Validity And Reliability of The Chicago-Quick Hand Function Test

ABSTRACT

Study Design: Clinical measurement and normative study.

Level of Evidence: II.

Background: The Chicago-Quick Hand Function Test (C-QHFT) is a brief performance-based measure of unilateral hand function. Before widespread use, evidence of validity, reliability, and normative performance is required.

Objective: To evaluate content and face validity, inter-rater reliability, intra-rater reliability, test–retest reliability, and normative reference values for the C-QHFT.

Methods: This four-phase study included expert review, iterative refinement of administration and scoring procedures, normative sampling, and repeated administrations across multiple sites. Content and face validity were assessed through structured expert feedback. Reliability was examined using intraclass correlation coefficients, standard error of measurement, minimal detectable change, and Bland–Altman methods. Normative data were collected from healthy adults aged 18 years and older, stratified into age groups.

Results: Expert reviewers supported strong content and face validity (S-CVI/Ave = 0.95). Inter-rater reliability for the total score was excellent (ICC [3,1] = 0.999) and intra-rater reliability was high (ICC [1,1] = 0.946), with small SEM and MDC_{95} values. Test–retest reliability, quantified using ICC (2,1) and Pearson correlations, showed moderate to high stability (r = 0.67–0.82) and narrow Bland–Altman limits of agreement for both hands. Age-stratified normative values derived from ANOVA/MANOVA demonstrated expected age-related slowing of performance.

Conclusions: The C-QHFT demonstrates strong validity evidence, excellent inter-rater and intra-rater reliability, and stable test–retest performance. The normative reference values enhance its

clinical and research utility. The C-QHFT is a concise and reliable assessment of unilateral hand function for adult populations.

Keywords: hand function; in-hand manipulation; reliability; test–retest; normative data; upper extremity assessment

INTRODUCTION

Hand impairments affect approximately 7.5 million individuals in the United States[1] and an estimated 200 million people worldwide,[2] contributing to significant limitations in self-care, work, and leisure. Hand function depends on the integrated performance of grasp, manipulation, dexterity, and psychomotor abilities (e.g., sequencing, pacing, and rapid sensorimotor coordination), all of which rely on coordinated musculoskeletal, sensory, and cognitive systems.[3] Comprehensive assessment of these components is essential for clinicians and researchers to guide intervention planning, monitor recovery, and evaluate clinical outcomes.[4–6]

Although numerous hand-function outcome measures (OMs) exist, many tools emphasize isolated components such as fine motor coordination or gross manipulation while failing to incorporate critical domains like in-hand manipulation (IHM) and psychomotor integration.[7–9] Widely used assessments—including the Jebsen-Taylor Hand Function Test (JTHFT), Nine-Hole Peg Test (NHPT), and Functional Dexterity Test (FDT)—capture important aspects of performance but do not provide a comprehensive profile of unilateral hand function.[10] This gap is increasingly important in the context of rehabilitation technologies and value-based care, where there is growing demand for objective, performance-based measures that can detect subtle functional changes and support treatment decisions.

Contemporary motor-control frameworks emphasize that hand function arises from the interaction of cognitive, perceptual, and motor subsystems rather than from isolated biomechanical movement alone.[5,7,11] Outcome measures should therefore assess multiple constructs to accurately reflect real-world hand performance, including dynamic IHM and psychomotor processing, rather than focusing solely on speed or isolated dexterity tasks. However, currently available tools do not fully operationalize this complexity. The Chicago-

Quick Hand Function Test (C-QHFT) was developed to address this need by providing a brief, standardized, performance-based assessment that integrates IHM, prehension changes, dexterity, and psychomotor integration within a unified scoring structure, offering a more comprehensive profile of unilateral hand function for clinical and research use.

LITERATURE REVIEW

Hand function encompasses prehension, grasp, fine motor coordination, dexterity, voluntary release, and in-hand manipulation (IHM). IHM represents the most advanced level of hand skill, consisting of shift, rotation, finger-to-palm translation, palm-to-finger translation, and stabilization.[12] Despite its prominence in everyday tasks and work demands, existing outcome measures rarely incorporate IHM in a standardized or comprehensive manner. Psychomotor functioning—including the integration of cognitive processing with motor execution—further contributes to dexterity and task adaptability.[13]

A review of 22 commonly used performance-based outcome measures (PBOMs) (see Supplement A) demonstrates several recurring limitations. While many tools capture aspects of grasping or fine motor coordination, few include IHM components, and even fewer address psychomotor integration. Additional constraints—such as high cost, lengthy administration time, limited portability, and incomplete construct representation—reduce their feasibility for routine clinical use and may limit sensitivity to subtle but functionally meaningful deficits.

Several PBOMs incorporate partial IHM elements (e.g., shift and rotation), including the Functional Dexterity Test (FDT), Sequential Occupational Dexterity Assessment (SODA), Smith Hand Function Evaluation, Sollerman Hand Function Test, Southampton Hand Assessment Procedure (SHAP), and Radboud Skills Test. The recently developed Corbett Targeted Coin Test (CTCT) includes stabilization and palm-to-finger translation,[14] and the Grooved Pegboard Test

(GPT) incorporates a psychomotor cognitive component. However, these tools remain limited by narrower task demands, longer administration time, or their primary focus on isolated dexterity rather than coordinated, dynamic manipulation with psychomotor complexity. No existing PBOM integrates the full range of IHM constructs and psychomotor demands in a brief, easily administered, clinically practical format.

The C-QHFT was designed to address these gaps by providing a standardized, portable, cost-effective PBOM that integrates IHM, prehension changes, dexterity, and psychomotor processing within a unified scoring structure. Beyond being compact and fast to administer, the C-QHFT targets coordinated, real-time manipulation demands that are common in daily activities but not well-represented in current hand-function assessments. The present study aimed to:

1. Standardize C-QHFT administration and scoring.
2. Evaluate content and face validity and inter-rater/intra-rater reliability.
3. Establish normative data and examine concurrent validity with the NHPT.
4. Determine test–retest reliability.
5. Derive age-group cutoff scores to support clinical interpretation.

METHODS

Study Design

This multi-phase clinimetric and normative study used narrative qualitative methods to evaluate face validity and a quantitative measurement design to examine content validity, inter-rater reliability, intra-rater reliability, test–retest reliability, and normative performance of the Chicago-Quick Hand Function Test (C-QHFT). Procedures were planned and interpreted in accordance with COSMIN principles for studies of measurement properties. Ethical approval

was obtained from the institutional review boards of Rocky Mountain University of Health Professions, Middle Georgia State University, and Lewis University. All participants provided informed consent prior to enrollment. Participants contributed solely as research subjects and did not participate in study design, analysis, interpretation, or manuscript preparation. No patient partners contributed to roles requiring authorship or acknowledgement.

Instrument

The C-QHFT is a performance-based assessment of unilateral hand function requiring timed manipulation of coins into and out of standardized containers with prescribed grasp, stabilization, and in-hand manipulation demands. The primary outcome is the total C-QHFT score (seconds), calculated as the observed completion time plus time penalties for tester cues and dropped coins (+1 second per cue; +1 second per drop). Secondary counts of cues and drops are also recorded. Qualitative observations of prehension, in-hand manipulation, dexterity, and cognitive behaviors are documented using a standardized checklist; these qualitative observations do not contribute to the total time score. The test apparatus and set-up are presented in Figure 1 (A–D); administrator guidelines and score sheets are available at www.c-qhft.org and in Supplements B and C. Because the C-QHFT includes rapid IHM demands, it is intended for healthy adults or individuals with mild upper-extremity impairments and may not be appropriate for those with severe peripheral nerve or tendon injuries.

Participants

All participants were healthy adults with no history of carpal tunnel syndrome, trigger finger, peripheral nerve or tendon injury, or other upper-extremity disorders that could affect hand function. Therefore, the present study reflects a normative non-clinical sample rather than a patient population.

Screening Procedures

To ensure adequate cognitive and motor capacity to follow instructions, participants completed two screening tasks:

1. Pointing and counting task: point to a corner of the room and count from one to five (Pass/Fail).
2. Coin manipulation task: pick up a coin while holding another in the palm (Pass/Fail).

