

Validation of a Chopsticks Manipulation Test for Screening Chinese Children with Fine Motor Dysfunction

CWP *LI-TSANG*, HCY *LEE*, LK *HUNG*

Abstract

Purpose: To study the test-retest reliability, concurrent and discriminant validity of a Chopsticks Manipulation Test for assessing children with fine motor delay. **Method:** Chopsticks Manipulation Test and Peabody Developmental Motor Scale-Fine Motor scale were administered on 190 children (120 without developmental disabilities and 70 with developmental disabilities). Another 40 children were selected to test for test-retest reliability. **Results:** (1) Test-retest reliability of the two tests mentioned above was found to be satisfactory (ICC ranged from 0.89 to 0.99). (2) There was a moderate correlation between the two tests ($r=0.39$, $p<0.01$). (3) There was significant difference between children with and without developmental disabilities in the Chopsticks Manipulation Test ($t\text{-value}=-4.71$, $df=180$, $p<0.05$). (4) Age and gender are factors affecting the Chopsticks Manipulation Test performance. **Conclusion:** The Chopsticks Manipulation Test was found to have good test-retest reliability. It is easy to administer in different clinical settings and the children are familiar with the equipment used in the test. It can also discriminate children with and without fine motor delay. Age and gender seemed to affect the performance of chopsticks manipulation of children.

Key words

Child; Developmental disabilities; Eating utensils; Motor skills

Introduction

The dexterous grasps of hands enable mankind to master their living environments through effective manipulation of objects in different shapes and tools for various functions.¹ Chopsticks manipulation is one of the major fine motor

achievements of children to accomplish in the Chinese culture. Using a pair of chopsticks in dining is also regarded as an important part of social life within a family or a social context.² It also represented the users' manner and respect towards the others. Children are encouraged to use chopsticks to feed themselves as early as three to four years of age.³⁻⁵ A child's ability to use a pair of chopsticks skillfully is affected by many factors such as age, sex and surrounding environment like family and social expectations.²

The hand development of children may be hindered by developmental disabilities such as developmental co-ordination disorders, cerebral palsy, congenital anomalies, mental handicap or developmental delay.^{6,7} Parents often regard the use of chopsticks as a developmental milestone for their children though no developmental test batteries adopted this task into the assessment. Being the major and primary eating utensil in the Asian population,⁸ its manipulation does have an impact on the development of eating skills.² Early screening and assessment of children with functional disabilities are essential such that children and parents could start the

Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China

CWP *LI-TSANG* (李曾慧平) *PDOT, MPhil, PhD*

School of Occupational Therapy, Curtin University of Technology, Australia

HCY *LEE* (李忠揚) *PDOT, MSc, PhD*

Department of Orthopaedics & Traumatology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong

LK *HUNG* (熊良儉) *MBBS, FRCS, FHKCOS*

Correspondence to: Dr CWP *LI-TSANG*

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intervention as early as possible.

Previous studies focused on the ergonomic analysis of chopsticks design to enhance the manipulation of objects.^{9,10} Yet, there are very few studies addressing the developmental progression of children in chopsticks manipulation skills.² Wong and her colleagues² studied on 445 non-disabled children and found that children at the age of 4.6 years could manage chopsticks to complete half of the meal while those at 6.7 years old could master the skills independently. However, the report was based on parents' subjective feedback and there was no standardised assessment on the task itself. It remains difficult to make judgment on whether a child has 'good' or 'poor' chopsticks manipulation skills without accurate and objective assessment. In Taiwan, Chang, Chien and Lin³ developed a chopsticks manipulation test for adults to determine their functional performance after severe hand injuries. Chen and Chang⁸ also developed the Test of Chopsticks Manipulation (TCM) in which relationship was found with the dexterity tasks. However, these studies did not report the developmental progression of children in this specific fine motor skill. Wu¹⁰ developed a series of tests to assess the biomechanics of the chopsticks in terms of food-pulling, food-shearing and food thrusting tasks in a laboratory with simulated environment. These tests are very objective and quantitative. Unfortunately, they had to be conducted in a laboratory situation and the procedures were difficult and complicated to be administered on young children. The process to complete the three tests may take about two hours and children between four to six years old might not have the patience to complete all the tasks.

