Original Article

Development and Validation of Shoaib Sensorimotor Development Tool for Normal Pediatric Population

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Abstract

Background: During the COVID-19 pandemic, concerns about developmental delays in babies were at their peak. During the COVID-19 pandemic, concerns about developmental delays in infants and young children increased substantially. However, culturally relevant, validated tools to assess sensorimotor development are scarce.

Objective: This study aimed to develop and validate the Shoaib Sensorimotor Development Tool (SSDT) to evaluate developmental milestones in typically developing children.

Methods: This was a cross-sectional psychometric validation study. A comprehensive tool encompassing nine domains, gross motor, fine motor, sensory, tone, balance, gait, reflexes, social interaction, and speech, was developed to assess sensorimotor development holistically. A total of 150 mothers of typically developing children aged 3 to 7 years participated in the exploratory factor analysis (EFA), while 300 mothers were included in the confirmatory factor analysis (CFA). In addition, the SSDT required an average of 21 ± 6.00 minutes to complete, with administration being feasible for trained therapists following a brief workshop. Data were analyzed using SPSS v26 and AMOS for factor analysis. Model fit was evaluated with regression weights and standard fit indices ($p < 0.05$).

Results: The mean age of mothers who participated in this study was 36.16±4.73 years, and the mean age of children was 4.45±0.784 years. Of the 150 mothers (EFA) and 300 mothers (CFA) enrolled, 144 and 288 completed the full assessment, yielding a 96% completion rate. Dropouts were minimal, 6 and 12, respectively, and the reasons have been detailed in the methods. 75 constructs were analyzed using EFA and three were removed due to cross-loading, resulting in a significant Bartlett's test ($p = 0.000$) and a high Kaiser-Meyer-Olkin (KMO) measure of 0.992. The final 72 constructs of SSDT formed a single factor, sensorimotor development, with a cumulative variance of 84.317% and an eigenvalue of 3.897. Fit indices indicated good model fit (CFI = 0.983, GFI = 0.962, TLI = 0.989, SRMR = 0.0325, RMSEA = 0.076). The SSDT demonstrated excellent internal consistency (Cronbach's $\alpha = 0.963$).

Conclusion: SSDT is a promising tool for early sensorimotor assessment, offering clinical, educational, and research utility; however, broader validation and longitudinal studies are needed for its universal adoption.

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Introduction

Development is the foundation of a child's cognitive, emotional, and communicative growth.[1] A range of factors, including metabolism, genetics, nutrition, parenting style, and interactions with peers and adults, shape this development.[2] The inhibition or integration of primitive or postural reflexes and righting reactions plays a vital role in sensory and motor development, collectively for better stability and movement.[3,4] Motor development includes muscle tone interacting with the central nervous system to learn gross and fine motor abilities that influence posture, gait, and balance,[5] whereas sensory development combines visual, auditory, and tactile inputs with speech, language, and social interactions.[6] For effective interpretation and processing of this information through the brain, this said process is vital, which eventually helps for better communication, emotional regulation, and proper social interaction.[7,8] The infant reflex system plays a significant role both in the motor and sensory areas, providing cues needed for the acquisition of skills, achievement of milestones, cognitive maturity, and emotional stability.[9]

The Gross Motor Functional Classification System (GMFCS) and gross motor functional measure (GMFM) are everyday measures of gross motor development in children with cerebral palsy. The GMFCS categorizes motor abilities into five levels, and the GMFM measures changes in motor function among children from 5 months to 16 years of age.[10]

Nevertheless, both instruments are primarily concerned with gross motor ability and mobility, without attention to important early milestones such as neck control, rolling, sitting, and standing, which are required to build further motor ability.[11] Bayley Scales of Infant and Toddler Development test children between 16 days and 42 months of age, measuring areas like cognition, language, motor, social-emotional development, and adaptive behavior.[12] Even with this wider scope, the Bayley Scales do not well assess balance, changes in muscle tone, walking, and sensory development and require lengthy administration.

