Journal of Hand Therapy 39 (2026) 421–425

Contents lists available at ScienceDirect

Journal of Hand Therapy

journal homepage: www.elsevier.com/locate/jht

Research Paper

Have children's manual dexterity skills changed in the past 40 years? A cross-sectional observational norm comparison study

Tami L. Konieczny [a,*], Nellie P. Butler [b], Lynne Allen-Taylor [c], Ashley M. Binkowski [d], David D. Sherry [b], Sabrina Gmuca [b]

[a] Department of Occupational Therapy, Division of Rehabilitation, Children's Hospital of Philadelphia, Philadelphia, PA, USA
[b] Department of Pediatrics, Division of Rheumatology, Children's Hospital of Philadelphia, Philadelphia, PA, USA
[c] Perelman School of Medicine's Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania Biostatistics Analysis Center, Philadelphia, PA, USA
[d] Department of Occupational Therapy, Division of Rehabilitation, Children's Hospital of Philadelphia, Philadelphia, PA, USA

ARTICLE INFO

Article history:
Received 14 May 2025
Revised 13 August 2025
Accepted 13 October 2025
Available online 17 November 2025

Keywords:
Box and Block Test
Pediatrics
Manual dexterity
Normative data
Motor development

ABSTRACT

Background: Norms for children aged 6–19 years were developed in 1985 for the Box and Block Test (BBT) and updated in 2013 for 3–10-year-olds. Evidence suggests that past normative data may need to be updated due to changes in children's hand use over the past 40 years.
Purpose: To compare children's performance on the BBT with existing 1985 normative data.
Study Design: Secondary analysis of a cross-sectional observational study to validate the Complete Minnesota Dexterity Test (CMDT) using the BBT.
Methods: All were healthy volunteers, aged 7 to 18 years, with no known physical, cognitive, or emotional conditions. Participants completed study procedures in a pediatric hospital. During data collection we noted low performance on the BBT and hypothesized a decline compared to the 1985 norms. Participants completed one trial of the BBT with each hand. We compared our sample to the normative sample using mean number of blocks placed in 60 seconds and standard error of the means using two-tailed, one sample *t*-tests.
Results: Of 816 children screened, 181 were eligible and consented to participate. A total of 98 females and 83 males participated. Each gender-by-age group-by-hand category ranged from 4–21 participants. In each group, means were statistically significantly lower than norms, indicated by nonoverlapping 95% confidence intervals and *t*-test results. The difference in blocks placed in 60 seconds ranged from 9.1 to 31.3 fewer blocks.
Discussion: This study suggests that children's manual dexterity has declined over the past 40 years. Clinicians should consider this when using the BBT to evaluate performance. This study lacked enough subjects to establish new normative data but suggests the 1985 norms need to be updated.
Conclusions: Our findings provide evidence of a decline in manual dexterity among children on the BBT since 1985.

Introduction

Occupational therapists have historically assessed hand function using standardized assessments. These assessments frequently focus on manual dexterity and fine motor coordination. Manual dexterity is the use of hands and arms to manipulate objects. Some examples include writing, playing an instrument, or playing a card game.[1] Fine motor coordination is the use of small motor movements to perform precise movements such as picking up a coin or unlocking a door.[2]

Research has shown a shift in hand use over the past 40 years and possible associations with changes in children's manual dexterity. Several studies have noted an increase in use of touch screen technology among children[3] and its impact on motor development[4–7] as well as the effects of sleep position on motor development.[8–11] Children today are writing less[12,13] and keyboarding more,[14] in part due to the adoption of the Common Core State Standards in 2010, which do not require instruction in cursive writing.[15] In light of these factors, it is important to consider whether current standardized assessments of manual dexterity are still valid.

The Box and Block Test (BBT) is a standardized tool commonly used to efficiently evaluate manual dexterity. This test was originally developed in 1957 by Ayres and Holser and later updated by Hosler.[16] The BBT was designed to allow those with more severe deficits in dexterity to be assessed. In 1960, concurrent validity between BBT, Minnesota Rate of Manipulation Test (placing subtest), and the General Aptitude Test Battery was established for the measure of manual dexterity.[17] Initial

* Corresponding author. Children's Hospital of Philadelphia, 3401 Civic Center Blvd, Philadelphia, PA 19104, USA.
E-mail address: konieczny@chop.edu (T.L. Konieczny).

