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ORIGINAL ARTICLE

Development and Validation of a Tool for Assessing Pre-Writing Skills of 2-5 y old Children

Babu George[1] · Jubyraj Aswathymana Raju[1] · Leena Mundappaliyil Leela[1] · Mini Appukkuttan Omana[1] · Deepa Bhaskaran[1] · Remadevi Saradamma[1] · Letha Sarasamma[1] · Lekshmi Madhavan Amrutha[1] · Reshma Kunjumon[1] · Lalikumari Indiradevi[1] · Preema Mahendran[1]

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Abstract

Objectives To develop a tool to assess pre-writing skills of 2-5 y old children in India.

Methods The tool development process followed the recommendations by Fitzpatrick et al. and the Consensus based Standards for the selection of health Measurement Instruments (COSMIN), and included 4 phases. In Phase I, an initial 35-item draft tool was developed by an expert panel for the tool-development. In Phase II, the 35-item draft tool was prevalidated through peer and expert reviews, pilot-study to assess the tool-comprehensibility, and assessment of test-retest and inter-rater reliability. In Phase III, the 35-item draft tool was administered on the 575 typically developing children aged 2-5 y, recruited from rural, urban, slum, and coastal areas through stratified random sampling. In Phase IV, the normative age-range for development of each item was generated by calculating the age-percentiles (10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}). Factor analysis and item reduction was done for items in 2-3, 3-4, and 4-5 y age-groups. The final tool was converted to graphic format with 10^{th}-90^{th} age-percentile bars.

Results The final tool had 26 items with a three-factor structure. Cronbach's alpha was within acceptable limits for all three age-groups (0.723, 0.778, and 0.823 in 2-3 y, 3-4 y, and 4-5 y respectively). Kappa coefficients of the items ranged from 0.6-1 in interrater reliability and 0.64-1 test-retest reliability analysis reflecting substantial agreement between ratings.

Conclusions A 26-item screening tool "Prewriting skills Assessment Tool" (PAT) to assess writing readiness of 2-5 y old children was developed. Tool reliability and construct validity have been established.

Keywords Pre-school child · Writing readiness · Screening tool · Reliability and Validity

Introduction

School readiness is the most integral concept of Early Child Care and Education (ECCE) models worldwide [1–3]. It is important for children entering schools to be at appropriate developmental levels to start writing, reading, and have some basic experience in numeracy or logic- that is, pre-writing, pre-reading, and pre-arithmetic skills. These skills should be developed at kindergarten level itself.

Children learn language through listening, speaking, and writing. Writing is composed of physical, intellectual, developmental and interactive processes. Along with physical processes (motor skills) including skills like holding a pencil, drawing a line and hand movements, orientation of the sensory system and well developed cognition are also necessary for writing [4–6].

Pre-writing skills are a set of basic, essential abilities and accomplishments a child needs to develop before he/she can write [5, 7, 8]. This includes perceptive and motor skills, their integration and coordination. Writing and reading skills play a major role in literacy development and have been linked to future academic achievements. The basic skills for writing like visual motor integration, and fine motor object manipulation have been found to be significant predictors of future writing, maths, reading and spelling skills in younger students, and maths achievement in older students [9–12].

Assessment of preschool children's prewriting skills is important for identifying those who lag behind and providing appropriate early interventions to develop these

✉ Deepa Bhaskaran
cdctvpm@gmail.com

[1] Child Development Centre, Thiruvananthapuram Medical College, Thiruvananthapuram 695 011, Kerala, India

skills. Individualizing writing instruction in this way will provide meaningful, amicable writing experiences for all children, setting the stage for writing readiness when they enter schools. Currently, there is a dearth of validated tools specifically for assessing prewriting skills of preschoolers, in India. It was in this background that the development of such a tool to assess pre-writing skills of children aged 2-5 y was conceived.

Material and Methods

The research followed a psychometric approach with theoretical foundations for developing and validating the new tool.