Participants who did not pass both tasks were not administered the C-QHFT.

Data Analysis and Measurement Properties

Inter-rater reliability was examined using a two-way mixed-effects, consistency, single-measures intraclass correlation coefficient (ICC [3,1]). Intra-rater reliability was examined using a one-way random-effects, single-measures ICC (ICC [1,1]). All ICCs were reported with 95% confidence intervals and interpreted using established benchmarks (poor <0.50, moderate 0.50–0.75, good 0.75–0.90, excellent >0.90).[15] Unless specified otherwise, $\alpha = 0.05$ (two-tailed). Measurement-error indices were calculated following COSMIN recommendations. For inter-rater and intra-rater analyses, the standard error of measurement (SEM) was calculated as $SEM = SD \times \sqrt{(1 - ICC)}$, and the minimal detectable change at the 95% confidence level (MDC_{95}) as $MDC_{95} = SEM \times 1.96 \times \sqrt{2}$. For test–retest analyses, $SEM = SDdiff / \sqrt{2}$ and $MDC_{95} = 1.96 \times SDdiff$. Agreement was further evaluated with Bland–Altman methods, including mean bias and 95% limits of agreement. Bland–Altman plots for inter-rater and test–retest agreement are presented in Figures 2–4, with additional plots for intra-rater agreement shown in Supplementary Figures S1 and S2.

Concurrent validity with the Nine-Hole Peg Test (NHPT) was evaluated using Pearson correlations. Group differences in normative data were examined using t tests, analysis of

variance (ANOVA), and multivariate ANOVA (MANOVA). Cutoff scores for each age group were calculated using Z = 1.64485 (95th percentile).[21–22] Intellectus Statistics[18] was used for most analyses, and Mangold-International software[17] was used for reliability analysis of video-rated data.

Phase I: Face and Content Validity and Initial Inter-Rater Reliability

Face and content validity were assessed with a focus group of ten expert clinicians recruited through professional networks and social media. Inclusion criteria required active clinical practice and familiarity with rehabilitation tools; sensory impairments (e.g., significant hearing or visual limitations) were exclusionary. Nine experts were from the United States and one from Canada, with an average of more than 25 years of experience; three held doctoral degrees. Experts reviewed training materials and participated in a two-hour virtual orientation. Face validity was assessed through a five-item Qualtrics survey[16] and group discussion. Content validity was assessed using a structured six-item survey and established CVI procedures.[19–20] Six experts also scored three standardized video cases to generate preliminary inter-rater data. Feedback informed refinement of scoring language, cueing rules, and procedural clarity.

Phase II: Inter-Rater Reliability

Eight occupational therapy practitioners served as raters: two occupational therapists (average 28 years of experience) and six occupational therapy assistants enrolled in an OTA-to-MOT bridge program (average six years of experience). Raters completed standardized training in administration and scoring. Three video cases were independently scored by all raters. Inter-rater reliability was quantified using ICC (3,1), and SEM, MDC_{95}, and Bland–Altman limits of agreement were derived.

Phase III: Normative Data, Concurrent Validity, and Intra-Rater Reliability

Participants were recruited through convenience sampling via social networks, social media, and distributed flyers. Although convenience sampling introduces representativeness limitations, recruitment was guided by U.S. Census age and sex distributions to reduce sampling imbalance. A total of 302 individuals consented; 278 met screening criteria; and 273 remained after removal of extreme outliers. Of these, 209 completed the NHPT. Participants represented multiple U.S. states (e.g., Washington, Texas, Illinois, Georgia, Florida). They were stratified into seven age groups: 18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and ≥80 years. Sex was self-reported. Exclusion criteria included hand impairments, hearing loss, ambidexterity, and screening findings suggestive of moderate-to-severe cognitive or motor impairment.

Concurrent validity was assessed by correlating C-QHFT scores with NHPT performance.

For intra-rater reliability, two occupational therapists each scored three repeated trials from four healthy adults. Although the intra-rater sample was small, n=4 falls within published norms for preliminary clinimetric evaluation and was intended to establish procedural consistency rather than population-level stability. ICC (1,1), SEM, MDC_{95}, and Bland–Altman indices were calculated.

Phase IV: Test–Retest Reliability

Test–retest reliability was evaluated in 32 participants from Phase III who repeated the C-QHFT 7–14 days later. Procedures were identical at both sessions. Test–retest reliability was examined using Pearson correlations, SEM, MDC_{95}, and Bland–Altman bias and limits of agreement.

Cutoff Scores by Age Group

Cutoff scores representing the 95th percentile were calculated using Z = 1.64485.[21–22] Tables 3 and 4 present dominant- and non-dominant-hand values, providing age-stratified thresholds for interpreting C-QHFT performance.

RESULTS

Results are presented by Phases I–IV to parallel the study design and align with recommended reporting standards.

Phase I: Face and Content Validity

Ten expert clinicians participated. Qualitative feedback indicated that the C-QHFT items were relevant, clear, and clinically feasible. Most experts reported they would consider incorporating the C-QHFT into practice. Item-level content validity indices (I-CVI) ranged from 0.83 to 1.00, and the overall scale-level content validity index (S-CVI/Ave) was 0.95[19,20], indicating excellent content validity. Table 1 provides item-level relevance ratings and expert agreement values. Six experts also completed initial video-based scoring, which guided refinement of administration and scoring procedures.

Phase II: Inter-rater Reliability

Inter-rater reliability for the total C-QHFT score was excellent (ICC [3,1] = 0.999, 95% CI [0.998, 1.000]). Reliability for cues, drops, and raw completion times also exceeded ICC > 0.90, indicating strong relative reliability across raters. The standard error of measurement (SEM) for the total score was 0.71 seconds, and the minimal detectable change at the 95% confidence level (MDC_{95}) was 1.96 seconds, suggesting that between-rater differences smaller than approximately 2 seconds are attributable to measurement error rather than true change. Bland–Altman analysis demonstrated small mean differences and narrow 95% limits of agreement, indicating minimal

systematic error and supporting strong absolute reliability. The Bland–Altman plot for inter-rater agreement is presented in Figure 2.

Phase III: Intra-rater Reliability, Concurrent Validity, and Normative Data

Intra-rater Reliability

Four healthy adults completed three repeated administrations. Intra-rater reliability was excellent (ICC [1,1] = 0.946). SEM values were 0.72 seconds (Rater 1) and 1.96 seconds (Rater 2), with corresponding MDC_{95} values of 2.00 and 5.45 seconds. Bland–Altman analyses showed small mean differences and acceptable limits of agreement. Bland–Altman plots for intra-rater agreement for Rater 1 and Rater 2 are provided in Supplementary Figures S1 and S2.

Concurrent Validity

Two hundred nine participants completed both the C-QHFT and Nine-Hole Peg Test (NHPT). Because both assessments are time-based, lower values reflect better performance; therefore, a positive correlation indicates that individuals who perform more slowly on one test also tend to perform more slowly on the other. C-QHFT total scores were moderately correlated with NHPT times for both hands (dominant hand: $r = .44$, 95% CI [.32, .54], $p < .001$; non-dominant hand: $r = .35$, 95% CI [.22, .46], $p < .001$). Normality of distributions was verified using the Shapiro–Wilk test.

Normative Data

Normative values were obtained from 273 healthy adults (57.5% female, 87.9% right-hand dominant). Sample characteristics, including sex, hand dominance, ethnicity, and age distribution, are summarized in Table 2. Mean C-QHFT scores were 35.8 (SD 9.9) seconds for the dominant hand and 36.1 (SD 9.6) seconds for the non-dominant hand. Performance differed significantly by age group (dominant hand: $F [6,266] = 10.68$, $p < .001$, $\eta^2p = 0.19$; non-dominant hand: $F [6,266] = 7.82$, $p < .001$, $\eta^2p = 0.15$). MANOVA confirmed age-related differences in combined dominant and non-dominant hand performance ($F [12,532] = 5.36$, $p < .001$, $\eta^2p = 0.11$). No significant differences were observed by sex (dominant hand: $p = .252$; non-dominant hand: $p = .067$).