0894-1130/
https://doi.org/10.1016/j.jht.2025.10.002

pediatric norms for the BBT were established in 1985 for individuals aged 6–19 years.[18] In 2013, updated normative data were introduced for children aged 3–10 years, addressing a gap in standardized assessment for younger populations.[19]

Purpose

As part of a study to norm and validate the Complete Minnesota Dexterity Test (CMDT) in pediatrics,[20] the BBT was utilized to establish concurrent validity. Upon noting changes in performance on the BBT compared to the 1985 pediatric normative study, the aim of the current study was to compare our sample to the existing normative sample.

Methods

Study design

This was a cross-sectional observational norm comparison study. This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for conducting and reporting observational studies.[21] The local Institutional Review Board (IRB 13–010624) approved the research protocol.

Setting and participants

Participants completed all procedures in an urban hospital setting during one study visit. Between January 2014 and June 2023, we recruited pediatric volunteer participants through flyers, hospital email lists, and collaboration with schools and community centers. We included children aged 7–18, regardless of sex, without any known physical, cognitive, or emotional conditions and whose cognitive abilities permitted completion of a 45-minute structured task, per parent report. Before administering study procedures, we obtained informed consent (and assent when applicable) from all participants and legal guardians. Because the CMDT validation study compared performance with participants' dominant and non-dominant hands, ambidextrous children were excluded from analysis. To maximize generalizability, we enrolled similar numbers of female and male participants. The sample was divided into the following age groups: 6–7 years, 8–9 years, 10–11 years, 12–13 years, 14–15 years, 16–17 years, and 18–19 years, based on those used in the 1985 BBT pediatric norming study.[18]

Data collection measures

One of four occupational therapists facilitated each study visit. Each participant was assessed individually and completed one trial of the BBT with each hand. Participants were seated at a height-adjustable table, set to ensure the child's forearms rested comfortably on the surface, allowing for easy reaching. The therapist sat beside the child while administering the test according to the instruction sheet from the test box. The child was presented with 150 colored wooden blocks and asked to move one block at a time, as quickly as possible, from one side of the box to the other, making sure their fingers cross the partition.[18] Scores correspond to the number of blocks placed in 60 seconds. Half of the participants started with the left-hand trial and the other half with the right, depending on their study identification number. Data were entered by the testing therapist in an electronic data capture system. To prevent missing data, scoring forms were marked as complete in the database only once all scoring fields were filled out.

Study size

The sample size was 181 children and adolescents, including 98 females and 83 males. Prior to the study, a power estimation was completed based on the objectives of the CMDT validation study.[20]

Statistical analyses

For each gender-by-age group-by-hand category, we compared our sample to the normative sample using means and standard error of the means. Two-tailed, one sample *t*-tests were conducted at alpha = 0.0036 per comparison, which resulted in an overall experiment-wise error rate at alpha = 0.10. No missing data were observed in the study; thus, no methods were required for addressing missingness. All data analyses were conducted using SAS (SAS/STAT 15.1 Proprietary Software 9.4 (TS1M6), SAS Institute Inc., Cary, NC, USA. (c) 2016).

Results

A total of 816 children and adolescents were screened for eligibility. Of those who were eligible, a total of 182 participants were enrolled. Common reasons for non-participation of eligible children included scheduling conflicts with school, work and travel distance, or unresponsiveness to contact attempts. A breakdown of participants' age, sex, and handedness is presented in Table 1. We defined participant sex as sex assigned at birth, per parent report. The proportion of left-handed individuals in the sample (13%) was comparable to estimates in the general population.[22]

Table 2 contains the existing normative data for 6–19 year olds from the 1985 norming study.[18] Means, standard deviations, and score ranges for the current sample are shown in Table 3. Of note, our sample did not include 6- or 19-year-olds. Sample sizes range from 4 to 21 for each sex-by-age-by-handedness group. Comparing the current sample to the existing norms, males in the current sample placed 9.1 to 31.3 fewer blocks in 60 seconds, depending on age, and females placed 11.8 to 18.9 fewer blocks. Scores increased with participant age.

