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Assessing manual dexterity: Comparing the WorkAbility Rate of Manipulation Test with the Minnesota Manual Dexterity Test

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ABSTRACT

Study Design: Cross-sectional study.
Introduction: The WorkAbility Rate of Manipulation Test (WRMT), an adaptation of the Minnesota Manual Dexterity Test (MMDT), contains a revised board and protocols to improve its utility for therapy or fitness assessment.
Purpose of the Study: To describe the development and preliminary psychometric properties of WRMT.
Methods: Sixty-six healthy participants completed MMDT and WRMT in a random order followed by a user experience survey. We compared tests using repeated-measures analysis of variance, test-retest reliability, and examined agreement between tests.
Results: Despite the similarities of these 2 instruments, the different administration protocols resulted in statistically different score distributions ($P < .001$). Results supported good test-retest reliability of WRMT (placing test ICC = 0.88-0.90 and turning test ICC = 0.68-0.82). The WRMT correlated moderately with MMDT ($r = 0.81$ in placing test and $r = 0.44$-0.57 in turning test). Bland-Altman plot showed that the differences in completion time were 3.8 seconds between placing tests and 19.6 (both hands), 0.3 (right hand), and 3.9 (left hand) seconds between turning tests. Overall, participants felt that the instruction of WRMT was easier to follow (44%) and preferred its setup, color, and depth of the test board (49%). Time required to complete 1 panel of 20 disks correlated highly with the time needed to finish a complete trial of 60 disks in both MMDT ($r = 0.91$-0.97) and WRMT ($r = 0.88$-0.95).
Conclusions: Caution is warranted in comparing scores from these 2 test variants.
Level of Evidence: 3b.

Introduction

Dexterity (hand function) is defined as a manual skill requiring rapid coordination of fine and gross movements based on a certain number of capacities developed through learning, training, and experience.[1] It requires speed and precision, high-level eye-hand coordination, and fine motor control of the hand to quickly move one or both hands rapidly and skillfully to perform gross grasping, placing, turning, and manipulation motions.[2,3] Such ability greatly impacts performance on many daily living and employment tasks. Throughout the life span, dexterity may be impaired due to aging, injuries, or disease, which results in varied degree of activity limitations and participation restrictions.[4-6]

Many measures have been developed to assess manual dexterity.[7-10] The Minnesota Manual Dexterity Test (MMDT) was introduced in 1991 by Lafayette Instrument Company. This test was an adaptation of a similar test called the Minnesota Rate of Manipulation Test (MRMT) that was developed in early 1930s by the Minnesota Employment Stabilization Research Institute but is no longer manufactured. Together, these 2 tests have been applied to measure manual dexterity function in persons with impairments of the hand,[11] assessment of functional outcomes after upper limb and hand surgery,[12-14] rehabilitation therapy,[15-17]

Disclosure: Rick Wickstrom, PT, DPT, CPE, CDM, is employed by the WorkAbility Network and WorkerFIT, West Chester, OH. Dr Wickstrom provided the assessment tool and the manual of the WorkAbility Rate of Manipulation Test but was not involved with data collection and data analysis. The remaining authors declare that they have no conflicts of interest to disclose.

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neuromuscular recovery after parathyroidectomy,[18] effectiveness of a prosthesis,[19] study of hand preference,[20] manual lateralization,[21] industrial work performance,[22] and to validate other outcome measures.[23]

The MMDT consists of 60 cylinders per disks painted red on one side and black on the other side that fit in a 4 × 15 hole pattern on a black plastic folding board that is 85.4 cm long, 22.8 cm wide, and 0.5 cm deep. The MMDT includes 2 subtests: a placing test that uses only the dominant hand, and a turning test that uses both hands simultaneously. The MMDT requires the participant to pick up and place the disks in a specific sequence while in a standing posture. In a review of physical fitness measures of older people, a concern was identified that MMDT may be less acceptable for administration to persons with lower cognitive functioning due to its complexity instructions.[24] For example, the turning test requires the disk to be transferred from leading hand to the other hand to place it down with the other side (color) facing up in a specific sequence that is difficult to teach to persons with lower cognitive functioning and which may not be the most productive method for turning over the disks. The MMDT placing test also requires a specific placing sequence to transfer the disks with the dominant hand only. The combination of using both hands for the turning test and only the preferred hand for the placing test does not allow a clinician to distinguish right vs left hand performance differences that are important to determine the impact of injury for an injured side to the uninjured side. Furthermore, the MMDT board width is too wide for accommodations to administrate the test within the usual ergonomic reach zone for seated work or on an adjustable-height tray table if the individual is unable to tolerate standing or bending over to perform MMDT at a standard desk height.

