The Egyptian Journal of Hospital Medicine (April 2022) Vol. 87, Page 1317-1321

Differences in Manual Dexterity between Dominant and Non-Dominant Side in Typically Developing Children

Salma A. Abd El Hameed*, Elham E. Salem, Marwa M. I. Ismaeel
Department of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Cairo University, Egypt
***Corresponding author:** Salma A. Abd El Hameed**, Mobile:** (+20)01099866600, **E-mail:** drsalmaashraf1111@gmail.com

ABSTRACT

Background: Manual dexterity is the ability to manipulate objects using the hands and fingers, which requires coordination between muscular, skeletal, and neurological systems, which start to develop during childhood.

Objective: We aimed to assess differences of gross manual dexterity and fine manual dexterity between dominant and non-dominant hand in typically developing children whose age between 8 to 10 years.

Subjects and Methods: Thirty typically developing children of both sexes participated in this study. Box and Blocks Test was used to assess gross manual hand dexterity and Nine Hole Peg Test was used to assess fine manual hand dexterity.

Results: There was no significant difference found between the dominant and non-dominant side in Box and Blocks Test ($p = 0.11$), but it showed a significant difference between the dominant and non-dominant side in Nine Hole Peg Test ($p = 0.02$) measures.

Conclusion: There was no significant difference in gross manual dexterity measured by Box and Blocks Test but there was significant difference in fine manual dexterity measured by Nine Hole Peg Test between the dominant and non-dominant hand in children at selected age group between 8 to 10 years.

Keywords: Manual dexterity, Box and Blocks Test, Nine Hole Peg Test, Typically Developing Children.

INTRODUCTION

Manual dexterity is the ability to manipulate objects through coordination of the hands and fingers and is a key indicator of motor function. It combines elements of cognitive acuity, tactile sensation, muscle strength, and force control. Manual dexterity can be quantified as the time to complete a pegboard test, such as the grooved pegboard test or the nine-hole peg test [(1)].

Primary school activities involve manual dexterity to an even higher degree [(2)]. In primary school, 30–60% of time is dedicated to learning writing and other manipulative tasks [(3)]. Therefore, the main goal during the preschool and elementary school periods should be to facilitate the development of a wide range of manual activities. **Yakimishyn and Magill-Evans** [(4)] maintain that the preschool period is especially important for the formation of the fundamental manipulative abilities required in elementary school. They encourage teachers to monitor the development of manual dexterity during exercises involving various implements [(4, 5)].

Manual dexterity in childhood is primarily considered a product of neuro-motor systems and a hallmark of a child's broader motor competence. While early childhood is a key period for the development of manual dexterity [(6)], recent studies demonstrate that manual dexterity undergoes continued refinement across the primary school years [(7)] and stabilizes in adolescence [(8)]. Where the development of manual dexterity is delayed or impaired during this period (e.g., in children with developmental coordination disorder), poor manual dexterity has been associated with increased anxiety, poor self-esteem and academic difficulties [(9)].

The Box and Block Test is a simple test that can be administered quickly to assess gross manual dexterity; these facets make the test a valuable and suitable test for very young children to compare atypically developing children with age related peers, and to assess the efficacy of the intervention [(10)].

The Nine Hole Peg Test (NHPT) is a component of the National Institutes of Health (NIH) Toolbox for the Assessment of Neurological and Behavioral Function, which provides a set of assessment tools that can be used across the lifespan (3-85 years). Norms of the NHPT that can be used to determine the presence of impairments in dexterity across this age span have been established as part of the NIH Toolbox Norming Project [(11)].

We aimed to investigate manual dexterity through measuring box and blocks test and Nine Hole Peg Test in typically developed children and compare between dominant and non-dominant mesures.

SUBJECTS AND METHODS

Subjects:

Thirty typically developing children of both sexes free from any type of deformities participated in this study. They were selected from the governmental Egyptian schools at Cairo Governorate according to inclusive criteria. Their age ranged from 8 to 10 years. All participants were able to follow the verbal and visual commands and free from any medical disease. The exclusion criteria included history of surgery, congenital deformity in upper extremities or trunk, injury to the upper extremities or back in the previous 6 months, neuromuscular damage of the spine and upper extremities.

Materials:

Informed consent form, Box and Block Test, Nine-Hole Peg Test. Box and Blocks testing form was used to record the number of blocks transported in one minute by the dominant and non-dominant side for each

Received: 12/10/2021
Accepted: 10/12/2021

participant. Nine-hole peg test form was used to record the time needed to complete the test in seconds by the dominant and non-dominant side for each participant, Adjustable table, Chairs with suitable heights and stopwatch.