The tool was developed at a tertiary level child developmental care and research centre in South India, and the normative study was conducted in private and public sector preschool centres and adjoining playschools/child day-care centres in Thiruvananthapuram district. The tool development activities were carried out from March 2019 through February 2020. Stratified random sampling procedure was employed to select preschool centres from rural, urban, coastal, and slum areas in the district. Only typically developing children aged 2-5 y, from the selected preschool centres were recruited in to the study, after screening children with Denver Development Screening Test-II (DDST-II). Those children who were absent on the day of assessment and whose primary caregivers were unwilling to give informed consent were excluded from the study.

Sample size was calculated based on recommendation of at least 10 subjects per item for validation studies by Everitt [13]. For normative evaluation, the tool was administered on the sample population of 575 typically developing 24-60 mo old children, with around 150-200 children belonging to each of the three age groups (2-3 y, 3-4 y, and 4-5 y) with similar gender representation, also meeting the recommended 50-70 participants per cell for developing pediatric norms [14]. To ensure representativeness, children from rural, urban, coastal, and slum areas in the district were recruited (Table 1).

The sample size of 575 was also adequate for exploratory factor analysis of the 35-item tool based on recommended guidelines [13, 15]. Twenty, and twenty-seven children were recruited for test-retest reliability, and inter-rater reliability assessment respectively [16–19]. The tool development and data collection for normative evaluation were conducted with the approval of the Institutional Ethics Committee of CDC, Kerala, following standard ethical norms. Measures to ensure privacy and confidentiality of the participants were followed.

The new tool- Prewriting skills Assessment Tool (PAT) was conceived as a screening tool to identify preschool aged children exhibiting delayed development of prewriting skills. The tool was to be in Malayalam and English with satisfactory psychometric properties. The tool-development process followed the recommendations by Fitzpatrick et al. and Consensus based Standards for the selection of health Measurement Instruments (COSMIN) [20, 21].

The tool was developed in 4 phases (Fig. 1).

Phase I: Development of the Initial Draft Tool

Step 1: Forming the expert panel for the technical advice for developing the tool: For the development of the new tool, a panel of 12 multidisciplinary experts including a Pediatrician, a Pediatric Neurologist, a Linguist, Special Educators, Occupational Therapist, Developmental Therapists, Preschool Teacher, Montessori-trained teacher, Epidemiologist, Sociologists, was formed who provided technical expertise in the development of the PAT through different rounds of discussion. The multidisciplinary team members had experience of more than 20 y of working with developmental aspects of under-5 children, and also had experience in developing, validating published measures.

Step 2: Agreeing on the measure and conceptualization of construct: The expert panel agreed upon the need for a tool to assess children's prewriting skills for identifying deviations and providing timely interventions. Items in 2-3 y age-group were also included in the tool in order to better understand the developmental process in pre-writing. As there are no standard measures to comprehensively assess children's writing development in India, the panel drew upon existing literature on children's adaptive skill development in writing and identified these major areas required for writing development-fine motor, visual-motor integration, hand manipulation, pencil-hold development, upper-body strength, and bilateral integration.

Step 3: Decision on the nature of the measure: The expert panel engaged in discussions about the nature of the tool and the items to capture prewriting development. The items were to reflect the development in the identified areas in the construct, in the form of functional tasks to assess progressive development in each domain, from two to five years (24-60 mo) of age corresponding to emergent and early literacy development. A normative age-range within which the child successfully performs each task in the tool was to be decided based on an extensive field-trial and incorporated in the tool. The tool would be a screening-tool for evaluating the prewriting-skills of 2-5 y old children, based on the child's performance of items within stipulated age-ranges.

Step 4: Item development: An item-pool having 80 items was prepared from extensive review of existing literature on writing development, developmental progression of