Similarly, fine motor assessment instruments have been developed to assess functional levels among preschool children; however, such instruments often overlook the early stages of development.[13] The Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) tests fine and gross motor skills in children and youths between the ages of 4 and 21. It measures dexterity, hand-eye coordination, body coordination, strength, and agility.[14,15] Moreover, the Lings' speech acquisition stages tool is also just concerned with speech and not language development as a whole.[16] Lastly, social interaction assessment tools exist but tend to be age-specific and may not fully match early-life development needs. Finally, tools for assessing social interaction are available, but are often age-specific and may not address early-life developmental needs comprehensively.[17]

During the COVID-19 pandemic, many mothers were concerned about their children's development, particularly those born during this period, as they experienced delays in achieving developmental milestones. This highlighted the need for a comprehensive tool to assess sensorimotor development and determine whether intervention was needed. This study aimed to create such a tool, the SSDT, to evaluate children's progress, support decision-making, and help track their developmental progress. By addressing developmental delays, the SSDT fosters a positive environment for both children and parents, strengthening emotional bonds and promoting overall well-being. Ultimately, it empowers families to navigate developmental challenges with confidence and resilience.

Methods

This descriptive validation study was conducted in Lahore, Pakistan, to develop and validate a tool for assessing typical child development on established milestone guidelines. Data were collected from mothers using purposive and convenience sampling techniques. Of the 150 mothers (EFA) and 300 mothers (CFA), 144 and 288 completed the full assessment, yielding a 96% completion rate. Twelve participants (4%) were excluded due to non-returned or incomplete responses (5 relocated, 4 withdrew, 3 incomplete) for CFA and half of these reasons for EFA. Completers and non-completers did not differ significantly in baseline demographics ($p>0.05$). Raters were physical therapists who completed a 2-hour workshop and five supervised administrations before data collection. Administration time averaged 21 minutes (range 12–34). The tool development process was divided into three phases: focus group discussion (FGD), content validity phase, and field-testing phase.

In the tool development phase, 20 experts participated in focus group discussions, following the international guideline of 2 to 20 members.[18] The panel consisted of six Physical Therapists, four Occupational Therapists, two Speech and Language Pathologists, two Pediatric Psychologists, two Psychiatrists, two Special Educationists, and two Neonatologists, with 70% holding advanced degrees. The initial draft of the tool consisted of 96 questions aligned with the theme and objectives of the study. A preliminary PowerPoint presentation was sent to the entire team one week before the FGD for review and editing. On the day of the FGD, the principal author presented the research topic, highlighting its necessity, justification, and potential methodology. Following the discussion, the final version of the tool, now comprising 79 questions of nine domains, was developed, incorporating all changes, ideas, and recommendations from the experts.

During the content validity phase, out of a pool of twenty experts, ten were randomly selected along with ten mothers for pilot testing (smaller sample size) to thoroughly evaluate the tool's relevance, clarity, simplicity, and ambiguity. The tool was organized into nine subdomains, each with relevant constructs. For face validity, the content, language, and physical appearance of the tool were also reviewed and approved.[19] Face validity was also being tested. Both the experts and mothers agreed that only 75 questions were adequate and easy to comprehend, so the remaining constructs were eliminated due to complexity.

In the field-testing phase, 150 mothers were sampled for EFA, and this was increased to 300 for CFA, in line with Kline's criterion of two to five samples per item. Mothers aged 25-40 were selected, excluding those with children who had developmental, neurological, musculoskeletal, genetic, nutritional, or traumatic issues. The tool had 76 questions, and the sample size was set at 300, calculated as 4 times the number of questions (4 × 76 = 304, rounded to 300). Questionnaires were distributed only to participants who provided consent and were willing to take part. Additionally, one-on-one assistance was offered to those who had difficulty understanding the questions.[20] After removing cross-loaded constructs, the final version consisted of 72 constructs (Figure 1).

