SCIENTIFIC ARTICLE

Hand Function With Touch Screen Technology in Children With Normal Hand Formation, Congenital Differences, and Neuromuscular Disease

David H. Shin, BA, Deborah K. Bohn, MD, Julie Agel, MA, Katy A. Lindstrom, BA, Sara M. Cronquist, Ann E. Van Heest, MD

Purpose To measure and compare hand function for children with normal hand development, congenital hand differences (CHD), and neuromuscular disease (NMD) using a function test with touch screen technology designed as an iPhone application.

Methods We measured touch screen hand function in 201 children including 113 with normal hand formation, 43 with CHD, and 45 with NMD. The touch screen test was developed on the iOS platform using an Apple iPhone 4. We measured 4 tasks: touching dots on a 3 × 4 grid, dragging shapes, use of the touch screen camera, and typing a line of text. The test takes 60 to 120 seconds and includes a pretest to familiarize the subject with the format. Each task is timed independently and the overall time is recorded.

Results Children with normal hand development took less time to complete all 4 subtests with increasing age. When comparing children with normal hand development with those with CHD or NMD, in children aged less than 5 years we saw minimal differences; those aged 5 to 6 years with CHD took significantly longer total time; those aged 7 to 8 years with NMD took significantly longer total time; those aged 9 to 11 years with CHD took significantly longer total time; and those aged 12 years and older with NMD took significantly longer total time.

Conclusions Touch screen technology has becoming increasingly relevant to hand function in modern society. This study provides standardized age norms and shows that our test discriminates between normal hand development and that in children with CHD or NMD.

Type of study/level of evidence Diagnostic III.

Key words Pediatric, hand, function.

Additional material is available online.

From the Departments of Orthopaedic Surgery and Internal Medicine, the Medical School, and Program in Occupational Therapy, University of Minnesota, Minneapolis; and Gillette Children's Specialty Healthcare, St. Paul, MN.

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Corresponding author: Ann E. Van Heest, MD, Department of Orthopaedic Surgery, University of Minnesota, 2450 Riverside Avenue, Suite R200, Minneapolis, MN 55454; e-mail: vanhe003@umn.edu.

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HAND FUNCTION TESTS ARE AN important clinical tool to assess children's functional daily task capabilities. Administration of such tests allows clinicians to measure performance more accurately, such as dexterity, strength,[1,2] range of motion, and effectiveness of treatment. Emerging technology with use of a touch screen for education, work, and entertainment has highlighted new functional tasks needed, particularly in children. Use of emerging technologies as an important hand function has called for the creation of new types of hand function testing.

In pediatrics, hand function tests are also used to assess developmental progress by comparing age norms. Gogola et al[3] noted, "Having population norms for a functional test is particularly helpful with pediatric populations, because ability changes with growth and development. Even if the absolute values for a population are not expected to reach normal values, comparing the rate of development over time is valuable." Age norms allow clinicians to evaluate the extent of injury or abnormality, track development, and monitor recovery progress.

Several validated hand function tests are currently in use, including the Purdue Pegboard, Bennett Hand Tool Dexterity Test, Rosenbusch Test of Finger Dexterity, Jebsen Hand Function Test, 9-Hole Peg Test, Box and Blocks, and Functional Dexterity Test.[4] These hand function tests are valuable but they do not consider emerging technological trends, such as the use of touch screens. All of the hand function tests with pediatric norms measure manual manipulation of small objects.[3,5–8] In a technologically evolving world in which communication, entertainment, and work increasingly rely on the ability to use touch screen devices, assessing hand function using a mobile device might be beneficial.

This report aimed to develop a hand function test using touch screen technology that could measure age norms for hand function for children with normal hand development and to discriminate differences in hand function for children with congenital hand differences (CHD) or neuromuscular disease (NMD).

MATERIALS AND METHODS

Development of the test

We developed the Minnesota Hand Function Test on the Apple iPhone 4 (Apple, Cupertino, CA) using their operating system known as iOS (Apple). Two hand surgeons, a therapist, and an avid technology user formed the working group to design the test. Hand function tasks with typical applications present on a touch screen phone were reviewed and deconstructed into 4 tasks. The first hand function, the ability to touch an item on the screen, was designed as "dots," a 3 × 4 grid of dots that light up in random order. As the dots are lit, the subject must be able to accurately touch them. Once a dot has been touched, another will light up and the task will be repeated. The second hand function, the ability to touch and drag an item on the screen, is designed as "shapes," which is 4 shapes displayed on the screen with an outline of a shape in the center of the screen. The subject must be able to touch and drag the shape accurately to match the shape in the center of the screen. The third hand function is the ability to hold the iPhone using 2 hands and to take pictures in different directions. The subject must point the phone toward the floor, ceiling, and wall while pushing the icon to take a picture. The fourth hand function, typing, is designed as a text message that is typed into the text message box. In addition, because of inherent difficulties in testing children, we wanted our test to be brief and easily administered in the outpatient setting. Owing to these aims, we designed each component of the test to be approximately equal in length for an experienced touch screen user, with each taking 15 to 30 seconds, for a total of 60 to 120 seconds. Finally, we designed an identical but shorter learning version of the test to familiarize participants with the test parameters and minimize any potential learning effect.

Phase I testing

Once the test had been developed, we obtained institutional review board approval for an initial study to determine whether the test was useful for discriminating between children with normal and impaired hand function. We administered the test to a total of 74 total subjects (32 were judged to be impaired and 42 were judged to be normal). Data demonstrated that the test showed an increase in completion time in the impaired group, but this difference was not statistically significant. We then expanded institutional review board approval to include more subjects so as to investigate this result further.

Testing protocol

The test was administered at Gillette Children's Specialty Healthcare in St. Paul, Minnesota, at an upper extremity orthopedics clinic under the supervision of a board-certified pediatric orthopedic hand specialist. Participants were seated on a chair next to the computer desk in the clinic room. The test administrator opened the application on the Apple iPhone 4 and recorded demographic information. The learning mode was selected and the device was handed to the participant. On-screen instructions were provided with verbalization of these instructions by the test administrator before the start of each segment. Instructions for each segment were as follows: dots (Fig. 1A), "Tap the red dots"; shapes (Fig. 1B), "Move the correct colored shape into the white space"; camera, "Take a picture of the wall"; and text, "Type the sentence into the box below (there is no autocorrect)." At the end of each segment, a prompt