Table 1 Participant characteristics

Characteristic	Category	Number of children, N (%)
Age Category	2-3 y (24 to 36 mo)	145 (25.2)
	3-4 y (37 to 48 mo)	202 (35.1)
	4-5 y (49 to 60 mo)	228 (39.7)
Gender	Male	275 (47.8)
	Female	300 (52.2)
Religion	Hindu	402 (69.9)
	Christian	128 (22.3)
	Muslim	45 (7.8)
Socio-Economic Status	APL	262 (45.6)
	BPL	313 (54.4)
Type of Family	Nuclear	352 (61.2)
	Joint	180 (31.3)
	Extended	43 (7.5)
Mother's Education	Till Higher Secondary	276 (48.1)
	Technical, Graduation or above	298 (51.9)
Father's Education	Till Higher Secondary	378 (65.7)
	Technical, Graduation or above	197 (34.3)
Mother's Occupational Status	Unemployed	433 (75.3)
	Employed	142 (24.7)
Father's Occupation	Unemployed/Unskilled/Semiskilled/Skilled labourer	391 (68.0)
	Clerical/Shop owner/Semi-professional/Professional	184 (32.0)
Type of Preschool	Not started schooling	71 (12.3)
	Anganwadi	169 (29.4)
	Government Preschool	166 (28.9)
	Private Preschool	169 (29.4)
Location	Rural	243 (42.3)
	Urban	202 (35.1)
	Coastal	68 (11.8)
	Slum	62 (10.8)

APL Above poverty line, *BPL* Below poverty line

children in the identified construct areas, and standard tools which measure development in these areas. From the item-pool, 48 items were short-listed after removing duplicates, avoiding over or under representation of sub-constructs. Further reduction of items was done using endorsement rate approach by 13 purposely chosen experts and consultants, including clinicians and subject experts like Pediatricians specialized in child development, Preschool Teachers, Occupational Therapists, and Developmental Therapists who reviewed the contents of the items, based on the clarity, and relevance of the items with respect to prewriting in the community, preschool settings in the target population [22], and recorded their opinion on a 4-point Likert scale (1 = not relevant, 2 = somewhat relevant, 3 = relevant, 4 = very relevant) [22, 23]. Items with an endorsement rate of 75% were retained and a 35-item draft tool was prepared.

Step 5: Item wording and sequencing: The items were worded in jargon-free, simple language of less than 20 words each. All items were individual tasks, with no double-barrelling or double negatives. Items which were difficult for the preschool teachers to understand were reworded.

Step 6: Formatting, endorsement, and scoring pattern: For obtaining normative age-ranges of the items from the community, a standardized assessment form was developed to record the child's performance, sociodemographic details, handedness, and wrist stability. The assessment form also provided the necessary shapes, and pictures for assessment as per the items in the tool. The child's performance of an item was given credit as 'Yes', and non-performance was given no-credit as 'No'. The final tool was to be graphic in nature, with stipulated age-ranges for performing each item based on the normative data.