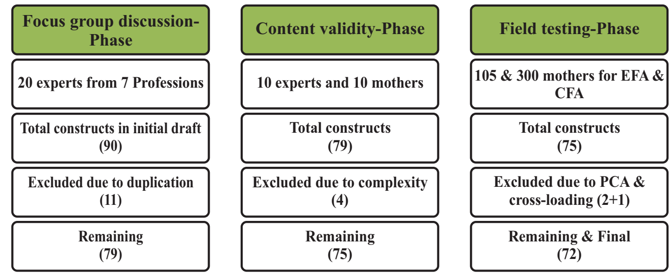

Figure 1: *Steps of tool development, validation and Testing*

This tool evaluates nine sensorimotor domains, including gross/fine motor skills, social interaction, speech, tone, coordination, gait, sensory processing, and reflexes, in children aged 0–36 months through 72 age-stratified questions. This tool is based on three-point scores (0, 0.5 and 1). Scores <36 (50%) indicated atypical development. Each score corresponded to developmental age, and children were categorized into six functional levels (I–VI), providing a structured developmental assessment (Table 3). SPSS v26 was used for EFA, with KMO and Bartlett's test applied to assess sampling adequacy. PCA was performed, and items with poor or cross-loadings were removed. Reliability was assessed using Cronbach's alpha. CFA was conducted in AMOS v26, using standardized regression weights and model fit indices ($p < 0.05$).

Results

Expert agreement on all aspects of the SSDT, including font, graphics, language, and content arrangement, was 100% for face validity. The findings also indicated excellent consensus on the tool's physical appearance

Table 1: *Content validity, exploratory factor analysis, and confirmatory factor analysis*

Variables	I-CVI				S-CVI	EFA n=150	CFA n=300
	Simplicity	Relevancy	Clarity	Ambiguity		Mean±SD	Mean±SD
Gross Motor Development	1	1	1	0.96	0.99	0.668±0.410	0.771±0.401
Fine Motor Development	1	1	1	1	1	0.645±0.439	0.649±0.423
Social Interaction Development	1	1	1	1	1	0.642±0.400	0.669±0.421
Tone Development	1	1	1	1	1	0.675±0.410	0.678±0.410
Balance Development	1	1	1	1	1	0.602±0.412	0.689±0.430
Gait Development	1	1	1	1	1	0.632±0.383	0.698±0.411
Sensory Development	1	1	1	1	1	0.630±0.390	0.630±0.400
Speech Development	1	1	1	1	1	0.639±0.400	0.693±0.401
Reflex Integration	1	1	1	1	1	0.645±0.410	0.640±0.431
Overall	1	1	1	0.995	0.998		

Table 2: *Principal Component Analysis on SSDT*

Gross Motor Development															
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
Communalities	0.871	0.84	0.85	0.917	0.904	0.933	0.934	0.935	0.835	0.859	0.902	0.921	0.875	0.935	0.901
Component matrix	0.923	0.907	0.907	0.952	0.948	0.957	0.964	0.964	0.922	0.902	0.942	0.949	0.901	0.891	0.895
Fine Motor Development															
	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25					
Communalities	0.971	0.979	0.916	0.845	0.958	0.889	0.828	0.891	0.903	0.869					
Component matrix	0.766	0.772	0.728	0.684	0.765	0.741	0.893	0.765	0.829	0.902					
Social Integration Development															
	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33							
Communalities	0.945	0.856	0.932	0.908	0.946	0.884	0.923	0.875							
Component matrix	0.758	0.684	0.959	0.944	0.901	0.877	0.949	0.921							
Tone Development															
	Q34	Q35	Q36												
Communalities	0.886	0.932	0.943												
Component matrix	0.858	0.888	0.898												
Balance Development															
	Q37	Q38	Q39												
Communalities	0.778	0.955	0.922												
Component matrix	0.862	0.911	0.896												
Gait Development															
	Q40	Q41	Q42	Q43	Q44	Q45									
Communalities	0.932	0.92	0.938	0.82	0.965	0.775									
Component matrix	0.962	0.954	0.961	0.618	0.977	0.874									
Sensory Development															
	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55					
Communalities	0.869	0.929	0.911	0.953	0.976	0.722	0.907	0.851	0.892	0.975					
Component matrix	0.931	0.959	0.952	0.972	0.984	0.693	0.949	0.921	0.942	0.981					
Speech Development															
	Q56	Q57	Q58	Q59	Q60	Q61	Q62	Q63	Q64	Q65					
Communalities	0.914	0.905	0.929	0.971	0.966	0.929	0.925	0.875	0.932	0.901					
Component matrix	0.952	0.946	0.96	0.981	0.979	0.961	0.891	0.921	0.966	0.923					
Reflexes Integration/Development															
	Q66	Q67	Q68	Q69	Q70	Q71	Q72								
Communalities	0.958	0.958	0.887	0.891	0.839	0.926	0.957								
Component matrix	0.973	0.973	0.924	0.934	0.909	0.954	0.975								