This paper is to study the reliability, concurrent and discriminant validity of the Chopsticks Manipulation Test (CMT) that was developed locally with cultural relevance to the Chinese children. The researchers would also like to find out the developmental progression of the children when developing this chopstick manipulation skill. Factors, such as gender and living habits would also be explored.

Method

Subjects

As Wong et al² reported that children will accomplish chopsticks skills at 4.6 years old and completely master it at age 6.7 years old, children aged between 4-7 years were selected in this study. Before the commencement of the assessment, the investigator restated the purposes and procedures of the study to the participants and their parents.

The investigator completed an initial screening procedure to ensure that the participants did not have pre-existing illnesses that could influence their hand functions. Each participant was welcomed by name and thanked for their assistance. The investigator endeavoured to build up a working relationship with the participants and effort was made to reassure them of the assessment environment.

The research was divided into two phases of study. The first phase of the study is to test for the reliability of the CMT. The second phase of the study was to test for the concurrent and discriminant validity of the CMT.

1st Phase of Study: Test for Reliability

In the first phase of the study, 30 children aged between four to six years old were selected from a kindergarten and 10 children diagnosed with developmental delay were chosen from an outpatient rehabilitation centre using convenience sampling method. Subject to their parents' consent, the children were assessed on two tests, namely, the Peabody Developmental Motor Scale-Fine Motor (PDMS-FM) and the CMT. One week after the initial assessment, the tests were repeated on the same group of subjects for test-retest reliability.

Instrumentation

(1) The Chopsticks Manipulation Test (CMT)

The fine hand functions of the participants were further assessed using the CMT as shown in Figure 1. Participants were asked to transfer 10 kidney beans from the container closer to them to another one 20 centimeters away. The testing procedures were set up with reference to Chang's³ investigation of chopstick usage with 397 adults. If a bean was dropped in between the containers, the children were



Figure 1 The arrangement of the participant with the Chopstick Manipulation Test (Reproduced with consent of the parent of the participant).

required to put the bean back in the first container and to repeat the procedure again until all the beans were transferred. Total time used was recorded after completion. An assessor's manual was designed to ensure uniformity and consistency of data collection procedures among participants. A debriefing session with the individual child and his/her parents to answer queries about the study was conducted after the hand evaluation.

(2) The Peabody Developmental Motor Scale-Fine Motor (PDMS-FM)

The PDMS-FM scale was selected in this study to assess the developmental progression of each child. The test was developed to identify children whose gross motor and fine motor skills were delayed relatively to a normative group. It was proven with good inter-rater and test-retest reliability.¹¹⁻¹⁵ It was easy to administer and the Chinese version was available with standardised verbal instructions.¹⁶ Each child would be assessed by a rater individually on the items listed in the fine motor scale based on the child's chronological age. A total score was obtained by adding all the scores of each item together and would be used for analysis.

2nd Phase of the Study

Test for Discriminant Validity Using Known Group Method

In the second phase of the study, 120 preschool children were recruited using a stratified sampling method for the study. Recruitment was accomplished with the assistance from four kindergartens located in different suburbs of Hong Kong. The children were randomly selected from the three grades (K1, K2 and K3) of the kindergartens with 10 from each grade of study (five boys and five girls). Seventy children diagnosed with developmental disabilities were recruited from the outpatient paediatric clinic of a regional hospital in Hong Kong using convenience sampling method. The Human Research Ethic Committee of the author's institute approved the project. Parental consent was obtained prior to the assessments.

Each child was assessed by a rater with previous experiences of using the PDMS-FM test and the CMT. For children in the kindergarten, they were assessed at the kindergartens they studied such that they would have no fear of new environment. For children with developmental disabilities, they were assessed in the occupational therapy department that they attended regular therapy sessions. The procedures of assessments were similar to the first phase of the study except that only one assessment was conducted on each child.

Test for Concurrent Validity Using the PDMS-FM

The raw scores of PDMS-FM were collected and the time score of the CMT was also recorded for the 190 subjects. This is to test for the concurrent validity of the CMT in relation to the fine motor sub-score of the PDMS-FM.