Procedures:

All participants had a full explanation for the evaluation procedures. The examiner were asked about age, gender, social level, and any other medical disease.

Ethical considerations:

This study was approved by the Ethical Committee. Faculty of Physical Therapy, Cairo University (NO: P.T.REC/012/003232) on 30 May 2021. Signed informed consent was obtained from each participant's parent as ethical principles of the Declarations of Helsinki were followed.

Box and blocks test:

Before testing begins each child was allowed a 15-second trial period. If the child transported two or more blocks at the same time, it was noted and the number subtracted from the total. Each child was instructed to grasp one block at a time, continue the task to complete one minute and repeat with the non-dominant side. Each child was instructed to continue doing this for one minute, the procedure then was repeated with the non-dominant hand. After testing, the examiner counted the blocks.

No penalty was made if the participants transported any blocks across the partition and the blocks bounced from the box to the floor or table. Instructions were given according to **Mathiowetz *et al.*[(12)].**

Nine Hole Peg Test:

Before testing begins each child was allowed a practice trial. The child's dominant arm was tested first. The child was instructed to remove the pegs one at a time and put them to the container beside his/her tasted hand, using the right hand only. The stopwatch was started when the child touches the first peg and was stopped when the last peg hit the container. The container was placed on the opposite side of the pegboard and the instructions were repeated with the non-dominant hand. Instructions were given according to **Mathiowetz *et al.*[(13)].**

Statistical analysis

Descriptive statistics were conducted including mean and standard deviation. Paired t-test was conducted for comparison of Box and Block Test score and Nine-hole peg test time within study group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical tests were performed through the Statistical Package for the Social Studies (SPSS) version 25 for windows. (IBM SPSS, Chicago, IL, USA).

RESULTS

Thirty children participated in this study, the mean ± SD age of the study group was 9.33 ± 0.71 years (Table 1).

Table (1) Participant characteristics

	Mean ± SD	Minimum	Maximum
Age (years)	9.33 ± 0.71	8	10
	N	**%**	
Sex:			
Girls	14	(47%)	
Boys	16	(53%)	

Box and blocks test:

The mean ± SD Box and Block Test score of the dominant hand of the study group was 27.4 ± 4.39 block and of the non-dominant hand was 26.46 ± 4.78 block (Table 2).

Table (2): Descriptive statistics of the Box and Block Test score of the study group (N=30)

Box and Block Test score (Block)	Mean±SD	Minimum	Maximum	Range
Dominant hand	**27.4 ± 4.39**	**20**	**37**	**17**
Non-dominant hand	**26.46 ± 4.78**	**19**	**39**	**20**

There was no significant difference in the Box and Block Test score between dominant and non-dominant hand of study group (Table 3 and Figure 1).

Table (3): Comparison of Box and Block Test score between dominant and non-dominant hand of study group (N=30)

	Dominant hand	Non- dominant hand	Mean difference	t- value	p-value
	Mean±SD	Mean±SD			
Box and Block Test score (Block)	27.4 ± 4.39	26.46 ± 4.78	0.94	1.64	0.11