and visual impression[19]. Content validity scores were highly convincing, with S-CVI values ranging from 0.99 to 1.00 across the nine domains. Based on at least nine experts, the CVI acceptance score was set at 0.78[21]. I-CVI and S-CVI showed a very good to exceptional power of acceptance (0.99 to 1.00) (Table 1).

Exploratory and Confirmatory Factor Analysis:

The mean age of the mothers was 36.16 ± 4.73 years, ranging from 20 to 45 years. A total of 150 mothers responded to 72 questions on development using a three-point Likert scale. The mean scores across the nine domains ranged from 0.602 to 0.675, reinforcing their alignment within acceptable thresholds for EFA, ensuring robust construct validity. Initially, out of 75 questions, two were rejected based on Principal Component Analysis, leaving 73 constructs with a high correlation (>0.9). After re-running the factor analysis, one additional question was excluded due to cross-loading. Ultimately, 72 questions remained, each with a positive correlation of over 0.82. The CFA of the 72 constructs was conducted on 300 mothers. The mean scores across the nine domains ranged from 0.630 to 0.771, providing strong empirical support for their alignment within acceptable thresholds in CFA and reinforcing the model's structural integrity (Table 1).

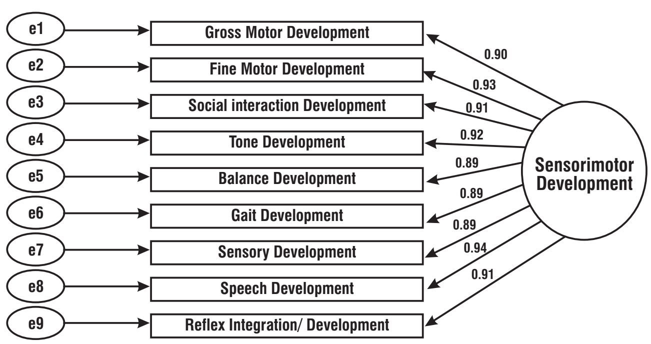

Figure 2: *Path diagram of Sensorimotor development*

Statistical Measures of Tool and Indices of the CFA Model [n = 300]:

The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy was 0.992, indicating excellent suitability for factor analysis, while Bartlett's test of sphericity yielded a value of 4154.718 with a highly significant p-value (0.000). For the entire variable set, the Eigenvalue of the primary factor was 80.711, accounting for a cumulative variance of 84.317%, demonstrating strong factor retention. Cronbach's alpha was 0.963 with 95% CI (0.94–0.97), confirming the high reliability of SSDT in assessing sensorimotor development. In model fit indices, the CMIN/DF value was 2.21 with a significant p-value (0.002), while other key indicators supported a strong model fit: SRMR (0.0325), RMSEA (0.076), CFI (0.983), GFI (0.962), and TLI (0.989). The AIC and BIC values were 18.9 and 17.34, respectively. These values met the standard criteria for good model fit: CMIN/DF < 3, RMSEA < 0.08, CFI > 0.90, GFI > 0.85, and TLI > 0.90, confirming the robustness of the model. The detailed structural relationships were illustrated in the path diagram (Figure 2). Reported Cronbach's alpha with 95% CI (α = 0.963; 95% CI 0.94–0.97).