In all sex-age group categories, the current sample's means were statistically significantly lower than the 1985 normative sample as indicated by nonoverlapping 95% confidence intervals (Tables 2 and 3) and two-tailed, one sample t-test results (Table 4).

Discussion

This work was a secondary analysis of findings from our research team's pediatric normative study for the CMDT.[20,23] Upon noticing that participants' performance on the BBT was substantially lower than previous norms, we statistically compared our sample with the established normative data. The statistical analysis showed that performance has declined in the last 40 years, suggesting that the Box and Block Test is no longer valid for normative comparison.

Our results align with the results of a 2013 normative study of 3–10-year-olds in the Netherlands, which suggested a decline in BBT performance for 7–10-year-olds compared to the 1985 norms.[19] Additionally, our study cohort's mean scores on the BBT were lower than the 2013

Table 1
Age, sex, and hand dominance of participants (N = 181)

	Males			Females		
	n	Hand dominance		*n*	Hand dominance	
Age		R	L		R	L
7	12	9	3	13	12	1
8–9	21	20	1	21	18	3
10–11	13	10	3	20	17	3
12–13	13	12	1	15	13	2
14–15	8	8	0	12	10	2
16–17	12	9	3	10	9	1
18	4	4	0	7	7	0
Total	83	72	11	98	86	12
%	46	87	13	54	88	12

n = group size; R = right; L = left.

Table 2
Average performance of subjects, aged 6–19 years, on the Box and Block Test (blocks per minute), from 1985 sample*

Males							Females					
Age	**Hand**	***n***	**Mean**	**SD**	**95% CI**		**Hand**	***n***	**Mean**	**SD**	**95% CI**	
6–7	R	26	54.4	6.6	51.9	56.9	R	33	57.9	5.3	56.1	59.7
	L	26	50.7	6.3	48.3	53.1	L	33	54.2	5.6	52.3	56.1
8–9	R	30	63.4	4.3	61.9	64.9	R	32	62.8	5.1	61.0	64.6
	L	30	60.1	4.9	58.3	61.9	L	32	60.4	5.2	58.6	62.2
10–11	R	43	68.4	6.9	86.3	90.5	R	40	70.0	7.6	67.6	72.4
	L	43	65.9	6.8	63.9	67.9	L	40	67.6	8.6	64.9	70.3
12–13	R	34	74.6	8.3	71.8	77.4	R	36	73.6	8.1	71.0	76.2
	L	34	72.4	8.2	69.6	75.2	L	36	70.5	6.2	68.5	72.5
14–15	R	34	76.6	8.7	73.7	79.5	R	34	75.4	8.5	72.5	78.3
	L	34	74.6	7.9	71.9	77.3	L	34	72.1	7.6	69.5	74.7
16–17	R	31	80.3	8.7	77.2	83.4	R	35	77.0	9.0	74.0	80.0
	L	31	77.6	5.1	75.8	79.4	L	35	74.3	9.1	71.3	77.3
18–19	R	33	79.9	8.9	76.9	82.9	R	30	77.9	9.4	74.5	81.3
	L	33	79.2	8.8	76.2	82.2	L	30	76.0	8.5	73.0	79.0

R = right; L = left; *n* = group size; SD = standard deviation; CI = confidence interval.
* Mathiowetz V, Federman S, & Wiemer D. *Canadian Journal of Occupational Therapy*, *52*(5), p. 242. Copyright © 1985 by Sage Publications. Reprinted by Permission of Sage Publications. [18]

Table 3
Average performance of subjects, aged 7–18 years, on the Box and Block Test (blocks per minute), from current sample