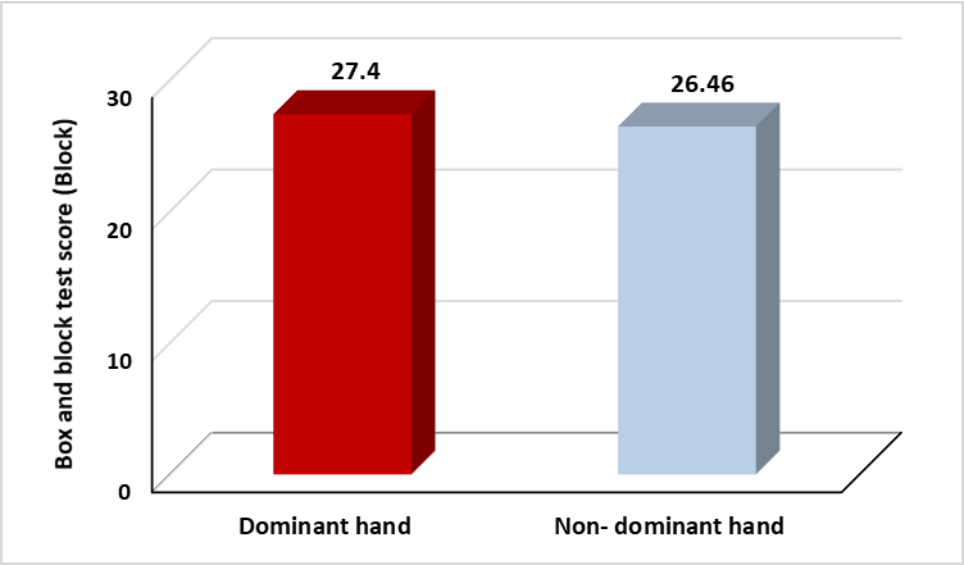

Figure (1): Mean Box and Block Test score of dominant and non-dominant hand of study group (N=30)

Nine Hole Peg Test:

The mean ± SD Nine-Hole Peg Test time of the dominant hand of the study group was 37 ± 5.28 sec. While the mean ± SD Nine-Hole Peg Test time of the non-dominant hand was 38.4 ± 5.17 sec (Table 4).

Table (4): Descriptive statistics of the Nine-hole peg test time of the study group (N=30)

Nine-Hole Peg Test time (Block)	Mean±SD	Minimum	Maximum	Range
Dominant hand	**37 ± 5.28**	**22**	**45**	**23**
Non-dominant hand	**38.4 ± 5.17**	**24**	**50**	**26**

There was a significant decrease in the Nine-Hole Peg Test time of the dominant hand compared with that of the non-dominant hand of the study group (Table 5 and Figure 2).

Table (5): Comparison of Nine-Hole Peg Test time between dominant and non-dominant hand of study group (N=30)

	Dominant hand	Non- dominant hand	Mean difference	t- value	p-value
	Mean ±SD	Mean ±SD			
Nine-Hole Peg Test time (sec)	37 ± 5.28	38.4 ± 5.17	-1.4	-2.71	0.02

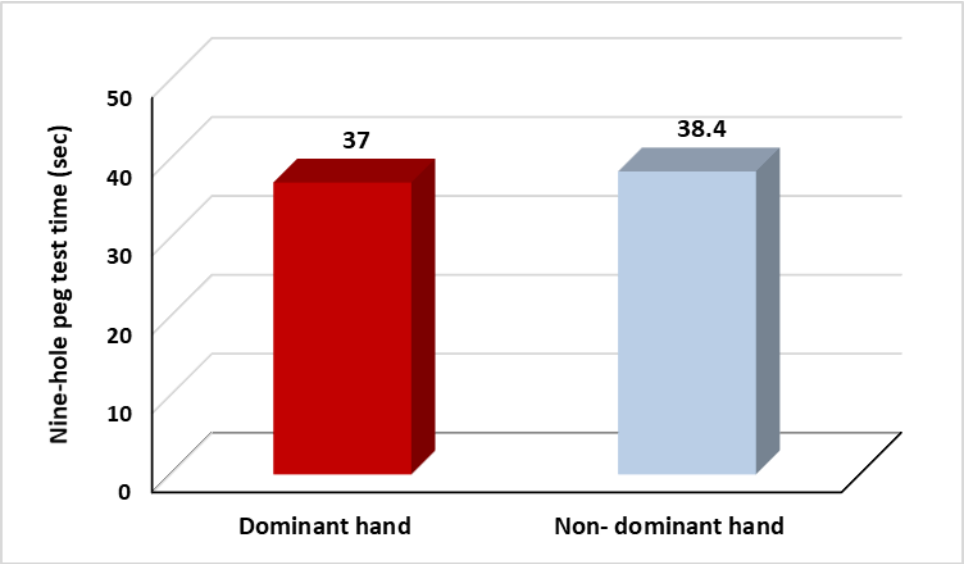

Figure (2): Mean Nine-Hole Peg Test time of dominant and non-dominant hand of study group (N=30)

DISCUSSION

The purpose of this study was to investigate the difference in manual hand dexterity between dominant and non-dominant hand in typically developing children whose age between eight and ten years old.

The development of manual dexterity is vital for overall development. Manual dexterity develops during early childhood in accordance with a predictable course of events, although the pace varies from child to child [(14)]. The superior performance of the preferred hand over the non-preferred hand in most tasks has been documented extensively. In particular, the preferred hand is faster and more accurate than the non-preferred one. This superiority has been attributed to cerebral laterality. In humans, one group of functions related to language and other motor and sensory performance is more or less localized to the neocortex [(15)]. Although overall superiority of the dominant hand has been established, the specific dominance-related differences in performance during various manual tasks have not been investigated to date. Identifying which differences are "typical" and obtaining reliable measurements of these would provide useful baseline performance values. These could be applied in both the diagnosis and treatment of impaired hand function [(16)].