Principal Component Analysis (PCA) on Shoaib Sensorimotor Development tool [n = 150]:

The component matrix of 72 constructs ranged from 0.622 to 0.981, with an acceptable cut value of 0.5, which was incorporated into the tool's final form (Table 2).

Shoaib Sensorimotor Development Tool:

The SSDT domains and their possible scoring system with levels of development (Table 3).

Discussion

The development of the tool is rooted in developmental milestones, which provide normative data reflecting

Table 3: *Shoaib Sensorimotor Development Tool*

SHOAIB SENSORIMOTOR DEVELOPMENT TOOL				
Sr. No	**Gross Motor Development-Domain I**	**Cannot do it = 0**	**Can do with assistance = 0.5**	**Can do without assistance = 1**
1	Is it possible for the child to elevate their head to 45–90 degrees while lying on their belly?			
2	Can a baby roll from prone to supine non-segmentally?			
3	Can a baby roll from supine to prone segmentally and sit independently with one or two secondary curves?			
4	Can a baby sit with one secondary curve independently?			
5	Can a baby sit with two secondary curves independently?			

6	Can a baby sit while placing both legs on one side?			
7	Can a baby begin to pull themselves up to a quadruped position using a chair?			
8	Can a baby stand independently?			
9	Can a baby cruise independently?			
10	Can a baby walk independently?			
11	Can the baby walk up the stairs foot by foot?			
12	Can a baby stand on one foot?			
13	Can a baby jump from the sofa to the floor?			
14	Can a baby run?			
15	Can a baby stand on tiptoes?			
	Attainable Score	**Total= [ ] / 15**		
	Fine Motor Development-Domain II	**Cannot do it = 0**	**Can do with assistance = 0.5**	**Can do without assistance = 1**
16	Is the infant tightly gripping their thumb inside the palm?			
17	Can a baby bring their hand to the midline?			
18	Can a baby transfer an object from one hand to the other?			
19	Can the baby release an object voluntarily?			
20	Can a baby reach for their favorite object?			
21	Can a baby self-feed and eat?			
22	Can a baby cut paper with scissors?			
23	Can a baby hold an object with a pincer grasp?			
24	Can a baby hold an object with a precision grasp?			
25	Can a baby throw and catch a ball a few feet overhead?			
	Attainable Score	**Total= [ ] / 10**		
	Social Interaction Development-Domain III	**Cannot do it = 0**	**Can do with assistance = 0.5**	**Can do without assistance = 1**
26	Is the baby aware of bright objects and friendly handling?			
27	Does the baby coo and chuckle?			
28	Is the baby aware of the tone of voice?			
29	Is the baby showing fear of strangers?			
30	Is the baby engaging in games like pat-a-cake and peek-a-boo?			
31	Is the baby active, restless, and showing tantrums?			
32	Is the baby displaying signs of sharing?			
33	**Is it possible for a baby to associate their toys with their friends?**			
	Attainable Score	**Total= [ ] / 8**		
	Tone Development-Domain IV	**Cannot do it = 0**	**Can do with assistance = 0.5**	**Can do without assistance = 1**
34	Is the physiological flexion present at birth still evident in the baby?			
35	Is your baby's body evolving from flexor to extensor tone through tummy time for neck control?			
36	For the integration of the Tonic Labyrinthine Reflex, can a baby lie on their side to balance tone?			
	Attainable Score	**Total= [ ] / 3**		