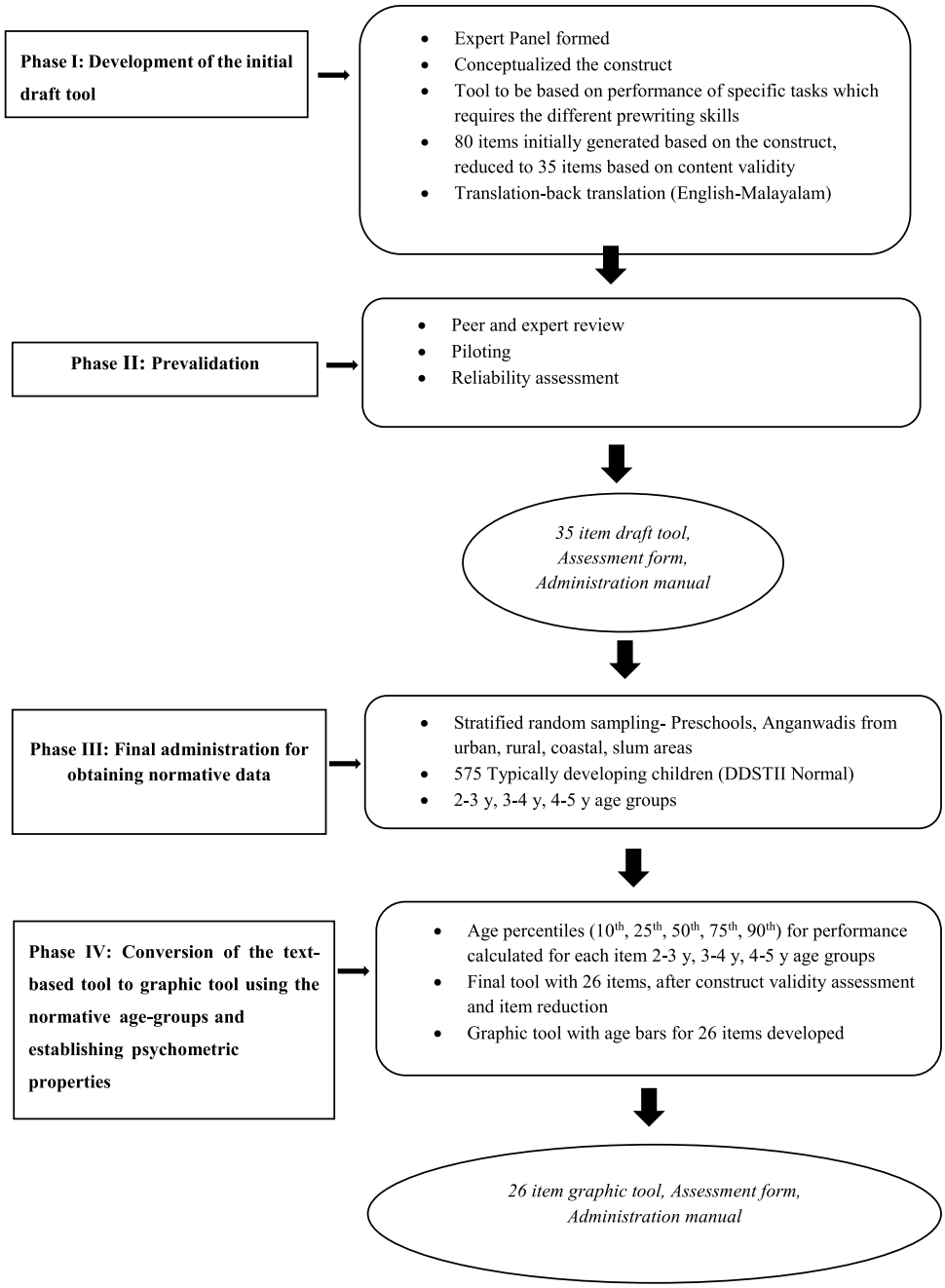

Fig. 1 Tool development process

Step 7: Translation and back translation: In the translation-back translation process that followed, the items were translated forward (English to Malayalam) and backward (Malayalam to English) by two teams with at least two independent, bilingual translators each, to achieve the proximity between the source (English) and target versions (Malayalam).

Phase II: Prevalidation

The tool was subjected to peer and expert review by 10 randomly selected preschool teachers from public and private sector, and subject experts, regarding the feasibility, readability, and clarity.

A pilot study was done on a representative sample of 20 children to assess the comprehensibility of the tool and the anticipated logistic issues in the final administration of the tool. Reliability assessment was also carried out.

Phase III: Final Administration for Obtaining Normative Data

The 35 item draft tool was administered on 2-5 y old children selected from rural, urban, slum, and coastal areas by trained developmental therapists following the administration manual.

Phase IV: Conversion of the Text-based Tool to Graphic Tool Using the Normative Age-groups and Establishing Psychometric Properties

Step 1: Determining normative age-ranges for performance of each item: Performance of children in each of the 6 mo age categories were evaluated. An item was considered redundant for age-groups where more than 95% children were able to perform it. Age percentiles (10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}) were calculated for each item after excluding the redundant age-groups.

Step 2: Reliability and validity assessment and item reduction: For validity assessments, the items were categorized for each age-group. Based on the normative age ranges, ten items were assigned for 2-3 y old (24-36 mo of age) children, fifteen items for 3-4 y olds (37-48 mo), and another ten for 4-5 y old children.

For assessing test-retest reliability (prior to final administration), the tool was administered to 20 children aged 2-5 y, and repeated after one week. For inter-rater reliability, the tool was administered on 27 children, by two developmental therapists, blinded to the child's performance each time, on the same day, the two assessments being separated by play-sessions. Cohen's kappa statistic was used to assess the reliability of items [17, 24]. Internal consistency of the tool was assessed by measuring the Cronbach's alpha coefficient.