Phase IV: Test–Retest Reliability

Thirty-two participants completed the C-QHFT twice, 7–14 days apart. Test–retest reliability was moderate to high (ICC [2,1] = 0.74, 95% CI [0.56, 0.86]; Pearson r for dominant hand = .67, 95% CI [.41, .82], and non-dominant hand = .82, 95% CI [.66, .91]; all $p < .001$). SEM values were 3.28 seconds (dominant hand) and 2.76 seconds (non-dominant hand), with corresponding MDC_{95} values of 9.10 and 7.64 seconds. Bland–Altman analyses demonstrated small mean differences (dominant hand bias = 0.78 seconds; non-dominant hand bias = 1.57 seconds) and acceptable 95% limits of agreement (dominant hand: −8.31 to 9.88 seconds; non-dominant hand: −6.07 to 9.21 seconds), indicating stable performance across sessions. The Bland–Altman plots for test–retest agreement of dominant- and non-dominant-hand scores are shown in Figures 3 and 4, respectively.

Cutoff Scores

Cutoff scores representing the 95th percentile were calculated using Z = 1.64485 for each age group. Age-stratified cutoff values for the dominant hand are presented in Table 3, with corresponding non-dominant hand values shown in Table 4.

DISCUSSION

This study examined the measurement properties and normative performance of the Chicago-Quick Hand Function Test (C-QHFT) using a four-phase mixed-method clinimetric design. The findings indicate that the C-QHFT is a valid, reliable, and clinically meaningful performance-based measure of unilateral hand function. The combined evidence from content validity, reliability analyses, measurement-error indices, and normative data supports the tool's ability to capture constructs that are often absent in commonly used assessments, particularly in-hand manipulation and psychomotor integration. Together, these results demonstrate that the C-QHFT provides interpretable and functionally relevant information for adult hand performance.

Content validity was strong, with item-level CVI values ranging from 0.83 to 1.00 and scale-level CVI exceeding established benchmarks for excellent content relevance (S-CVI/Ave = 0.95). Expert clinicians affirmed that the domains represented—prehension, in-hand manipulation, stabilization, dexterity, and psychomotor behaviors—align well with contemporary models of hand function and occupational therapy practice. Minor areas of disagreement helped refine scoring language and clarify cueing procedures, strengthening the conceptual alignment between test demands and real-world task performance.

Reliability findings further support the robustness of the tool. Inter-rater reliability was excellent (ICC = 0.999), demonstrating that different raters with varying clinical experience can score the test with high precision. Intra-rater reliability was comparable (ICC = 0.946), with narrow

Bland–Altman limits of agreement indicating consistent scoring across repeated administrations. These values are similar to or exceed those reported for established assessments such as the Sollerman Hand Function Test (ICC 0.96–0.98) and the Nine-Hole Peg Test (r 0.98–0.99). Test–retest reliability was moderate to high (r = 0.67–0.82), aligning with performance-based measures such as the Arthritis Hand Function Test (ICC 0.83–0.96) and reported NHPT retest values. These patterns suggest that while day-to-day biological variability may affect speed-based motor tasks, the C-QHFT maintains acceptable temporal stability for clinical use.

The moderate correlations with the NHPT (r = 0.35–0.44) are consistent with expected relationships between tools that measure overlapping yet distinct constructs. The NHPT primarily indexes fine distal dexterity with high motor repetition, whereas the C-QHFT requires alternating grasp patterns, cognitive–motor integration, and multiple forms of in-hand manipulation. Similar moderate associations among hand-function measures have been documented between the Functional Dexterity Test and Jebsen–Taylor Hand Function Test (r = 0.52) and between the Minnesota Manual Dexterity Test and Box and Block Test (r = 0.63–0.67). These findings reinforce that the C-QHFT complements rather than duplicates existing dexterity assessments.

Normative results demonstrated clear age-related variation, with performance peaking between 30 and 50 years and declining with age. Adults aged 80 years and older performed significantly slower, reflecting recognized neuromuscular, sensory, and psychomotor changes associated with aging. The slightly lower performance of the 18–29 group relative to mid-adult cohorts may relate to ongoing maturation of executive and sensorimotor systems into the mid-twenties as well as lower habitual engagement in tasks requiring rapid in-hand manipulation. No significant sex differences emerged, which aligns with literature showing minimal sex-based variation in

unilateral dexterity when age and handedness are controlled. Dominant and non-dominant hand scores were also similar, consistent with research indicating limited differences in unilateral motor performance and the influence of bilateral neural networks on dexterity.

This study's design offers several methodological strengths that enhance confidence in the findings. The multi-phase structure allowed each measurement property to be examined using appropriate and sequential methods, beginning with expert-derived content validation and moving through rater-based reliability, normative sampling, and temporal stability testing. Standardized rater training, scripted cueing procedures, and video-based scoring supported consistency across administrators. The use of established clinimetric metrics—ICC models aligned with the specific reliability questions, Bland–Altman agreement analyses, and calculation of SEM and MDC—provided a transparent quantification of both relative and absolute reliability. The large, age-stratified normative sample further strengthened the precision of reference values. Collectively, these features underscore the rigor of the study and support the robustness of the reported psychometric outcomes.

CLINICAL IMPLICATIONS

The C-QHFT offers several implications for hand therapy practice. From a patient-outcome perspective, the test captures aspects of performance—such as psychomotor efficiency and in-hand manipulation—that are directly relevant to daily activities involving rapid object handling, fine coordination, and multitasking. These features allow clinicians to detect functional deficits that may not be apparent on more reductionistic dexterity tests. In terms of patient experience, the brief administration time and clear structure may reduce fatigue and improve engagement during evaluation.

For provider experience, the standardized scoring rules, small measurement error, portability, and minimal equipment needs support efficient clinical workflow. The test's structure may also reduce documentation burden by integrating both quantitative scoring and qualitative descriptors useful for intervention planning. The tool is cost-effective compared with lengthier or more equipment-heavy alternatives, addressing the cost dimension of the Quintuple Aim. Equity considerations are supported by the C-QHFT's low-resource requirements, making it suitable for community-based clinics, home health, and resource-limited settings. For education, the C-QHFT provides an opportunity for occupational therapy students to learn structured evaluation of prehension patterns, in-hand manipulation, and psychomotor behaviors, complementing traditional dexterity assessments.

STRENGTHS AND LIMITATIONS

This study's strengths include its multi-phase clinimetric design, excellent inter-rater and intra-rater reliability, and a relatively large, age-stratified normative sample. Standardized rater training, scripted cueing, and video-based scoring supported consistency across administrators, and expert clinician input strengthened content validity and refinement of administration and scoring rules.

Several limitations should be noted. Convenience sampling may introduce selection bias and limit generalizability of the normative values to the broader U.S. population. The intra-rater reliability analysis included only four participants and two raters, which reduces precision and limits conclusions about within-rater consistency across a wider range of clinicians. The sample consisted solely of healthy adults, and individuals with hearing impairments were excluded, so psychometric properties and interpretability in clinical populations or sensory-impaired groups cannot be assumed. In addition, although total time scoring was validated using video-based

methods, cues and coin-drop scoring were not independently video-validated; future work should examine the reliability of these secondary metrics. Finally, while minimal detectable change (MDC) values were calculated, estimation of a minimal clinically important difference (MCID) was not appropriate in this study because it lacked a clinical population and an external anchor of perceived improvement; MCID will need to be determined in future studies involving patients with upper-extremity conditions.

FUTURE RESEARCH DIRECTIONS

Future studies should evaluate the C-QHFT in clinical populations to determine responsiveness, minimal clinically important differences, and condition-specific validity. Cross-cultural adaptation and analyses of measurement invariance would strengthen the tool's global applicability. Larger test–retest and intra-rater samples would help refine measurement-error estimates, and digital scoring or sensor-based cue detection may further improve objectivity. Developmental studies examining young adult performance may clarify mechanisms underlying age-related trends. In addition, future research should investigate the clinimetric properties of the C-QHFT in outpatient orthopedic populations and in neurological groups such as Parkinson disease, multiple sclerosis, and stroke.

