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Hand grip strength and dexterity function in children aged 6-12 years: A cross-sectional study

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ABSTRACT

Study Design: Cross-sectional and clinical measurement.
Introduction: Assessment of hand function considers an essential part in clinical practice.
Purpose of the Study: To develop normative values of hand grip strength and dexterity function for 6-12-year-old children in Saudi Arabia.
Methods: Grip strength and dexterity function was measured in 525 children using Grip Track hand dynamometer (JTECH Medical, Midvale, UT, USA) and 9-hole pegboard test respectively.
Results: The grip strength and dexterity function was improved as age progressed regardless of gender. Across all age groups, the hand grip strength of boys was significantly higher than girls for dominant hand (31.75 ± 10.33 vs 28.24 ± 9.35; $P < .001$) and nondominant hand (31.01 ± 10.27 vs 27.27 ± 9.30; $P < .001$). The girls performed slightly faster than boys for dominant hand (19.70 vs 20.68; $P < .05$) and nondominant hand (21.79 vs 23.46; $P < .05$). In general, girls completed a 9-HPT faster than boys in the 2 of 7 age groups: 11 years (9-HPT scores = 2.10 seconds; $P < .01$) and 12 years (9-HPT scores = 1.93 seconds; $P < .01$).
Discussion: The overall patterns of hand grip strength and dexterity function observed in the present study are similar to the previous studies that established acceleration of grip strength with advanced age, and faster performance scores in older children than younger children in both genders.
Conclusions: Norms of hand grip strength and dexterity enable therapists to identify some developmental characteristics of hand function among Saudi children, determine the presence of impairment, and compare scores from children in different clinical settings.
Level of Evidence: Not applicable.

Introduction

Hands are the most effective means of communication and performing the complex tasks of daily living activities (eg, eating, grooming, and bathing). Work activities as well as play and leisure activities require both grip strength and manual dexterity.[1-3] Moreover, 60% of school activities require fine motor and manual dexterity skills.[4] Therefore, the assessment of hand function is an essential part of physical and occupational therapy evaluation for children with a range of disorders, such as trauma, congenital, and neurologic disorders. Normal data on hand grip strength and manual dexterity are important to identify the developmental level and degree of disability; determine efficacy of rehabilitation and assess the integrity of upper limb functions; and compare scores from typical and atypical children according to the age, gender, race/ethnicity, and body measures.[1-3,5,6]

A few studies have been published on measurement of manual dexterity of the hand in children.[7-11] Smith et al[7] and Yim et al[8] published a normative data of hand dexterity using the 9-hole peg test (9-HPT) for children aged 5-10 and 7-12 years, respectively. Furthermore, Poole et al[9] measured manual dexterity in

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children aged 4-19 years using 9-HPT. The authors proposed that the 9-HPT may be an appropriate screening tool because it reflects multiple aspects of motor control, such as preshaping the hand, grasping, moving, and releasing the object.[8,9] However, this manual screening test is not routinely performed for children to detect their dexterity level, and there is no report on the normative values among Saudi children.

Several studies have reported norms of hand grip strength in children.[8,12-27] The most recent studies provided data from children in Sweden,[20] Korea,[8] The Netherlands,[21] the United States,[22] Spain,[23] England,[24] and Canada.[25] Earlier studies were from children in the United States[13,15,17,18] and Australia.[14,16] A thorough review of these studies suggests a decreased grip strength over the past 3 decades and concluded that hand functions (eg, grip strength and manual dexterity) might be changed over generations and across countries.[20-25] Thus, establishing the norms of hand grip strength and manual dexterity for each geographic region is important for hand therapists to assess impairment and tracking progress among patients. Moreover, past research has suggested that Saudi children have lower values of height and weight than Western children.[28,29] This variation in demographic characteristics might influence grip strength and dexterity vs existing Western demographics. Therefore, the norms of grip strength and manual dexterity from Western countries are inappropriate because they did not consider the differences in physical characteristics according to race/ethnicity and region.[20] Therefore, the purpose of this study was to develop reference values for grip strength and dexterity function in Saudi children aged 6-12 years.