Data Analysis

All data were analysed using SPSS.¹⁷ Intra-class correlation coefficient (ICC) was used to test for the test-retest reliability of the CMT and PDMS-FM scores. Pearson's correlation was used to correlate CMT scores with the PDMS-FM scores to test for the concurrent validity of the two tests. Independent t-test was used to compare the CMT scores between the normal children group and the children with developmental disabilities. Three way ANOVA was used to find out the factors affecting the CMT performance, namely age, gender and the kindergartens that the children attended. The four kindergartens selected were based on the geographical division of HK Island, Kowloon, New Territories East and New Territories West. One kindergarten was randomly picked from the lists of kindergartens within these four districts. A significance level of $p < 0.05$ was used for analysis.

Results

Test-retest Reliability of the CMT and PDMS-FM

Among the 40 children selected for the reliability testing, there were even distribution of boys and girls in both groups. The mean age of the group without developmental disabilities was 64.4 months (SD=11.0 months) and the group with developmental disabilities was 65.8 months (SD=10.5 months). Both of the test-retest reliability for the PDMS-FM scale, ranging from 0.79 to 0.89 (see Table 1), and for the CMT scores, ranging from 0.89 to 0.99 (see Table 1) were satisfactory.

Table 1 Test-retest reliability of PDMS-FM and CMT

	Normal children		Children with developmental disabilities	
	ICC	Range	ICC	Range
PDMS-FM	0.89	0.74-0.95	0.79	0.4-0.94
CMT	0.89	0.97-0.99	0.99	0.97-0.99

Demographic Data of the Normal and Disabled Children Groups

One hundred and twenty children without developmental disabilities and 70 children diagnosed with developmental disabilities were recruited in the study. Table 2 showed the distribution of age and gender between the two groups of children. One hundred and eleven children (92.5% of the sample group) were right handed in the group of children without developmental disabilities. For the children with developmental disabilities, there were 40 of them diagnosed

with congenital anomalies of upper extremities, 15 with cerebral palsy resulting hand dysfunction and 15 children with developmental delay. There was no significant difference in the mean age between the two groups.

The Chopsticks Manipulation Test (CMT) Scores for Children Between 4-7 Years Old

The average time to complete the Chopsticks Manipulation Test ranged from 21.87 to 140.13 seconds (mean=58.71 sec, SD=35.92 sec). Figure 2 showed the

Table 2 Demographic data of children participating in the study

Characteristics		Children without developmental disabilities (N=120)	Children with developmental disabilities (N=70)
Gender	Boys	60 (50.00%)	44 (62.86%)
	Girls	60 (50.00%)	26 (37.14%)
Age	4-year-old	25 (20.83%)	9 (12.86%)
	5-year-old	52 (43.33%)	24 (34.29%)
	6-year-old	43 (35.83%)	37 (52.86%)
Hand dominance	Right Handed	111 (92.50%)	52 (74.29%)
	Left Handed	8 (6.67%)	15 (21.43%)
	Ambidextrous	1 (0.83%)	2 (2.86%)
Birth history	Normal delivery/Natural birth	90 (75.00%)	50 (71.43%)
	Caesarian Section	22 (18.33%)	0 (0%)
	Complications	0 (0%)	17 (24.29%)
Others		0 (0%)	1 (1.43%)