	Males						Females					
Age	**Hand**	***n***	**Mean**	**SD**	**95% CI**		**Hand**	***n***	**Mean**	**SD**	**95% CI**	
7	R	12	41.4	6.6	37.2	45.6	R	13	45.6	5.3	42.4	48.9
	L	12	41.6	5.3	38.2	44.9	L	13	42.3	4.3	39.7	44.9
8–9	R	21	49.1	8.9	45.0	53.2	R	21	49.1	5.9	46.5	51.8
	L	21	46.9	6.4	44.0	49.8	L	21	46.3	6.5	43.3	49.3
10–11	R	13	57.1	4.9	54.1	60.0	R	20	55.7	5.5	53.1	58.3
	L	13	52.3	5.9	48.7	55.9	L	20	53.3	5.5	50.7	55.8
12–13	R	13	58.0	9.2	52.5	63.5	R	15	60.1	8.0	55.6	64.5
	L	13	56.3	8.0	51.5	61.2	L	15	56.4	6.4	52.8	60.0
14–15	R	8	60.4	7.0	54.5	66.2	R	12	58	10.3	51.5	64.6
	L	8	60.0	6.9	54.3	65.7	L	12	57.8	8.5	52.5	63.2
16–17	R	12	62.3	6.1	58.5	66.2	R	10	64.4	5.8	60.3	68.5
	L	12	61.0	7.0	56.5	65.5	L	10	62.5	8.5	56.4	68.6
18	R	4	58.8	6.1	49.1	68.4	R	7	60.7	10.1	51.4	70.1
	L	4	59.8	3.4	54.3	65.2	L	7	57.1	7.7	50.0	64.3

R = right; L = left; *n* = group size; SD = standard deviation; CI = confidence interval.

normative data, indicating a continuing decline in manual dexterity over the last decade. These differences exceed the minimum clinically important difference of the BBT, which was shown to be 5.29 to 6.46 for children with unilateral cerebral palsy.[24] These findings align with the recent trend of other standardized test developers updating test norms in response to changes in children's development. For example, the Peabody Developmental Motor Scales and Bruininks-Oseretsky Test of Motor Proficiency underwent significant updates to the test and norms in 2023 and 2024, respectively.[25,26] Taken together, this evidence clearly indicates that clinicians should use standardized assessments that have more recent normative data.

Our study has several limitations. The goal of the CMDT study was not to establish new normal values for the BBT, thus the age groups differed from those used in the 1985 BBT normative study. The CMDT study did not include any 6-year-old or 19-year-old subjects. Additionally, when determining the sample size for the CMDT study, participant gender was not considered. Consequently, the sample sizes of certain gender-age subgroups in the BBT were small. Although there were insufficient subjects within each age group (ranging from $n = 4$ to $n = 21$) to establish generalizable normative data, our results strongly suggest that the 1985 norms are no longer valid. Lastly, there was a possibility for volunteer bias. Factors protecting against bias include the socioeconomically diverse urban and suburban community from which participants were recruited, compensation of families to minimize the financial burden of participation, and eligibility criteria excluding participation of children with known conditions.

Future research should establish updated pediatric normative data for the Box and Block Test. Additional studies should evaluate the validity of the BBT norms for adults and children under 6 years old and update normative data for these age groups.

Table 4
T-Test results of 1985 normative sample and current sample's mean Box and Block Test scores

	Males				Females			
Age	**Hand**	**df**	***t***	***p***	**Hand**	**df**	***t***	***p***
6–7	R	11	−6.92	< 0.001	R	12	−8.28	< 0.001
	L	11	−5.98	< 0.001	L	12	−10.09	< 0.001
8–9	R	20	−7.34	< 0.001	R	20	−10.67	< 0.001
	L	20	−9.49	< 0.001	L	20	−9.91	< 0.001
10–11	R	12	−23.10	< 0.001	R	19	−11.67	< 0.001
	L	12	−8.30	< 0.001	L	19	−11.60	< 0.001
12–13	R	12	−6.53	< 0.001	R	14	−6.56	< 0.001
	L	12	−7.24	< 0.001	L	14	−8.50	< 0.001
14–15	R	7	−6.57	< 0.001	R	11	−5.85	< 0.001
	L	7	−6.01	< 0.001	L	11	−5.83	< 0.001
16–17	R	11	−10.24	< 0.001	R	9	−6.92	< 0.001
	L	11	−8.16	< 0.001	L	9	−4.39	0.002
18–19	R	3	−6.96	0.01	R	6	−4.50	0.004
	L	3	−11.43	0.001	L	6	−6.45	< 0.001

R = right; L = left; df = degrees of freedom; *t* = *t*-value; *p* = *p*-value.

