Journal of Hand Therapy 28 (2015) 144–150

Contents lists available at ScienceDirect

Journal of Hand Therapy

journal homepage: www.jhandtherapy.org

JHT Read for Credit Article #362.

Special Issue

Innovative evaluation of dexterity in pediatrics

Susan V. Duff EdD, PT, OTR/L, CHT[a,*], Dorit H. Aaron MA, OTR, CHT, FAOTA[b], Gloria R. Gogola MD[c], Francisco J. Valero-Cuevas PhD[d]

[a] Thomas Jefferson University, Department of Physical Therapy, 901 Walnut St., Suite 510, Philadelphia, PA 19107, USA
[b] Aaron & Winthrop Hand Therapy Services, Inc, 2723 Amherst, Houston, TX 77005, USA
[c] Shriners Hospitals for Children, Houston, 6977 Main St, Houston, TX 77030, USA
[d] University of Southern California, Biomedical Engineering Department and Division of Biokinesiology & Physical Therapy, 3710 S. McClintock, RTH 402, Los Angeles, CA 90089, USA

ARTICLE INFO

Article history:
Received 22 December 2014
Received in revised form
12 January 2015
Accepted 12 January 2015
Available online 22 January 2015

Keywords:
Dexterity
Measurement concepts
Functional Dexterity Test
Strength–Dexterity

ABSTRACT

Study design: Review paper.
Introduction: Hand dexterity is multifaceted and essential to the performance of daily tasks. Timed performance and precision demands are the most common features of quantitative dexterity testing. Measurement concepts such as rate of completion, in-hand manipulation and dynamic force control of instabilities are being integrated into assessment tools for the pediatric population.
Purpose: To review measurement concepts inherent in pediatric dexterity testing and introduce concepts that are infrequently measured or novel as exemplified with two assessment tools.
Methods: Measurement concepts included in common assessment tools are introduced first. We then describe seldom measured and novel concepts embedded in two instruments; the Functional Dexterity Test (FDT) and the Strength–Dexterity (SD) Test.
Discussion: The inclusion of novel yet informative tools and measurement concepts in our assessments could aid our understanding of atypical dexterity, and potentially contribute to the design of targeted therapy programs.

Introduction

Clinicians examine dexterity to gauge skill level and change in performance after hand surgery or rehabilitation. Differences in proficiency based on age, development, hand dominance, cognition and clinical conditions are verified through assessment. The purpose of this paper is to review measurement concepts integral to pediatric dexterity testing and introduce concepts that are seldom measured or novel as exemplified with two assessment tools.

The terms “dexterity” and “manipulation” have many definitions and connotations. In children dexterity and manipulation skills change with development which also presents a challenge to their assessment. Therefore, it is critical that the clinician select and use a tool that can quantify, and is sensitive to changes in the components of dexterity of clinical interest in the developing child. Our objective is not to advocate for a specific dexterity assessment tool—as this depends on the scientific and clinical purpose of measurement. Instead, we review features of dexterity and measurement concepts that are integral to common tools validated in pediatrics and introduce innovative concepts embedded within the design of a few sample instruments.

Dexterity measurement

Dexterity can be measured by observing task performance, recording from a checklist or using a standardized assessment tool. Common features of standardized tools are timed performance and precision. The time for task completion is often measured in seconds or minutes using a timer.[1,2] Precision is illustrated by the expectation to place small rings on thin pegs as in the Purdue Pegboard Test.[3] Table 1 outlines features of dexterity testing measured with common tools that have normative values for children. Normative reference values are useful with pediatric populations, where it is important to distinguish between expected developmental changes and the effects of intervention.

Features of dexterity that are not often measured or are more difficult to measure include: 1) rate of completion; 2) in-hand manipulation; and 3) dynamic force control. For example, in-hand manipulation has been explored but not fully integrated into dexterity testing (see Table 1). To better understand the value of including innovative measurement concepts in our assessments,

* Corresponding author.
E-mail address: susan.duff@jefferson.edu (S.V. Duff).

0894-1130/$ – see front matter © 2015 Hanley & Belfus, an imprint of Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jht.2015.01.004

Table 1
Features of common pediatric dexterity tests with normative data

Dexterity test	Pediatric norms	Timed test	Precision	In-hand manipulation	Time to administer
Box and Block[4–6]	6–19 years	Yes	Yes	No	<5 min[a]
Grooved Pegboard Test[1,7]	3–20 years	Yes	Yes	Yes – rotation of peg	>5 min
Jebsen Taylor Hand Function Test[6,8]	6-19 years	Yes	Yes – stack checkers	Yes – rotation of spoon	>5 min
Nine Hole Peg Test[1,2]	3–20 years	Yes	Yes	Yes – rotation & translation of peg assessed – not validated[9,10]	<5 min
Purdue Pegboard[1,3,6,11,12]	2.6–5.11 years, 5–15 years, 14–19 years	Yes	Yes	No	<5 min

[a] <5 = less than 5; >5 = more than 5; min = minutes.

we will review the concepts and describe a few dexterity tests that incorporate them.