	Balance Development-Domain V	Cannot do it = 0	Can do with assistance = 0.5	Can do without assistance = 1
37	Can a baby maintain their body when there is a slight change in equilibrium and base of support (righting reactions)?			
38	Can a baby maintain their body when there is a moderate change in equilibrium and base of support (equilibrium reactions)?			
39	Can a baby maintain their body when there is a severe change in equilibrium and base of support (protective extension)?			
	Attainable Score	**Total= [ ] / 3**		
	Gait Development-Domain VI	**Cannot do it = 0**	**Can do with assistance = 0.5**	**Can do without assistance = 1**
40	Can a baby's lower extremity musculature work against gravity?			
41	Is the baby walking with a wide base of support (with side-to-side stability being better than anterior-posterior stability)?			
42	Does the baby frequently fall while walking due to inadequate hip strength to control gravitational forces?			
43	Are the baby's legs straight after resolving varus angulation?			
44	Is the baby's single-leg stance more stable?			
45	Is the child walking with a mature heel-to-toe pattern?			
	Attainable Score	**Total= [ ] / 6**		
	Sensory Development-Domain VII	**Cannot do it = 0**	**Can do with assistance = 0.5**	**Can do without assistance = 1**
46	Is it possible for a baby to recognize the scent of their mother's breast milk?			
47	Can a baby move food in their mouth with their tongue?			
48	Can a baby distinguish between edible and inedible objects?			
49	Can a baby tolerate a range of different textured foods?			
50	Can a baby use the toilet with assistance and have daytime control?			
51	Can a baby differentiate between different shapes?			
52	Can a baby recognize the majority of colors?			
53	Can a baby point out five to six parts of a doll when asked?			
54	Can a baby develop friendships and express emotions?			
55	Can a baby begin to reason and argue using "why" and "because"?			
	Attainable Score	**Total= [ ] / 10**		
	Speech Development-Domain VIII	**Cannot do it = 0**	**Can do with assistance = 0.5**	**Can do without assistance = 1**
56	Can a baby develop different cries for different needs?			
57	Can a baby develop a social smile towards family members?			

58	Is the baby expressing their desires through sounds?			
59	Is the baby expressing their desires through gestures?			
60	Can a baby babble, repeating sounds like "dada" or "bibi"?			
61	Can a baby use word more frequently?			
62	Is it possible for a baby to use 2–3-word sentences?			
63	Is it possible for a baby to point out pictures in books?			
64	Has the baby developed a vocabulary of 50-300 words for expressive purposes?			
65	Has the baby developed a vocabulary of 500-1000 words for receptive purposes?			
	Attainable Score	**Total= [ ] / 10**		
	Reflex integration/Development-Domain IX	**Not Integrated = 0**	**Partially integrated = 0.5**	**Fully integrated = 1**
66	Are the Moro and startle reflexes being integrated?			
67	Are feeding reflexes, such as rooting and sucking, being integrated?			
68	Is the Tonic Labyrinthine Reflex (TLR) being integrated?			
69	Is the Symmetrical Tonic Neck Reflex (STNR) being integrated?			
70	Is the Asymmetrical Tonic Neck Reflex (ATNR) being integrated?			
71	Is the Optical and Labyrinthine Righting (OLR) reaction being integrated?			
72	Are Body Righting Reactions (BOH and BOB) being integrated?			
	Attainable Score	**Total= [ ] / 7**		

Interpretation

Total Score	**(Domain-I) + (Domain-II) + (Domain-III) + (Domain-IV) + (Domain-V) + (Domain-VI) + (Domain-VII) + (Domain-VIII) + (Domain-IX) / 72**

Sr. No	**Developmental age**	**Score Range**
1	One Month	00 - 02
2	Two Months	02 - 04
3	Three Months	04 - 06
......	....	....
34	Thirty-Four Months	66 - 68
35	Thirty-Five Months	68 - 70
36	Thirty-Six Months	70 - 72
	Functional level	
Level -VI	Children can run with a proper heel -to-toe gait pattern with excellent balance in extreme changes in equilibrium, use hands for manipulating things with a precision grasp and integrated righting reactions while maintaining tone, recognize colors, understand the concept of friendship and express emotions, and have excellent expressive speech skills.	**61-72**
Level -V	Children can run and jump with two feet with very good balance in extreme changes in equilibrium, catch and throw the ball with integrated rightin g reactions while maintaining tone, differentiate between shapes and different textures of foods with the concept of sharing, and use a two-to-three-word sentence efficiently.	**49-60**