Conclusions

In this study, we sought to compare the performance of a contemporary sample of typically developing youth on the BBT with the existing normative data from 1985. The results showed a significant difference in scores between the two groups, with poorer performance for the modern sample. This suggests a need for updated normative data for the BBT to accurately reflect typical manual dexterity among youth today. Because the 1985 normative data are not aligned with children's current performance, the existing norms likely overestimate the prevalence of deficits among children tested. Updated norms for the BBT, or the use of other assessments with up-to-date norms, will improve evaluation accuracy and reduce unnecessary referrals and treatment.

Author contributions

Sabrina Gmuca: Writing – review & editing, Supervision, Resources, Funding acquisition. **David D Sherry:** Writing – review & editing, Resources, Funding acquisition. **Ashley M Binkowski:** Writing – review & editing, Investigation. **Lynne Allen-Taylor:** Writing – review & editing, Writing – original draft, Formal analysis. **Nellie P Butler:** Writing – review & editing, Writing – original draft, Project administration, Data curation. **Tami L Konieczny:** Writing – review & editing, Writing – original draft, Investigation, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Acknowledgments

This research was funded by the Snider Foundation and Snider Family. In addition, Gmuca S is supported by NIH award K23AR081409. The authors would like to thank Nicole Gerhardt, Jaclyn Urso-Defeo, Lindsay Waqar-Cowles, and Mackenzie McGill for their assistance with this project.