Rate of completion and in-hand manipulation

In addition to measuring the time to task completion, performance can be expressed as a rate of task completion (i.e., speed).[13] This scoring strategy allows for statistically valid numerical comparisons against other quantitative functional variables and graphing of *rate of completion* along a continuous age scale. Although useful, this scoring strategy is rarely used in dexterity testing.

In-hand manipulation (IHM) is defined as movement or adjustment of an object as it is held with one hand.[13] Although there are other taxonomies for IHM,[14–16] the classification scheme by Exner[17,18] is described here by three main features: shift (movement across finger pads), translation (finger-to-palm and palm-to-finger), and rotation (simple and complex). The three components of IHM are assessed with the task of picking up a coin and placing it in a vertical slot. In this example, shift is displayed when we move the coin across the finger pads. Palm-to-finger translation is demonstrated when we move the coin from the palm to the finger pads. Finally, complex rotation is illustrated when we turn the coin on its axis with the fingers before placement in a slot.

IHM develops between 18 months and 7 years of age.[17,19] By 3 years of age, IHM has developed to the point that standardized testing can be reliably performed.[9,10,18] IHM is required to complete the Functional Dexterity Test (FDT).[13,20]

Functional Dexterity Test (FDT)

The Functional Dexterity Test (North Coast Medical, Gilroy, CA) is a timed pegboard instrument.[20] The FDT is not new but employs the unique concepts of rate of completion and in-hand manipulation that are not commonly measured. When validated in adults, the FDT had excellent test-retest (ICC = 0.95) and intra-rater (ICC = 0.91) reliability.[20] When compared against performance tests that assess activity and participation, it had the highest ratings for clinimetric quality.[21] Adult FDT normative reference values are published[20] and were recently updated.[22] Pediatric normative values are also available.[13]

The FDT consists of 16 cylindrical pegs (4 cm × 2.2 cm) arranged in four rows of four pegs each (Fig. 1). It requires a tripod pinch and two aspects of IHM: rotation and shift. Participants turn over all pegs (*rotation*) in a specified order by manipulating each peg with the finger pads (*shift*). Participants complete one practice trial and the second trial is timed. Results are recorded as the number of pegs completed divided by time elapsed (pegs/time). This calculation of a test score provides a measure of *speed*.[23] The original FDT scoring involved assessing penalties and adding their point values to the test completion time to arrive at a final score.[20] Even though the penalties were subsequently modified for children,[24] they proved inadequate. As grasp and movement patterns develop, a true assessment of pediatric penalties would require a menu of changing, age-specific items, which hampers the ease of test administration. Inefficient movements are reflected in decreased speed, thus do not require the additional adjustment for penalties.[13] The FDT is sensitive enough to detect *functional* inefficiencies of IHM; therefore, penalties have been eliminated from pediatric FDT scoring.

Normative FDT speed (pegs/sec) for the dominant and non-dominant hands among typically-developing children increases linearly with age at a constant rate of 0.037pegs/sec/year between 3 and 17 years of age (Fig. 2).[13] There are no gender differences through 17 years of age. Dominant hands are faster than non-dominant hands at all ages and the difference between the two remains constant.

Presenting normative values as a "growth chart" of FDT speed versus age facilitates easy visualization of expected speed for any given age using a continuous age scale. The use of regression on fractional age provides a more precise estimate of performance than would be possible by presenting the data in a table grouped by

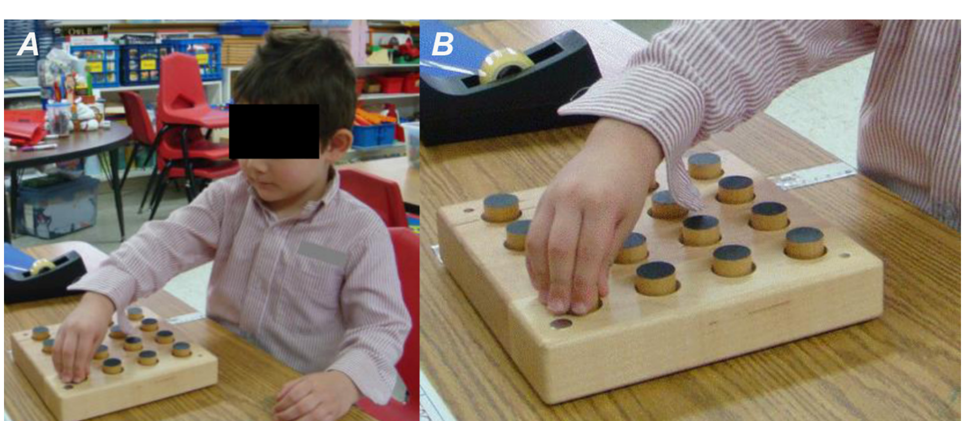

Fig. 1. A: The FDT can be easily administered to very young children, allowing for longitudinal evaluation into adulthood. B: An unimanual 3-jaw chuck prehension pattern is required.