The selection of Box and Blocks Test (BBT) to be used in this study as an appropriate method of assessment suitable to the selected sample age comes in agreement with **Guimarães *et al.*** [(17)] who used it in their study on brazilin children and stated that it was possible to use the BBT in the normal population and the Down Syndrome (DS) population in different age brackets, especially between 7 and 9, and 14 and 15 years of age, periods corresponding to entering elementary school and high school in Brazil, respectively.

Using NHPT in the current research for being an appropriate screening tool that helps the therapist to assess a child's ability to make grasping, transferring the object, and release it matched the finding of **Omar *et al.*** [(18)] who measured manual dexterity in children aged 4-19 years using 9-HPT. The authors proposed that the 9-HPT is an appropriate screening tool because it reflects multiple aspects of motor control, such as reshaping the hand, grasping, moving, and releasing the object.

While the literature concerning handwriting readiness and fine motor skills in children is abundant [(2, 19,20)], little is known about age-related changes related to children's manual dexterity parameters. Some methods have been created to assess children's fine motor skills [(5,19-21)], but none of these instruments includes all necessary components to evaluate different aspects of manual dexterity parameters [(21)].

Many individuals with a strong right-hand preference may perform a unimanual motor skill equally well with both hands (or even slightly better with the left non-dominant hand) [(22)]. For instance, a recent study on circle drawing confirmed that the asymmetry in dexterity and handedness for a given skill may substantially vary at the individual level [(23)].

Results of the current study showed no significant difference between the dominant and non-dominant side in BBT measures but showed a significant difference between the dominant and non-dominant side in NHPT measures. This may be attributed to that, the BBT asses gross manual dexterity, which relays on arm and hand muscles with little precision as it uses powerful grip, which carried by using the five fingers in addition to object characteristics as grasping the blocks, which were small regular shaped squares that are much easier than grasping smooth regular and tiny cylinder-shaped objects as NTPT, which relay on precision grip using thumb and index only.

This attribution may come in agreement with **Li *et al.*** [(24)] who mention that gross manual dexterity is motion involved in manipulating larger objects, and it involves the global movement of the arms, hands, and fingers driven by flexor digitorum with little precision. And also with **Gentier *et al.*** [(25)] **and Ives** [(26)] who stated that fine motor dexterity is defined as precise motions associated with controlling small objects using thumb and index fingers with eye-hand coordination.

Results of the current study showed no differences in manual dexterity between the dominant and non-dominant sides in BBT measures, which comes in agreement with **Turco *et al.*** [(27)] who stated that in the sample analyzed, there was no performance difference between girls and boys in the age group 7-10 years between dominant hand (DH) and non-dominant hand (NDH) as the mean of blocks transferred with DH was (62.03) and NDH was (60.07) for girls and mean of blocks transferred with DH was (61.79) and NDH was (60.04) for boys.

But the results of the current study contradict the results of **Vallabadoss *et al.*** [(28)] who stated that, comparison between right- and left-hand mean values have a very high statistical significance difference at 99.9% ($p<0.001$) with all age groups using the paired t-test. Based on the calculation of their correlation ranges from 0.789 to 0.814, positive high correlation, they have a strong association between left and right hands participants. In their study of on Indian children whose age was 6 to 10 years and were divided to four age groups assessing Norm Scores-Box and Block Test.

Results of the current study showed differences in manual dexterity between the dominant and non-dominant sides in NHPT measures, which come in agreement with **Gogola *et al.*** [(29)] who found that dominant hands were faster than non-dominant hands at all ages, and the difference between dominant and non-dominant hands remained constant at 0.088 pegs/sec at all ages.The results of the current study showed that hand preference and asymmetries in motor performance are strongly related as the dominant hand significantly outperforms the non-dominant in the measures of NHPT. That comes in agreement with the results of **Karthik and Mahantha** [(30)] in their study of evaluating the association between hand preference and hand performance by assessing handgrip strength, finger

tapping, and hand steadiness in TDC between 10 and 14 years.

CONCLUSION

There was no significant difference in gross manual dexterity measured by Box and Blocks Test but there was significant difference in fine manual dexterity measured by Nine Hole Peg Test between the dominant and non-dominant hand in children at selected age group between 8 to 10 years.

Source of funding: This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest: The authors have no conflicts of interest to declare.

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