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was derived for each age-group. Bartlett's Test of Sphericity was conducted to assess the suitability of the data for factor analysis [25].

Exploratory factor analysis and Promax (oblique) rotation was done on the extracted factors for better interpretation. A factor loading above 0.35 was taken as the cut-off point for deleting or retaining the items

Step 3: Development of the final graphic tool for assessing Prewriting skills: For developing the graphic tool, the items represented by horizontal age-bars corresponding to the 10^{th} to 90^{th} percentile age-limits (in months) for development of each skill were stacked in ascending order. The 25^{th}, 50^{th} and 75^{th} percentiles were also marked within the age-bars. For identification of age-limits, vertical age-lines from 24-60 mo were also included. The tool is accompanied by an assessment form for recording the child's performance, handedness and wrist-stability. To apply the tool, a line is to be drawn vertically through the chronological age of the child marked (bottom) in the tool. The items whose 75^{th} percentile age limit lie to the left of the line are expected to be attained by the child normally. If the child attains the skill in the 75^{th} to 90^{th} percentile age limits, it is considered as 'caution' in that domain. If any item is not attained by the child by the 90^{th} percentile age limit, it is considered as 'suspect'. Caution in any one domain will be 'normal', and that in two or more domains will be categorized as 'suspect'.

Results

The screening tool was named as Prewriting skills Assessment Tool (PAT). An administration manual was also prepared for the tool and got it approved by the content experts.

The 35-item tool was administered in 575 children (275 boys and 300 girls) aged 2-5 y (24 to 60 mo of age). The socio demographic details of the participants have been summarised in Table 1.

Kappa coefficients of the items in the tool ranged from 0.6 to 1 in inter-rater reliability analysis and 0.64 to 1 test-retest reliability analysis reflecting moderate to almost perfect agreement between the ratings [24, 26].

Almost all children were able to perform items with the lowest age of attainment at 24 mo for one or both testings, and showed 100% agreement, although kappa could not be calculated. The age-limits of the study subjects were 24-60 mo and this limited the inclusion of children in whom these skills have yet to be developed.

There was an element of natural development of the children and learning from the exposure during testing, even though it was minimal. This was especially true in children with basic motor and cognitive development required for tasks where the evaluator demonstrates the items. An example was the items imitating 'square', and copying 'square'. Older children with mature pencil-grip unable to copy the square shape initially were able to do so by imitating the evaluator, and were able to copy the shape on their own in the retest.

KMO values were 0.711, 0.712, and 0.805 respectively for 2-3 y, 3-4 y, and 4-5 y age-groups indicating the sample size of the study is adequate (Table 2). Chi square values for Barlett's test of sphericity were significant for each age group indicating that the data is suitable for factor analysis (Table 3).

The communalities of the items ranged from 0.4 to 0.72 in the 2-3 y age group, 0.4 to 0.86 in 3-4 y, and 0.35 to 0.85 in the 4-5 y age group (Table 4).

A three factor structure was identified for the components in each of the three age groups, accounting to cumulative variance of more than 60%, with factor loadings ranging from 0.37 to 1. The final factors were labelled as 'Fine motor coordination', 'Hand manipulation', and 'Visual motor integration' for each age-group, after expert-panel discussions (Table 4). The final

Table 2 Kaiser-Meyer-Olkin measure and Barlett's Test of sphericity

Age-Group	KMO measure	Chi square value	*p*
2-3 y	0.711	121.99	0.0001
3-4 y	0.712	485.01	0.0001
4-5 y	0.805	1012.59	0.0001

Table 3 Reliability analysis

Age-Group	Cronbach's alpha (35-items)	Cronbach's alpha (26-items)
2-3 y	0.714 (10 items)	0.723 (7 items)
3-4 y	0.827 (15 items)	0.778 (9 items)
4-5 y	0.823 (10 items)	0.823 (10 items)

tool had 26 items-seven items for 2-3 y, nine items for 3-4 y, and ten items for 4-5 y age-groups respectively, arranged in the ascending age-order, with specific color-coding for each domain (Table 4).