To improve the utility of manual dexterity testing for disability evaluation and fitness monitoring, WorkAbility Center proposed the WorkAbility Rate of Manipulation Test (WRMT) in 2013. This is an adaptation of MMDT that uses the same black and red disks as MMDT but with a different board design and subtests. The WRMT board is white rather than black for better color contrast for persons with low vision. It has 3 sections that may be connected in different configurations using pins. This allows test administration with a more compact board (67.2 cm long, 27.9 cm wide, and 0.8 cm deep) that fits on an adjustable tray table. The 5 × 12 hole pattern for WRMT is favored by rehabilitation professionals who perform the WorkAbility Functional Capacity Evaluation because this compact board dimension enables administration with a seated or elevated surface accommodation that is consistent with ergonomic guidelines for reach limits during seated or standing manipulation tasks.[25] In addition, the board is thicker and has more adequate hole clearance for the disk than the folding board supplied with MMDT. This change in board design makes it easier to lift the board off the disks for setup for the placing test. Finally, a simpler method and instructions are described for WRMT to render this version more acceptable for administration to persons with lower cognitive functioning.

The manual for current version of MMDT references reliability and reference values for MRMT. There was 1 prior study that compared the current version of MMDT with the original MRMT in a small sample of healthy elderly people that demonstrated an acceptable to high test-retest reliability for 1 trial (intraclass correlation coefficient [ICC], 0.79-0.88) and a high correlation (0.85-0.95) between these versions despite different results.[26] Although WRMT is similar to MMDT, the norms, reliability, and validity results cannot be generalized from MMDT because of the different testing procedures and setup.[22,27]

The purpose of this study was to describe the development of WRMT and compare the psychometric properties between MMDT and WRMT by assessing the participants' score distributions (first 20 and 60 disks), test-retest reliability, concurrent validity, and user experience.

Methods

Participants

Participants were recruited from the community within close proximity to the University of Wisconsin-Milwaukee campus and were eligible for inclusion if they were between 18 and 80 years and healthy without major orthopedic or neurologic impairments. Individuals were excluded if they had severe cognitive or comprehension deficits that prevented them from following verbal commands and concurrent and/or confounding medical conditions (eg, cardiopulmonary illness, musculoskeletal injury, stroke, spinal cord injury, multiple sclerosis, arthritis) that would render them unfit to participate. Institutional Review Board at the University of Wisconsin-Milwaukee approved the project.

Protocol

Eligible participants signed informed consent form and answered questions related to demographics to ensure eligibility. Within a single session, participants completed MMDT and WRMT in a random order. A trained test administrator followed the instruction manual to administer each test. Participants watched video demonstrations on each test battery before each administration. Each subtest was completed twice while standing. At the end of the session, participants completed a survey to evaluate their user experience.

Minnesota Manual Dexterity Test

The MMDT includes 2 subtests: placing test (dominant hand) and turning test (both hands). During the placing test, the plastic folding board was placed proximal to the participant on table with disks aligned behind board. Participants were asked to place the disks into the holes of the board using their dominant hand and predetermined pattern. Beginning with the bottom disks on the furthest right column, participants used to dominant hand to pick up and insert disks to the top hole of the corresponding column on the board. Working bottom to top, right to left, participants inserted disks as fast as they could until the entire board was filled. During the turning test, participants followed instructions using both hands in predetermined pattern and were instructed to complete task as quickly as possible. The participants began with the disk in the upper right hand corner, continues leftward, moves down to row 2 and works rightward, and continues to snake across board until ending at lower right-hand corner. For the first and third rows, participants moved right to left, using their left hand to pick up the disk, turning the disk while passing to the right hand and returning disk to original hole in the board with bottom side facing up. The second and fourth rows, participants moved left to right, using their right hand to pick up the disk, turning the disk while passing to the left hand and returning disk to original hole in the board with bottom side facing up.

WorkAbility Rate of Manipulation Test

The WRMT includes 4 subtests: (1) placing test (dominant), (2) both hands turning test, (3) right-hand turning test, and (4) left-hand turning test. For placing test, participants were instructed to place disks into the holes of the board from the back of the table to the front of the table. The instructions were simple to "*Reseat the cylinders in the board with the same color facing up as quickly as you can*." For the turning test, the examiner (in the video clip) demonstrated 1 trial with both hands, with each hand picking up and turning over an individual disk simultaneously. The