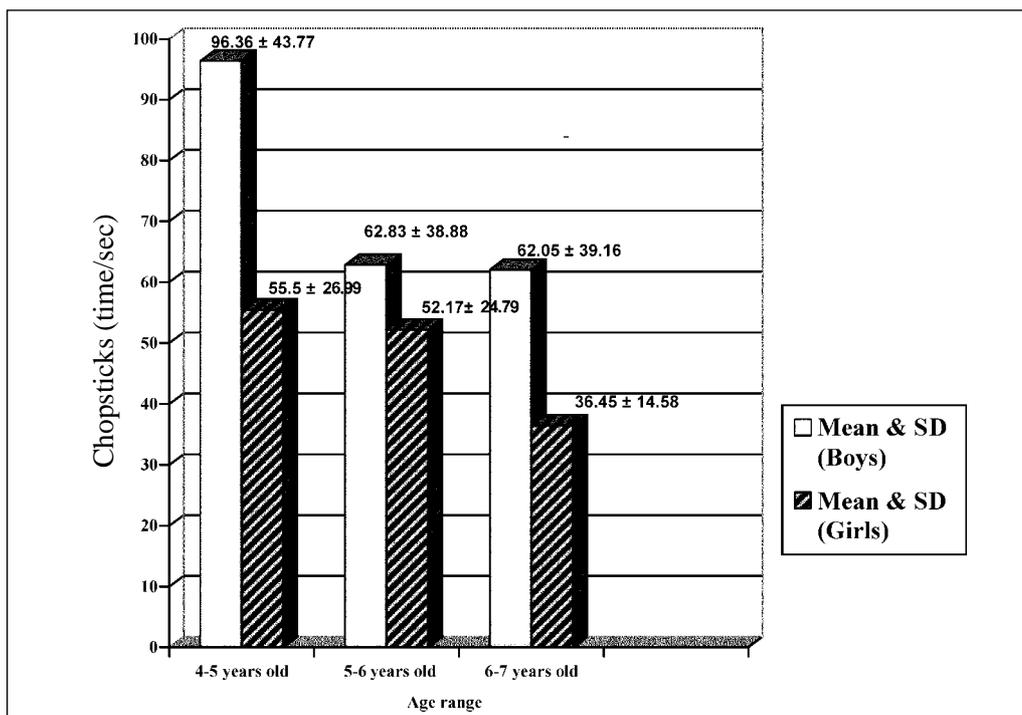


Figure 2 Performance of CMT for children aged between 4-7 years old.

mean values of CMT scores among the three age groups and gender. There was a fair negative correlation between the mean completion time and the age of participants ($r=-0.31$). The 6-7 years group completed the task faster than their younger counterparts. The boys required longer time (mean difference=22.8 sec) to complete the task than girls. There was also a correlation of CMT scores with the types of kindergarten. The mean values of the four kindergartens ranged from 41.51 to 93.38 seconds (see Table 3). One kindergarten had exceptional low mean scores of 86.29 seconds ($SD=41.64$ sec) when compared to the other three kindergartens with mean scores of 41.52 seconds ($SD=28.84$ sec), 54.38 seconds ($SD=26.48$ sec) and 56.33 seconds ($SD=32.62$ sec) respectively.

Three way analysis of variance (ANOVA) showed that age and gender appeared to be the main factors affecting the chopsticks manipulation skills of children (see Table 3). It also showed that boys between 5-6 years (62.83 sec) and 6-7 years old (62.05 sec) had similar performance in terms of speed.

Concurrent Validity of the PDMS-FM Scores and the CMT Scores

There was a moderate correlation of the PDMS-FM scores and the CMT scores found in both groups of children ($r=0.39$, $p<0.01$). There were significant differences in PDMS-FM among the three age groups of children in which showing the developmental progression of children in fine motor skills. The Chinese children appeared to have higher

scores in the fine motor scores than their counterparts of similar age based on the normative data collected by Folio and Fewell.¹⁸ As indicated in Table 4, the mean score differences were significant at all age groups.

Discriminant Validity Between the Children With and Without Developmental Disabilities

It was found that there was a significant difference between the two groups of children (with and without developmental disabilities) in both PDMS-FM scores and CMT scores. Children with developmental disabilities were found to have poorer performance in CMT scores when compared to those children of similar age group ($t=-4.71$, $df=180$, $p<0.05$, 95% CI=-53.5 to -21.8). The mean scores of the children without developmental disabilities is 58.71 seconds ($SD=35.92$) and the mean scores of children with developmental disabilities is 96.36 seconds ($SD=60.38$).