CONCLUSION

The Chicago-Quick Hand Function Test demonstrated strong content validity, excellent inter-rater and intra-rater reliability, and acceptable test–retest stability, along with clear age-related normative patterns. These results indicate that the C-QHFT provides precise and clinically relevant measurement of unilateral hand performance in healthy adults. However, interpretation should consider that findings are based on a healthy, convenience-sampled population and that secondary scoring metrics were not independently video-validated. Future research should

evaluate the tool's responsiveness, minimal clinically important difference, and construct validity in clinical populations, as well as verify the reliability of cue and drop scoring. Taken together, the present findings support the C-QHFT as a robust foundation for further clinical and translational investigation.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the author(s) used ChatGPT in order to polish and concise the draft. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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Table 1. Relevance ratings on the item scale

Domain	Item	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9	EC10	Expert Agreement (EA)	I-CVI
Voluntary grasp and release	–	1	1	1	1	1	1	1	0	1	1	9	0.90
Finger-to-palm translation	–	1	1	1	1	1	1	1	1	1	1	10	1.00
Palm-to-finger translation	–	1	1	1	1	1	1	1	1	1	1	10	1.00
Stabilization	–	1	1	1	1	1	0	1	1	1	1	9	0.90
Dexterity (FMC, speed, accuracy)	–	1	1	1	1	1	1	1	1	1	1	10	1.00
Psychomotor integration	–	1	1	1	0	1	1	1	1	1	1	9	0.90

Note. EC = expert clinician. EA = number of experts rating item as "relevant." I-CVI = item-level content validity index.

Table 2. Descriptive statistics

Variable	**n**	**%**
Sex		
Female	157	57.5
Male	116	42.5
Hand dominance		
Right-handed	240	87.9
Left-handed	33	12.1
Ethnicity		
Asian	43	15.8
White	155	56.8
Black	61	22.3
Hispanic	13	4.8
Jewish	1	0.4
Age group (y)		
18–29	53	19.4
30–39	46	16.9
40–49	46	16.9
50–59	38	13.9
60–69	42	15.4
70–79	33	12.1
≥80	15	5.5

Note. n = number of participants.

Table 3. Cutoff C-QHFT scores for dominant hand (DH)

Age group (y)	Mean (s)	SD (s)	Cutoff score (95th percentile) *
18–29	34.8	9.1	49.8
30–39	31.8	7.2	43.5
40–49	31.4	6.8	42.6
50–59	33.9	7.9	46.9
60–69	39.3	12.3	59.6
70–79	41.9	9.0	56.8
≥80	46.0	10.3	63.0

Note. SD = standard deviation.
*Cutoff score = mean + (SD × 1.64485), representing the 95th percentile for each age group.

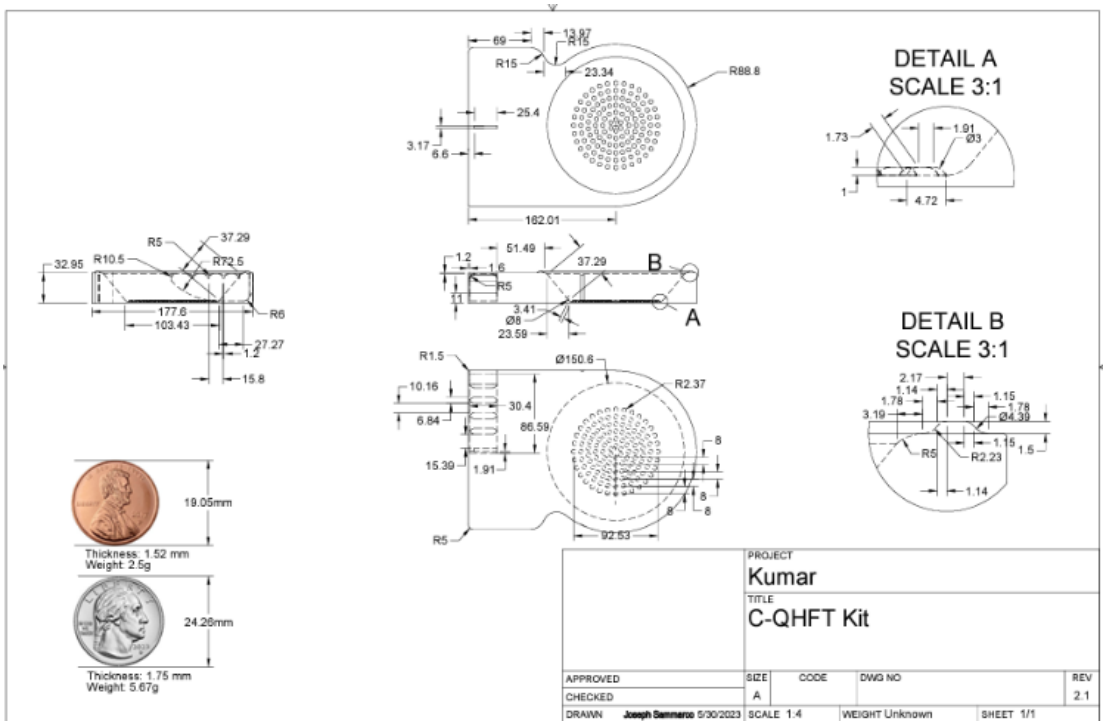
Table 4. Cutoff C-QHFT scores for nondominant hand (NDH)

Age group (y)	Mean (s)	SD (s)	Cutoff score (95th percentile) *
18–29	35.6	8.9	50.3
30–39	31.4	6.6	42.2
40–49	32.9	7.7	45.7
50–59	35.7	6.4	46.2
60–69	38.4	10.2	55.2
70–79	41.6	12.4	61.9
≥80	44.4	11.6	63.4

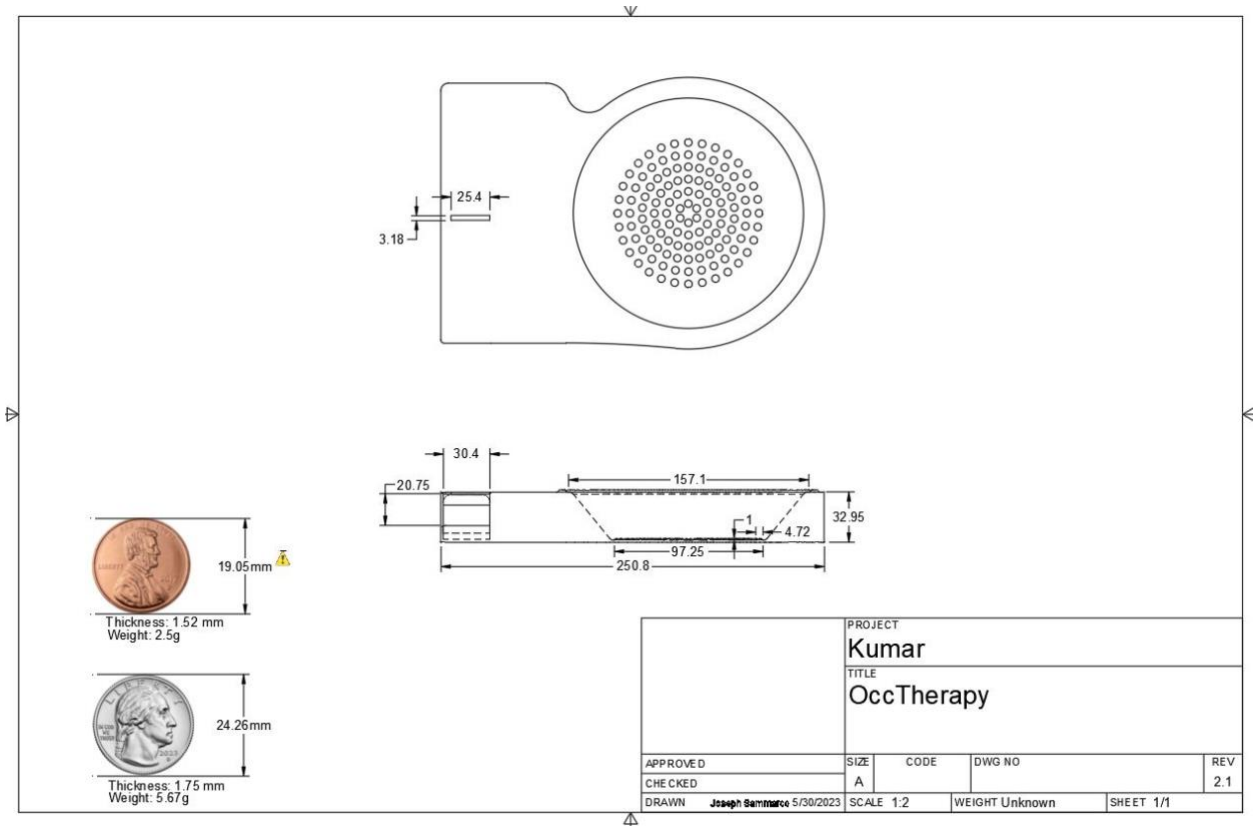
Note. SD = standard deviation.
*Cutoff score = mean + (SD × 1.64485), representing the 95th percentile for each age group.