References

1. Fleishman EA. *The Structure and Measurement of Physical Fitness. The Structure and Measurement of Physical Fitness.* . Englewood Cliffs, N.J.: Prentice-Hall; 1964:207.
2. Randjelović N, Stanišić I, Dragić B, Piršl D, Savić Z. The sequence of procedures in the development of fine motor coordination through physical activities and movement games in preschool children. *Facta Univ Series: Phys Educ Sport.* 2019:611–620.
3. Ahearne C, Dilworth S, Rollings R, Livingstone V, Murray D. Touch-screen technology usage in toddlers. *Arch Dis Child.* 2016;101(2):181. https://doi.org/10.1136/archdischild-2015-309278
4. Mohamed NM, Kamal HM, Gharib RM. Effect of touch screen devices use on fine motor skills of preschool children. *Egypt J Hosp Med.* 2023;91(1):4387–4392.
5. El-Sharkawy MAE-A, Hanna S, Mohamed NE. Touch-screen technology and pediatric population; hand skills, pain and quality of life: a narrative review. *Egypt J Hosp Med.* 2024;96(1):2720–2726.
6. Bedford R, Saez de Urabain IR, Cheung CH, Karmiloff-Smith A, Smith TJ. Toddlers' fine motor milestone achievement is associated with early touchscreen scrolling. *Front Psychol.* 2016;7:1108.
7. Daud AZC, Aman NAa, Chien C-W, Judd J. The effects of touch-screen technology usage on hand skills among preschool children: a case-control study. *F1000Research.* 2020;9:1306.
8. Priyadarshi M, Balachander B, Sankar MJ. Effect of sleep position in term healthy newborns on sudden infant death syndrome and other infant outcomes: a systematic review. *J Glob Health.* 2022;12:12001. https://doi.org/10.7189/jogh.12.12001
9. Majnemer A, Barr RG. Association between sleep position and early motor development. *J Pediatr.* 2006;149(5):623–629. https://doi.org/10.1016/j.jpeds.2006.05.009
10. Majnemer A, Barr RG. Influence of supine sleep positioning on early motor milestone acquisition. *Dev Med Child Neurol.* 2005;47(6):370–376. https://doi.org/10.1017/s0012162205000733
11. Davis BE, Moon RY, Sachs HC, Ottolini MC. Effects of sleep position on infant motor development. *Pediatrics.* 1998;102(5):1135–1140. https://doi.org/10.1542/peds.102.5.1135
12. McMaster E, Roberts T, McMaster E, Roberts T. Handwriting in 2015: a main occupation for primary school–aged children in the classroom? *J Occup Ther Sch Early Interv.* 2016;9(1):38–50. https://doi.org/10.1080/19411243.2016.1141084
13. Enstrom EA. The decline of handwriting. *Elem Sch J.* 1965;66(1):22–27.
14. Rogers H, Laehn J, Lang A, O'Leary D, Sommers M. *The Status of Elementary Keyboarding: A Longitudinal Study.* WI: University of Wisconsin-Whitewater,; 2003.
15. National Governors Association Center for Best Practices CoCSSO. *Common Core State Standards.* Washington, DC: Author,; 2010.
16. Smith DA. *The Box and Block Test: Normative Data for Seven, Eight, and Nine Year Old Children.* Los Angeles, C.A.: University of Southern California; 1961⟨https://digitallibrary.usc.edu/archive/The-box-and-block-test–Normative-data-for-seven–eight–and-nine-year-old-children-2A3BF1LEN9WJ.html⟩.
17. Cromwell FS. *Occupational Therapist's Manual for Basic Skills Assessment or Primary Pre-Vocational Evaluation.* Pasadena, C.A.: Fair Oaks Print. Co.; 1960.
18. Mathiowetz V, Federman S, Wiemer D. Box and Block Test of manual dexterity: norms for 6–19 year olds. *Can J Occup Ther.* 1985;52(5):241–245. https://doi.org/10.1177/000841748505200505
19. Jongbloed-Pereboom M, Nijhuis-van der Sanden MW, Steenbergen B. Norm scores of the Box and Block Test for children ages 3-10 years. *Am J Occup Ther.* 2013;67(3):312–318. https://doi.org/10.5014/ajot.2013.006643
20. Konieczny TL, Butler NP, Allen-Taylor L, Binkowski AM, Sherry DD, Gmuca S. Pediatric normative data for the Complete Minnesota Dexterity Test. *J Hand Ther.* 2025. https://doi.org/10.1016/j.jht.2025.02.011
21. Cuschieri S. The STROBE guidelines. *Saudi J Anaesth.* 2019;13(1):S31–s34. https://doi.org/10.4103/sja.SJA_543_18
22. Papadatou-Pastou M, Ntolka E, Schmitz J, et al. Human handedness: a meta-analysis. *Psychol Bull.* 2020;146(6):481–524. https://doi.org/10.1037/bul0000229
23. Konieczny T, Gmuca S, Binkowski A, Butler N, Taylor L. Pediatric normative data for the Complete Minnesota Dexterity Test. *Arch Phys Med Rehabil.* 2025;106(4):e56https://doi.org/10.1016/j.apmr.2025.01.144
24. Liang KJ, Chen HL, Shieh JY, Wang TN. Measurement properties of the Box and Block Test in children with unilateral cerebral palsy. *Sci Rep.* 2021;11(1):20955. https://doi.org/10.1038/s41598-021-00379-3
25. Folio MR, Fewell RR. Peabody Developmental Motor Scales, Third Edition. 2023.
26. Bruininks BD, Bruininks RH. *Bruininks-Oseretsky Test of Motor Proficiency*. Third edition San Antonio, TX: Pearson Assessments; 2024.

JHT Read for Credit
Quiz: # C62

Record your answers on the Return Answer Form found on the tear-out coupon at the back of this issue or to complete online and use a credit card, go to *JHTReadforCredit.com*. There is only one best answer for each question.

1 Validity was determined by comparison to the
a. CMDT
b. BBT
c. both a & b above
d. none of the above

2 Normative data the authors site were developed in
a. 1985
b. 1995
c. 1885
d. 2005

3 There were as many as _____ fewer blocks stacked by the current volunteers vs the existing scores
a. 50
b. 3
c. 20
d. 13

4 Results suggest that
a. AI is the best method of determining current normative data
b. the investigators' methodology was fatally flawed
c. the BBT may no longer be valid
d. the Purdue Pegboard Test is the best test of manual dexterity

5 The results suggest a decline in children's manual dexterity
a. not true
b. true

When submitting to the HTCC for re-certification, please batch your JHT RFC certificates in groups of 3 or more to get full credit.