Discussion

A child's ability to manipulate a pair of chopsticks is often judged by subjective observation from parents.² This study attempted to develop a more objective method of assessing chopsticks manipulation using a standardised speed test. The CMT test was found to have good test-retest reliability. The correlation of the CMT scores and the PDMS-FM scores reflected that there were relationships

Table 3 ANOVA table of completion time of the CMT, age, gender and types of kindergartens

Source of variation	Sum of squares	DF	Mean squares	F ratio	p value
Age	3.50	1	3.50	12.81	<0.001
Gender	4.04	1	4.04	14.80	<0.001
Types of kindergarten	31.94	3	0.27	-	-
Total	39.79		0.33	-	-

Table 4 Comparison of fine motor scores of the PDMS between the study sample and the children of same age groups in the United States of America

Year of age	Participant sample		Normative data (United States of America)		Independent T-test		
	Mean	SD	Mean	SD	t value	DF	p value
4 yr. to 4 yr. 11 months	213.4 (n = 23)	5.0 (n = 52)	195.4	13.9	8.26	71.3	<0.001
5 yr. to 5 yr. 11 months	218.7 (n = 51)	4.9 (n = 50)	210.5	8.5	5.96	78.2	<0.001
6 yr. to 6 yr. 11 months	220.1 (n = 43)	3.4 (n = 55)	217.0	5.2	3.65	93.6	<0.001

between the developmental progression of a child's fine motor skills and the chopsticks manipulation skills. The CMT was shown to be able to discriminate children with and without fine motor dysfunction. Children with developmental delay were found to have lower scores on CMT when compared to children without delay at similar age.

In the past, there were very few studies looking at the developmental progression of chopsticks manipulation among the children. This study showed that the attainment of the chopstick manipulation skill emerges at the age 4, then quickly progresses to the mastery of the skill at age 5. As the child moves to 6-7 years of age, the skill appears more mature in terms of the quality of grasp and also the speed of transfer of objects. The findings were similar to those reported by Wong et al² that the mean age of mastering chopsticks skills was 4.6 years old. However, the findings were different from Oppen's study⁴ that children at age 3 had already learned how to use the chopsticks to pick up food.

If a child was found to have difficulties of manipulating a pair of chopsticks during feeding, parents and therapists would tend to believe that the child may be delayed in fine motor skills. However, from this study, we found that children from different kindergartens scored differently in CMT ($p < 0.05$). It was revealed the mean CMT scores of children from one of the kindergartens scored poorly when compared to the other three kindergartens. On further exploration, the location of this kindergarten is at one of the upper class private residential estates and most of these children were brought up by Philippine maids. The families were more westernised and the children were taught to use a spoon to eat rather than using a pair of chopsticks. Some children were seen using very primitive grasp patterns to hold the pair of chopsticks. This might indicate that the environmental factors such as methods of upbringing, modeling and encouragement by parents might also affect the acquisition of chopsticks manipulation skills.

When comparing the normative data of American children of the same age groups, the children in the current study are more dexterous in their fine motor skills. A number of factors including different living environments and learning expectations at the preschool levels could contribute to the differences in their fine motor skill development between Chinese and American children. Oppen⁴ also commented that the curriculum of kindergartens in Hong Kong nourishes fine motor development of children by focusing on delicate writing practice, efficient use of small tools in handicraft session, and adroit upper limbs activities in physical education.

The participants who volunteered for this study cannot be taken as representative of the entire children population because the sample was not randomly selected but only covered some sectors of the community. Despite the inherent selection bias of our recruitment procedure, random sampling is neither possible nor practical for this type of study. In spite of the unrepresentative nature of the sample, this study provides new pathway towards culturally relevant hand evaluation and extends the common assessment tools available in the Chinese society.

Conclusion

In conclusion, this study has successfully validated a culturally related hand function assessment, the CMT, to assess hand functions of children in the Chinese community. The test is easy to administer with good test-retest reliability. The equipment was reasonably cheap and convenient in preparation of assessment. It has also proved to have concurrent validation properties with PDMS-FM, which is a standardised test for assessing the fine motor function of children. In addition, the test appeared to discriminate those children with poor hand functions. With broader population based sample, this test could be developed as an efficient clinical tool to identify Chinese children who are suspected to have poor hand function and to be used as outcome indicators to evaluate various hand function training programme.

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