Figure 1. Chicago-Quick Hand Function Test (C-QHFT) apparatus and standardized setup. (A) Kit components and dimensions. (B) Line drawing of the C-QHFT kit. (C) Left-hand test setup. (D) Right-hand test setup.

(A) Kit components and dimensions



(B) Line drawing of the C-QHFT kit



C) Left-hand test setup

(D) Right-hand test setup

Figure 2. Bland–Altman plot for inter-rater agreement of total Chicago-Quick Hand Function Test (C-QHFT) scores. This figure displays the agreement between individual raters and the overall mean score for the total C-QHFT time (seconds) across three standardized video cases (n = 8 raters). The solid line represents mean bias, and the dashed lines denote the 95% limits of agreement. Minimal bias and narrow limits indicate high scoring consistency across raters. C-QHFT = Chicago-Quick Hand Function Test.

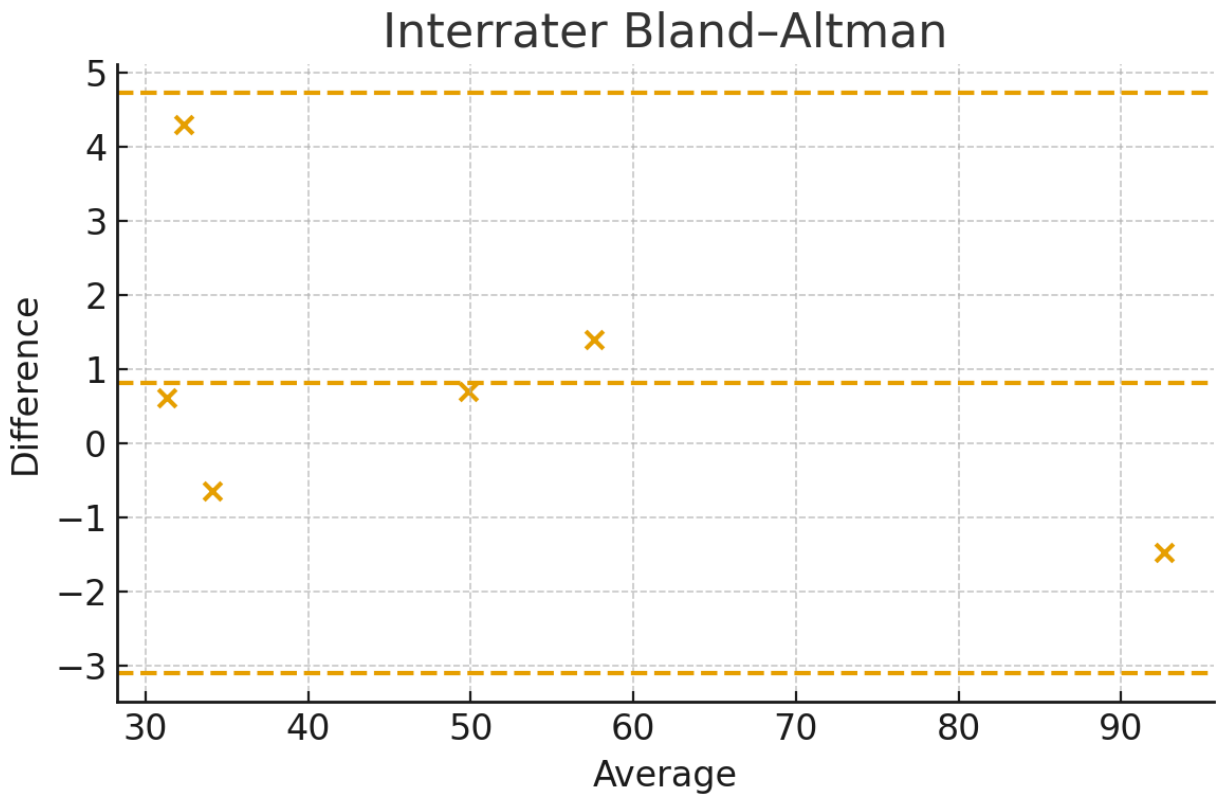


Figure 3. Bland–Altman plot for test–retest agreement of dominant-hand (DH) C-QHFT scores. This figure illustrates agreement between Time 1 and Time 2 dominant-hand scores collected over a 7–14-day interval (n = 32). The solid line represents mean bias, and the dashed lines represent the 95% limits of agreement. The small bias and acceptable limits suggest stable performance across sessions. DH = dominant hand; C-QHFT = Chicago-Quick Hand Function Test.