Level -IV	Children can walk with a wide base and climb stairs with a foot-over-foot pattern with good balance in medium changes in equilibrium, hold things with a pincer grasp with integrated righting reactions while maintaining tone, differentiate between edible and inedible while remaining active and throwing tantrums, and frequently use words.	**37-48**
Level -III	Children can walk independently with fair balance in medium changes in equilibrium, reach their favorite object, self -feed and release things voluntarily with integrated optical and labyrinthine righting reactions w hile retaining tone against gravity, move food in his or her mouths with tongue, enjoy simple games, and babble/repeat words such as dada, bibi.	**25-36**
Level -II	Children can cruise, stand, and sit independently with poor balance in slight changes in equilibrium, bring their hands in the midline, and transfer objects bimanual with integrated symmetrical and asymmetrical tonic neck reactions while balancing flexor and extensor tone, be aware of the tone of voice and strangers, and express him or herself through sounds and gestures.	**13-24**
Level -I	Children can roll and control their neck efficiently with bad balance in slight changes in equilibrium, clench and indwell their thumbs with integrated rooting, sucking, and palmer grasp reflexes while shifting flexor tone into extensor tone for neck control, recognize the scent of their mother's breast milk, be alert with bright light and objects, and express their needs through different cries.	**1-12**

typical progress in children's abilities at different ages. Such milestones enable comparison of a child's chronological age to their developmental age in several areas critical to their development. This study focused on the effectiveness of the SSDT through its emphasis on targeting a broader spectrum of a child's developmental domains. These include gross motor, fine motor, social interaction, muscle tone, balance, gait, sensory and speech development, and reflex integration or inhibition. Unlike other assessment measures, SSDT presents multidimensional data on developmental milestones and chronological age that meet this dimension. The study findings verified that the SSDT is a reliable as well as valid tool for assessing child development and is backed by strong statistical analyses. Not only does its design improve the precision of developmental examinations, but it also presents useful directions for the domains that require heightened attention to intervention. This instrument has profound implications for the multidisciplinary pediatric team. For healthcare professionals, it allows for the precise area and skill in which a plan of care can be established. Educators are able to utilize the tool to determine and correct learning needs in early education settings, and researchers are able to utilize this tool for developmental paths and outcomes for a range of populations.

The GMFCS was initially designed for the functional level of children in relation to walking both in and outdoors, with an interrater agreement of 0.84. The assessment of locomotion, specifically the walking skills, is the primary goal of this instrument and does not address the basic developmental milestones required in order to walk. Conversely, the SSDT examines not only walking status but also patterns of gait, balance, and maintenance of tone and provides a greater understanding of how the milestone fits into total development.[22] The validity of SSDT is 0.963, verifying and expanding the comprehensive approach to gross motor assessment, as the GMFCS first intended.[5,23]

Unlike GMFCS and GMFM, which focus mainly on gross motor skills, or tools such as FINGA and handwriting assessments that target fine motor function, the SSDT integrates nine domains, including motor, sensory, social, and reflex development. This breadth makes it uniquely suited for early childhood multidomain assessment. The current study uses the SSDT instrument to test comparable gross motor abilities in typically developing toddlers aged 0 to 36 months. This tool showed performance on motor function assessment with excellent reliability on a broader population, with a wide window of age. Integrating typically developing children into this assessment backdrop is an enhancement, filling a void in currently available tools, such as the GMFM, which targets only CP children who are currently evaluated over a relatively limited age range. With near-perfect Kappa-based results of SSDT, it's a great tool to be used as a guideline to assess gross motor development covering a wide range of diverse populations.[23,24]