Methods

Subjects

Elementary school children (6-12 years; $n = 525$) were recruited from the urban central area of Riyadh, Saudi Arabia. All children and their parents signed consent form describing the aims and procedures of this study. The study was approved by the Ethics Committee, Rehabilitation Research Chair, King Saud University, Saudi Arabia. To establish accurate norms, children with certain abnormalities were excluded from this study such as cognitive/neurologic disorders, delayed milestones, pain or functional limitations of the upper limbs, or inability to understand the test procedures.

Instrumentation and procedures

Researchers collected the demographic data, including age, gender, weight, and height. The body weight was measured using a portable weighing scale (Camry, model: EF921; Zhonghan, Camry Electronic, Co, Ltd, China) to the nearest 0.1 kg. The height was measured with a stadiometer to the nearest 0.1 cm. Then, body mass index 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.[8,20] All measurements were obtained in the air-conditioned room of the health supervisor during the school day from 8 to 11 AM. The children were allowed to short practice using the dynamometer and 9-HPT to become familiar with test procedures. A sample of 40 children was randomly selected to evaluate test-retest reliability of the hand dynamometer and 9-HPT among Saudi children under the same conditions and procedures with a mean interval of 7 days.

Assessment of hand grip strength

Hand grip strength was measured using a standard adjustable hand dynamometer (J-Tech 12-0259 Commander Grip Track Dynamometer, JTECH Medical, Midvale, UT, USA) based on the recommendation of the American Society of Hand Therapists.[5]

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.[4,30,31] Children were instructed to squeeze the handle of the dynamometer as hard as they could and to sustain the effort for 5 seconds. Verbal encouragement (ie, squeeze as hard as you can) was provided to children during testing. Children performed 3 trials for each hand, and the mean values of these trials were recorded. Children were given 1 minute to rest between trials, and trials were completed with alternating hands to minimize the effects of fatigue.[32] Results were recorded in pounds. If a measurement showed a difference greater than 10% from previously obtained measurements, then we did not retain that measurement and instead conducted a fourth trial.[21] These procedures have been previously well documented as reliable.[33,34] The calibration of instruments was tested periodically during the study according to the manufacturer's manual.

Assessment of hand dexterity

Hand dexterity was measured using the 9-HPT (Sammons Preston, PO Box 93040, Chicago, IL). The 9-hole pegboard is on a 5-inch square pegboard. Each peg hole is 3 cm deep, 2.5 cm diameter, and located 2 cm from adjacent peg holes, which are arranged in 3 rows of 3. Each peg measures 4 cm in height and 2.2 cm in diameter and has a dot marked on 1 side. A stopwatch was used to time the 9-HPT. The procedures described by Mathiowetz et al[35] were used in this study. Each child was tested separately while he and she sat at a desk and chair of appropriate height with their feet supported on the floor to ensure that the tabletop was at the midchest level. The pegboard was centered in front of a child with the container next to the board on the same side of the hand being tested.[7-9] The dominant hand was tested first followed by the nondominant hand. The child was instructed to pick up 1 peg at a time using 1 hand only and to put them in the holes until all 9 were filled. The child then removed the pegs from the holes one by one. The order of placement was not prescribed. For the nondominant hand, the pegboard was turned so that the container was on the same side as the nondominant hand. During the test, the therapist instructed the child not to touch the peg with the free hand and chest.[7-9] The score was the total time in seconds to complete the task. Timing began on contact with the first peg and ended with return of the final peg to the dish. The average time of 3 trials was used in analysis.

Statistical analysis

Data were described as mean and standard deviation for continuous variables and median and mode for categorical variables. Test-retest reliability was analyzed using interclass correlation coefficient (ICC). Unpaired and paired t tests were used to determine between-subjects and within-subject differences regarding hand grip differences and dexterity, respectively. A 2-way mixed-design analysis of variance was used to compare sex (between-subject factor) and hand dominance (within-subject factor). The Tukey post hoc test in separate analyses of variances was used to examine differences between specific age groups for boys and girls. Correlation between variables was assessed using Pearson correlation coefficient, and simple and multiple liner regression