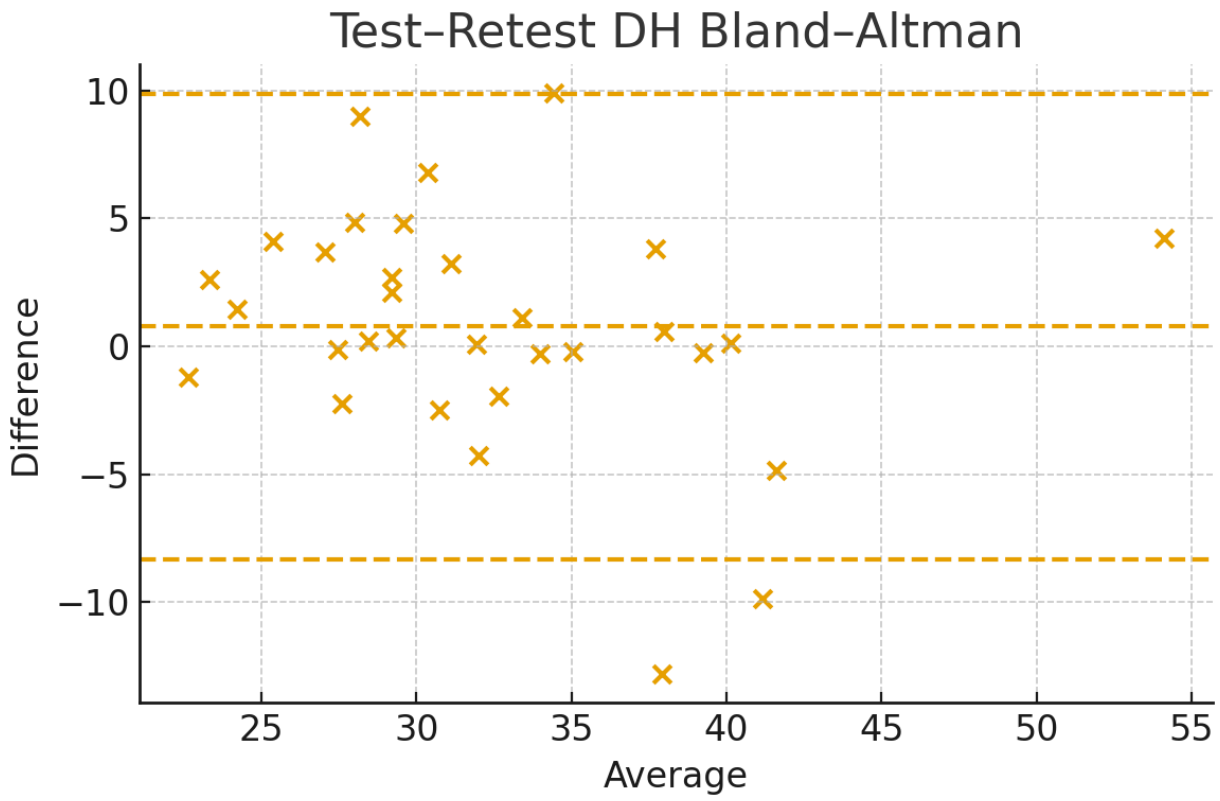
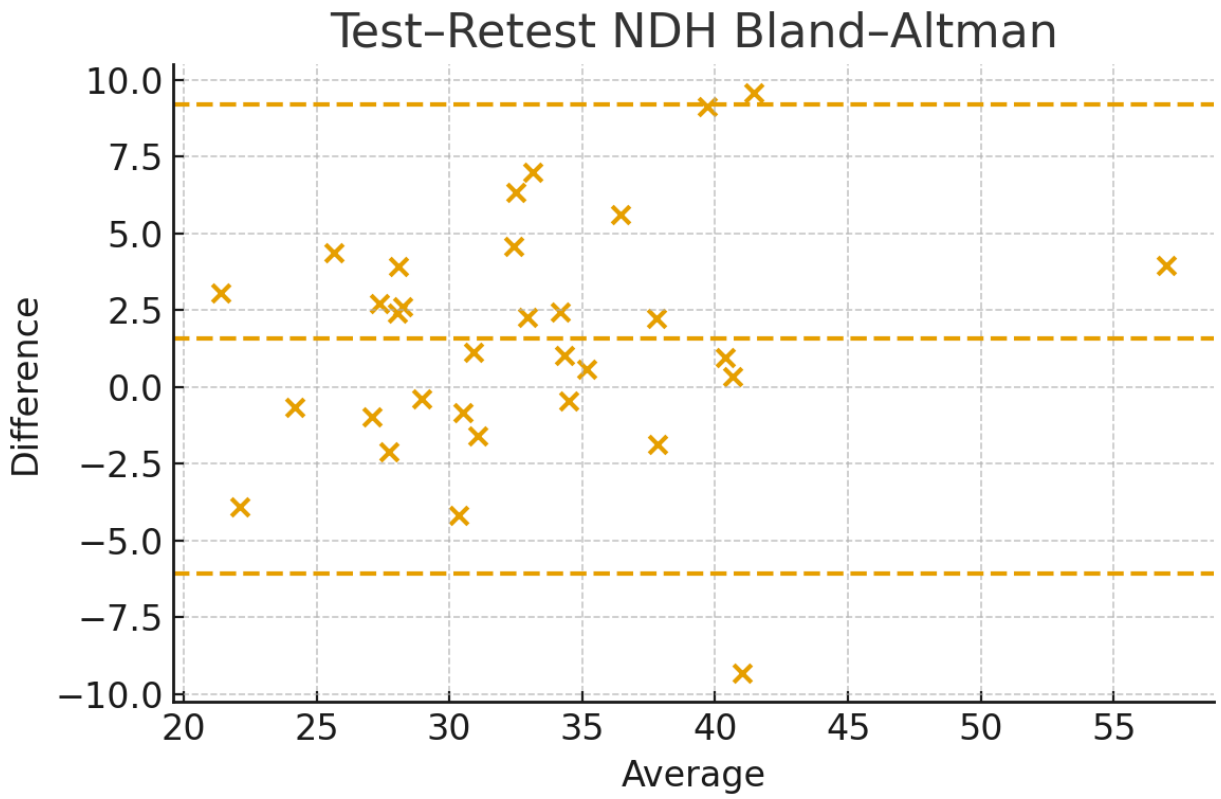
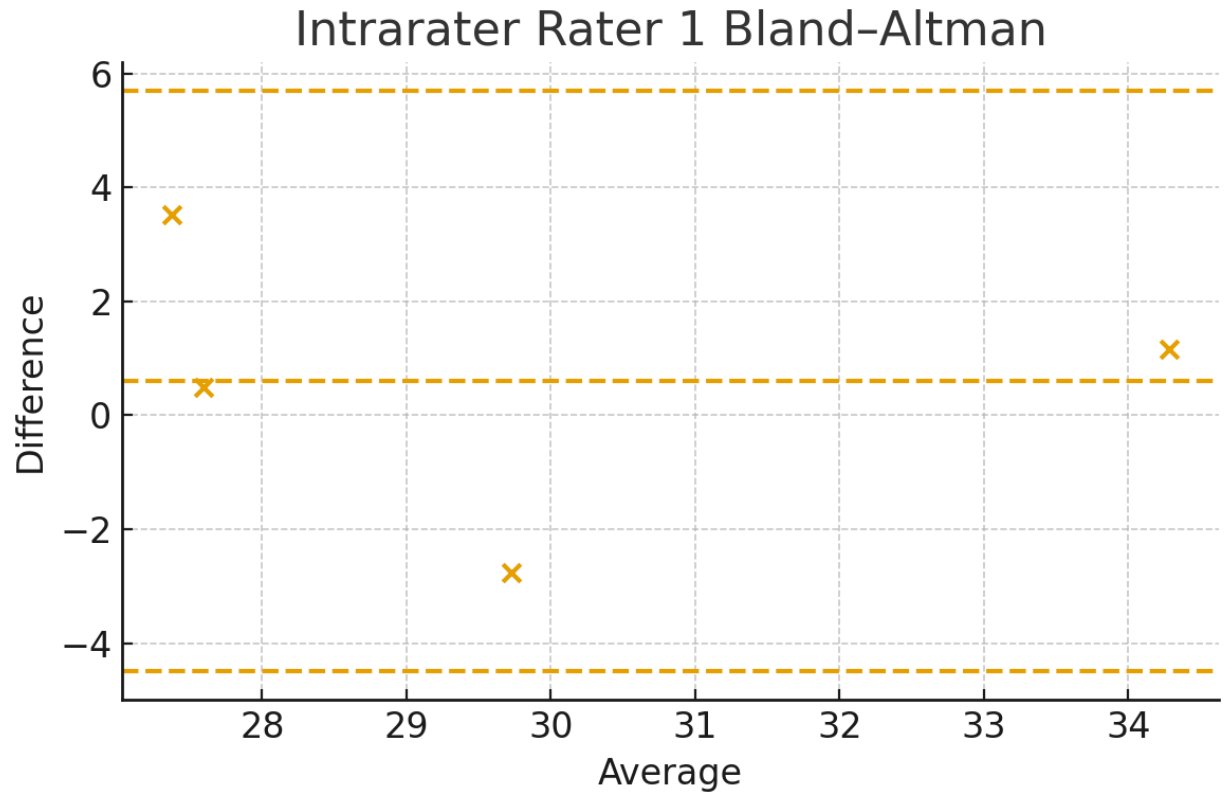