The internal consistency of the set of items for each age group was assessed separately. The Cronbach's alpha was acceptable in the youngest groups (0.723 in 2-3 y; 0.778 in 3-4 y), and good (0.823) in 4-5 y (Table 3).

Discussion

The 26-item screening tool named as "Prewriting skills Assessment Tool" (PAT) to assess the prewriting skills of children aged 2-5 y was developed based on normative evaluation of children in different socioeconomic backgrounds in an Indian setting. The currently used tools for assessing prewriting skills in India are limited to tools developed and validated outside the country or those which assess aspects related to prewriting as part of general developmental assessment or overall preschool performance assessment like the DDST or International Development and Early Learning Assessment (IDELA) [27–29]. The internal consistency, reliability and construct validity of the tool have been shown to be within acceptable standards. Since this was a normative validation, criterion validity of the measure has not been assessed against other standard measures which will be addressed in future studies.

The design of the tool also facilitates easy and early identification of preschoolers who may require prewriting stimulation and further detailed evaluation and intervention.

The tool has been designed for use by preschool teachers or primary caregivers of 2-5 y old children with minimal training and materials. The administration of the tool takes less than 15 min, and does not involve any score calculations making it easier to administer and interpret than other tools for assessing writing readiness.

Table 4 Factor structure of the 26-item tool

Item	Communality	Component			% of Cumulative Variance
		Factor 1	Factor 2	Factor 3	
PAT 12. Open and close zip	0.71	0.893			62.30% (2-3 y)
PAT 03. Line up six or more blocks horizontally	0.63	0.652			
PAT 05. Three or more vertical strokes	0.63	0.585			
PAT 04. Imitates folding square towel in half	0.66		0.858		
PAT 01. Circular strokes	0.62		0.603		
PAT 13. Press soft ball using thumb and fingers only	0.72			0.887	
PAT 02. Vertical stack of six or more blocks	0.4			0.519	
PAT 27. Draws zig-zag lines by imitating	0.66	0.844			62.70% (3-4 y)
PAT 34. Completes simple dot pictures by joining the dots	0.66	0.804			
PAT 35. Colors simple pictures or shapes within its limits	0.59	0.702			
PAT 09. Imitate drawing Circle	0.4	0.614			
PAT 07. String four big beads	0.86		0.937		
PAT 16. String four or more small beads in kangoos	0.77		0.899		
PAT 06. Three or more horizontal strokes	0.56		0.536		
PAT 23. One hand on top left of the book, while turning pages with the free hand	0.72			0.896	
PAT 26. Touching other fingertips with the thumb	0.46			0.597	
PAT 29. Draws Cross by imitating teacher	0.81	0.992			65.05% (4-5 y)
PAT 30. Copies Cross	0.74	0.898			
PAT 18. Draws Square through imitating the teacher	0.5	0.488			
PAT 19. Copies Square	0.67	0.37			
PAT 33. Copies Triangle	0.84		1.00		
PAT 32. Draws a Triangle by imitating teacher	0.85		0.973		
PAT 28. Drawing curved wave shapes by imitating	0.35		0.424		
PAT 20(d). Tripod grasping pencil	0.52			0.752	
PAT 17. Draws a simple picture by him/herself or through imitating	0.71			0.656	
PAT 31. Draws a man with four parts	0.58			0.556	

Conclusions

A 26-item screening tool "PAT" to assess writing readiness of 2-5 y old children has been developed. The reliability and construct validity of the tool have been established.

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Authors' Contributions BG, RS, and DB were involved in the conceptualization of the study, critical revision and final approval of the manuscript. LML was involved in the study conceptualization, manuscript drafting, its critical revision and approval. RK, MAO, LS, LMA, LI, PM were involved in data collection for normative study, manuscript revision and approval. MAO and LI were involved in administering the tool and collecting data for reliability analysis. JAR was involved in the data analysis and conversion of the tool to graphic form, along with manuscript drafting, revision and approval. DB is the guarantor for this manuscript.

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Declarations

Conflict of Interest None.

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