To develop fine motor skills, a device called FINGA was specifically developed to allow an accurate estimation of a child's fine motor skills. This tool was put to the test, and evidence of reliability was seen with a coefficient of

0.94. The development of FINGA was based on well-developed instructions and a standard so that the evaluation was valid and equal for a variety of populations. This tool was part of a larger project that aimed at developing valid tools for assessing specific areas of development in children.[13] Similarly, another instrument was also created to assess the handwriting skill of children, following the same rigorous methodology used for FINGA. The handwriting assessment tool has been made to provide a comprehensive analysis of children's handwriting skills, which are among the most important parts of fine motor development. The instrument demonstrated very high content validity, between 0.99 and 1 validity coefficient. This indicates that the measure is very good at assessing what it is supposed to assess, and thus a useful resource for clinicians and educators who are dealing with children.[25]

In the realm of social interaction, the Social Communication Questionnaire was created to assess social communication skills in special needs populations who may experience challenges with social interaction. This tool was initially developed in Turkish and adapted to address the needs of these groups. Its reliability was established at 0.80, indicating that it consistently and dependably measures social communication skills.[26] The tool developed in Persian for speech and language development is the Language Development Scale. The questionnaire was designed for 2 to 6-year-old children, which happens to be a critical age range during which language acquisition and development take place. It has been tested extensively with a reliability coefficient of 0.88. This high reliability ensures the tool's ability to effectively measure language development in young children and thus offers valuable insights to parents, educators, and clinicians. What differentiates this study from the current one is that it's based on an age range, while the current study focuses on birth onward.[27,28]

These tools represent significant progress in measuring children's development, offering reliable assessments across fine motor skills, handwriting, social communication, and language. This study introduced a tool to assess motor development based on baby milestones, covering nine key domains: gross motor, fine motor, social interaction, tone, balance, gait, sensory, speech, and reflexes. With a Cronbach's alpha of 0.963 and content validity indices ranging from 0.99-1, the instrument is highly reliable and valid. There are a few limitations to the study that should be mentioned. The majority of the questions were brief and focused on developmental milestones in children aged between 0-36 months, excluding topics of interest to mothers, for example, school function and extracurricular activities. Also, the reliability of the tool, such as test-retest and inter-interpreter agreement, was not assessed, indicating a significant need for further research to improve and validate its efficacy. Closing these loopholes could make the tool more complete and solid for its future application. The tool can be tailored across cultures with forward–back translation and pilot testing, which makes it more globally applicable. This research was confined to a single-center urban population, which could limit generalizability.

Test–retest and inter-rater reliability were not assessed, and responsiveness to change over time is unknown. In addition, cross-cultural validation has not been undertaken. These weaknesses emphasize the necessity for multicenter, longitudinal studies. In spite of these, the instrument is promising. Its brevity and minimal training needs make it an option for primary healthcare and early education screening. Cross-cultural adaptation can be a rapid multidomain assessment in low-resource environments. Future studies should involve multicenter validation, responsiveness over the long term, and the determination of minimal clinically important differences.

Conclusion

The SSDT is an optimistic and valid measure for early childhood sensorimotor development that fills crucial lacunae in existing measures. Although initial validation is positive, testing with diverse groups and longitudinal designs is required before its general use. With further research, the SSDT can inform early interventions and have a positive impact on clinical practice and developmental science.

Ethical Approval

Formal approval was granted by the university's Research Ethics Committee under reference number REC-UOL-272-08-24 on July 11, 2024, for a PhD project.

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Authors' Contribution

SW: Conception & design, acquisition of collection, drafting of article, critical revision for important intellectual content, final approval

AA: critical revision for important intellectual content, final approval

JBG: Analysis & interpretation of data

AH: Analysis & interpretation of data, drafting of article
MT: Final approval of the version to be published
AN: Acquisition of data

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