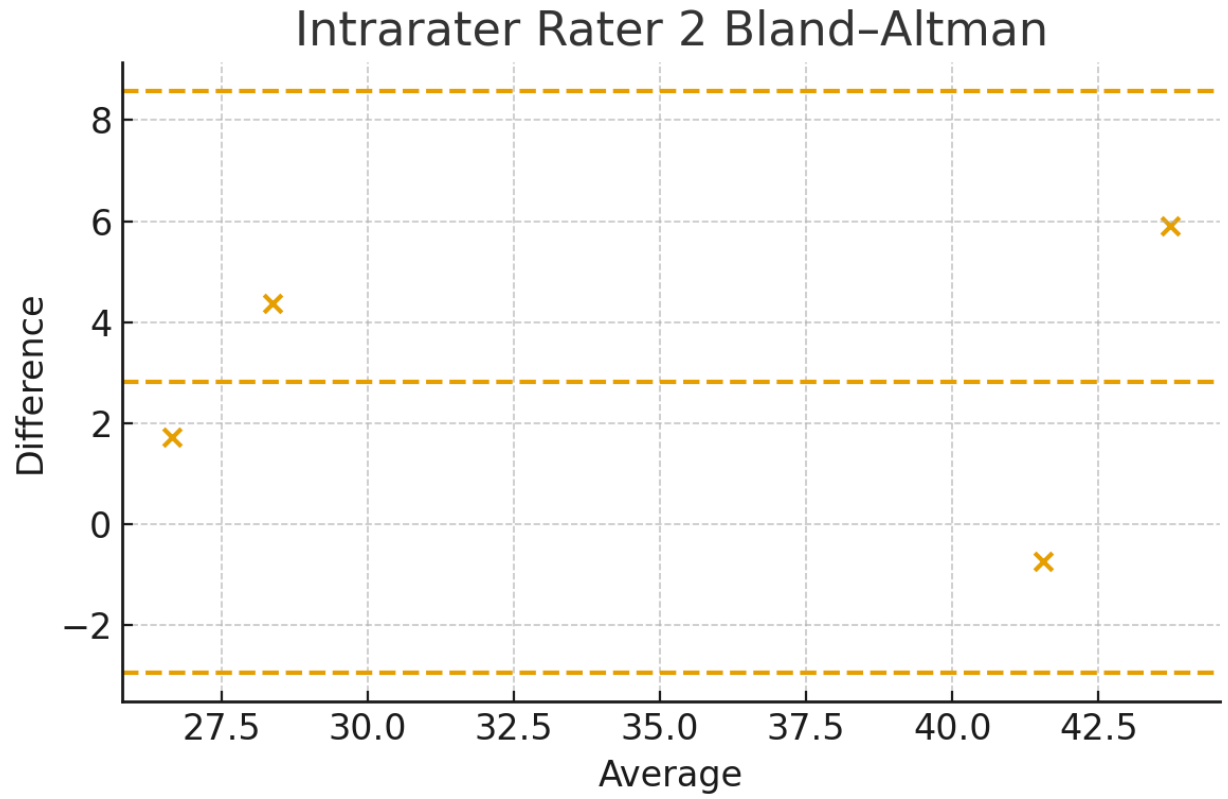
Figure 4. Bland–Altman plot for test–retest agreement of non-dominant-hand (NDH) C-QHFT scores. This figure shows agreement between initial and retest non-dominant-hand total times (n = 32). The solid line shows mean bias, and the dashed lines indicate the 95% limits of agreement. Results demonstrate minimal systematic error and adequate test–retest stability. NDH = non-dominant hand; C-QHFT = Chicago-Quick Hand Function Test.



Supplementary Figure S1. Bland–Altman plot for intra-rater agreement: Rater 1. This plot presents agreement between repeated C-QHFT administrations scored by Rater 1 (n = 4 participants × 3 trials). The solid line indicates mean bias and the dashed lines represent the 95% limits of agreement. Small differences and narrow limits reflect consistent scoring within the rater. C-QHFT = Chicago-Quick Hand Function Test.



Supplementary Figure S2. Bland–Altman plot for intra-rater agreement: Rater 2. This plot presents agreement between repeated C-QHFT administrations scored by Rater 2 (n = 4 participants × 3 trials). The solid line indicates mean bias and the dashed lines represent the 95% limits of agreement. Results indicate acceptable within-rater consistency. C-QHFT = Chicago-Quick Hand Function Test.



Supplement A. Summary of Performance-Based Outcome Measures (PBOMs) of Hand Function: Characteristics and Measurement Properties of Performance-Based Outcome Measures of Hand Function

PBOM	Constructs Assessed	IHM Included	Psychomotor Component	Time-Based Scoring	Penalty System	Normative Data Available	Reliability & Validity Evidence	Cost / Portability / Administration Time
Arthritis Hand Function Test (AHFT)	Finger dexterity, FMC, grasp, IHM	Shift & rotation	—	✓	—	—	Test–retest ICC = 0.83–0.96 (n=25); inter-rater ICC = 0.45–0.99 (n=30). Concurrent: HAQ r = 0.46–0.73; Duruoz Index r = 0.36–0.54.	~$500; multi-item battery; ~30 min
Box and Block Test (BBT)	Manual dexterity, grasp	—	—	✓	—	Age, sex, HD	Test–retest ICC = 0.89–0.90 (n=35); intra-rater r = 0.999–1.000; IRR r = 0.999–1.000. Concurrent: ARA r = 0.80–0.82; MMDT r = 0.63–0.67.	~$200; highly portable; ~5 min
Corbett Targeted Coin Test (CTCT)	IHM, dexterity	Palm-to-finger translation, stabilization	—	✓	✓	Age, sex	Emerging tool; early psychometrics reported.	~$50–60; compact
Crawford Small Parts Dexterity Test (CSPDT)	Dexterity	—	—	✓	—	—	Intra-rater r = 0.56–0.90.	Not commonly used clinically
Functional Dexterity	Dexterity, grasp	Shift & rotation	—	✓	✓	Age, sex, HD	Intra-rater r > 0.90; IRR r = 0.73–0.88;	~$100; ~5 min

PBOM	Constructs Assessed	IHM Included	Psychomotor Component	Time-Based Scoring	Penalty System	Normative Data Available	Reliability & Validity Evidence	Cost / Portability / Administration Time
Test (FDT)							test–retest r = 0.90. Concurrent: JTHF r = 0.52.	
Grooved Pegboard Test (GPT)	Dexterity, FMC, grasp	—	✓	✓	—	Age, sex, HD	Test–retest r = 0.64. Used in multiple aging/neurological studies.	~$140; ~10 min
Jebsen–Taylor Hand Function Test (JTHFT)	Dexterity, FMC, grasp	—	—	✓	—	—	Test–retest r = 0.38–0.88; concurrent with HDT r = 0.38–0.88.	~$300; limited portability; ~15 min
Minnesota Manual Dexterity Test (MMDT)	Dexterity, FMC, grasp	—	—	✓	—	Age, sex	Test–retest ICC = 0.79–0.88; concurrent: BBT r = 0.63; PPT r = 0.67.	~$375; large kit; ~20 min
Moberg Pick-Up Test	Sensory function, grasp	—	—	✓	—	—	IRR: eyes open r = 0.60; eyes closed r = 0.80. Concurrent: HAQ r = 0.36–0.48 (operated vs non-operated hands).	~$30; very portable
Minnesota Rate of Manipulation Test (MRMT)	Dexterity, FMC, grasp	—	—	✓	—	—	Historical test. Intra-rater r = 0.89; test–retest r = 0.87–0.97; IRR r = 0.79–0.87.	Largely replaced by MMDT
Nine-Hole Peg Test (NHPT)	Finger dexterity	—	—	✓	—	Age, sex, HD	Test–retest r = 0.43–0.69; IRR r =	~$75; quick; easy to

PBOM	Constructs Assessed	IHM Included	Psychomotor Component	Time-Based Scoring	Penalty System	Normative Data Available	Reliability & Validity Evidence	Cost / Portability / Administration Time
							0.984–0.993. Concurrent: PPT r = 0.53–0.61.	store; ~5 min
O'Connor Finger Dexterity Test	Finger dexterity, grasp, FMC	—	—	✓	—	Age	Test–retest r = 0.50; intra-rater r = 0.87.	~$175; portable; ~15 min
O'Neill Hand Function Assessment	Dexterity, grasp	—	—	✓	—	—	Test–retest r = 0.82; IRR r = 0.96–0.99. Concurrent: NHPT r = 0.98.	Low portability; ~30 min
Purdue Pegboard Test (PPT)	FMC, fine manual dexterity	—	—	✓	—	Age, sex, HD	Intra-rater ICC = 0.37–0.90; test–retest r = 0.68; concurrent with MMDT r = –0.63 to –0.67.	~$175; portable; ~10 min
Radboud Skills Test	ADL tasks, FMC, grasp	Shift & rotation	—	✓	—	—	Test–retest κ = 0.40–0.71; intra-rater d = 0.61–1.00; IRR d = 0.47–0.96.	~30 min; moderate portability
Rosenbusch Test of Finger Dexterity	Fine dexterity	Shift & rotation	—	✓	—	—	Test–retest r = 0.73–0.93; IRR r = 0.97–0.99.	~10 min
SHAP (Southampton Hand Assessment Procedure)	ADL tasks, grasp	Shift & rotation	—	✓	—	—	IRR and test–retest nonsignificant (n=21).	~30 min; specialized kit
Smith Hand	ADL tasks,	Shift & rotation	—	✓	—	Age, sex	IRR ICC > 0.75 for all	~30 min

PBOM	Constructs Assessed	IHM Included	Psychomotor Component	Time-Based Scoring	Penalty System	Normative Data Available	Reliability & Validity Evidence	Cost / Portability / Administration Time
Function Evaluation	FMC, bilateral dexterity						items except button board (ICC = 0.579).	
SODA (Sequential Occupational Dexterity Assessment)	ADL tasks, grasp, bimanual dexterity	Shift & rotation	—	✓	—	—	Test–retest r = 0.93 (RA). Concurrent: AUSCAN r = 0.81.	~30 min
Sollerman Hand Function Test	ADL tasks, grasp	—	—	✓	—	—	Test–retest ICC = 0.96–0.98; IRR ICC = 0.96–0.98; intra-rater ICC = 0.96–0.99. Concurrent: SODA r = 0.79; VAS r = 0.83.	~$200; limited portability; ~20 min
TEMPA	ADL tasks, grasp	—	—	✓	—	—	Concurrent: ARA r = 0.90–0.95; BBT r = 0.73–0.78.	~30 min
Upper Extremity Function Test (UEFT)	ADL tasks, grasp	—	—	✓	—	Age, sex, HD	Test–retest ICC = 0.85; IRR ~97%.	—

Abbreviations

ADL = activities of daily living; FMC = fine motor coordination; HD = hand dominance; ICC = intraclass correlation coefficient; IRR = inter-rater reliability; RA = rheumatoid arthritis; PPT = Purdue Pegboard Test; BBT = Box and Block Test; MMDT = Minnesota Manual Dexterity Test; MRMT = Minnesota Rate of Manipulation Test; NHPT = Nine-Hole Peg Test; SODA = Sequential Occupational Dexterity Assessment; SHAP = Southampton Hand Assessment Procedure; UEFT = Upper Extremity Function Test; IHM = in-hand manipulation.

Sources

Adapted and synthesized from van de Ven-Stevens et al. (2009), Causby et al. (2014), Yancosek & Howell (2009), and instrument-specific validation studies.

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Supplement B.
Administrator Guidelines
Instructions to the Test Administrator

1. The test involves a C-QHFT board, four quarters, and four pennies (one additional penny and a quarter are provided if the coin lands on the floor and is difficult to retrieve during the test).
2. Clients are comfortably seated in a chair, and the kit is placed in front of the clients on a table of appropriate height.
3. Position the kit so that the bowl is closer to the testing hand and the slot is closer to the non-testing hand. The middle of the kit should be aligned with the client's midline. Each side of the kit has a yellow marker in the middle to help position the kit in the client's middle. The yellow marker should align with the client's midline.
4. Place four quarters towards the top of the bowl, four pennies towards the bottom, and one extra quarter and penny on the table towards the bowl.
5. The test starts with the dominant hand first.
6. Each cue earns one penalty point (one cue = one second).
7. Each coin drop from the palm or fingers earns one penalty point. (one coin drop = one second).
8. If a corrective cue is given during the coin drop, it accounts for two penalty points: one for the coin drop and another for the corrective cue.
9. The administrator provides the prompts needed to perform the test accurately. Cues count is based on the action, not the number of words or sentences used during the cueing. Limit the use of cues and provide them in the following situations only unless they are required in other instances. If the client a) picks up the wrong coin, b) does not move the picked-up coin to the palm, c) places the wrong coin in the slot and uses another hand to maneuver the coin. The administrator keeps count of corrective cues/prompts provided to the client. Encouraging cues provided, such as you are doing good, that is right, etc., are not accounted for in the penalty point.
10. The administrator keeps count of the # of times the coins fall out of the palm or fingers. If the coin drops in the bowl, it is still counted as a drop.
11. Total Raw Score = Time to complete the task + # of corrective cues required to complete the task + # of times the coin falls out of hand/fingers using the qualitative assessment, and the administrator notes down the deficits.
12. Noted deficits are used for intervention or documentation purposes only. It does not account for the final score.
    a. Grasp
    b. Release
    c. IHM
        i. Finger-to-palm translation
        ii. Stabilization
        iii. Palm-to-finger translation
    d. Dexterity
    e. Coordination
    f. Motor speed
    g. Cognitive skills
        i. Attention

ii. Memory
iii. Difficulty following directions
iv. Any other cognitive challenges

13. The administrator demonstrates the test to the client:
    a. Pick up a quarter and roll it into your palm.
    b. While holding the quarter in your palm, pick up a penny.
    c. Roll the penny into your palm and shift the quarter to your fingertips.
    d. Place the quarter into the slot.
    e. Repeat steps 1-4, alternating placement of quarters and pennies in the slots.
    f. C-QHFT Demonstration Video
14. One practice trial with each hand to be tested is mandatory.
15. If needed, the administrator clears up client doubts before the test begins.

Instructions provided by the Test Administrator to the Client

1. The objective is to alternately pick up quarters and pennies with one hand, switch them in the palm, and place the coins into the slot until all eight coins are successfully placed as quickly as possible, as I demonstrated.
2. You earn penalty points when the administrator provides cues and prompts during the test if the test is not performed as instructed.
3. You also earn penalty points when the coin drops from the palm or fingers.
4. You pick up the dropped coin if it is within your reach with the same hand and continue with the test.
5. If it falls outside your reach, I will pick up the coin for you, and you will continue with extra coins that are kept on the table for such events.
6. Use the hand being tested to maneuver the coins.
7. Hold the kit with a non-testing hand to stabilize the Board if needed.
8. The timer starts when you touch the first quarter and ends when you place the last coin in the slot.
9. I will demonstrate the test for you.
10. Ask me if you have questions before you start the test.

Score Sheet
Name (Initials only):_____Age:_____ Hand dominance:_____ Gender:___
Ethnicity_____ Profession: _____ Hobbies in which you frequently use your hands (please list): _____
Diagnoses that may affect hand function:
_____
Declaration: I declare that I do not have any health issues that I know of which will affect hand function _____(Initials only)
Screening:

1) Point to a corner in the room and count to five: Pass ___ Fail____
2) Pick up a coin while holding another coin in the palm: Pass ___ Fail____

*Please do not proceed with testing if the participant fails in either of the two screenings

C-QHFT Scoring Criteria	Dominant Hand (Trial 1)	Non-dominant Hand (Trial 1)	Dominant Hand (Trial 2)	Non-dominant Hand (Trial 2)
Time in seconds:				
# of cues used:				
# of times the coin dropped:				
Total Raw Score = Time to Perform the test +# cues provided + # of time coin fell out of hand.				
Deficits that may have affected performance (**Check all that apply)**				
Prehension				
• Grasp				
• Release				
In Hand Manipulation (IHM)				
• Finger-to-palm translation				
• Stabilization				
• Palm-to-finger translation				
Dexterity				
• Coordination/Motor accuracy				
• Motor speed				
Cognitive skills				
• Attention				
• Memory				
• Difficulty in the following direction				
Any other cognitive and behavioral challenges (low frustration tolerance, anxiety, etc.):				
Any other factors that may have influenced performance (such as insufficient light, background noise or distraction, competitiveness, etc.):				
NHPT (time in seconds)				
If tested for NHPT, circle the test order: C-QHFT 1st/NHPT 2nd or NHPT 1st / C-QHFT 2nd				

Test administrator Name:_____