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Construct Validity and Reliability of a Researcher-Made Muscular–Motor Readiness Assessment Tool for Children Aged 3–7 for Specialized Instrument Training

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A B S T R A C T

Purpose: The study aimed to examine the construct validity and reliability of a researcher-made muscular–motor readiness assessment tool designed to evaluate the preparedness of children aged 3–7 years for specialized musical instrument training.
Methods and Materials: This methodological study was conducted in 2025 in Mashhad using a multi-stage cluster sampling procedure. A total of 251 children aged 3–7 years who were enrolled in music-education programs participated in the study. The researcher-developed assessment tool was designed based on an integrated framework derived from the Denver II, the Movement Assessment Battery for Children-2 (MABC-2), and the Bruininks–Oseretsky Test of Motor Proficiency-2 (BOT-2). The instrument evaluated fine and gross motor coordination, postural stability, visual–motor integration, muscle tone, and motor sequencing abilities relevant to early instrumental performance. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were performed to evaluate construct validity. Reliability and convergent validity were assessed using Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE). Data analyses were conducted using SPSS and SmartPLS version 4.
Findings: Exploratory factor analysis identified four underlying factors that collectively explained 79.7% of the total variance. Confirmatory factor analysis supported the four-factor structure, with all factor loadings statistically significant ($p < .001$). Reliability analysis demonstrated strong internal consistency, with Cronbach's alpha coefficients ranging from 0.805 to 0.971 and composite reliability values ranging from 0.909 to 0.984. Convergent validity was confirmed through AVE values between 0.759 and 0.926. Furthermore, discriminant validity was supported by both the Fornell–Larcker criterion and HTMT ratios below the recommended threshold.
Conclusion: The findings indicate that the researcher-made muscular–motor readiness assessment tool possesses satisfactory construct validity, reliability, convergent validity, and discriminant validity for evaluating children's readiness for specialized musical instrument training.
Keywords: *Muscular–motor readiness; Construct validity; Reliability; Music education; Children; Motor development*

1. Introduction

Early childhood is widely recognized as one of the most sensitive and formative developmental periods in the human lifespan. During the ages of 3 to 7 years, children experience rapid neurological, cognitive, emotional, and motor development, and these developmental systems interact continuously with one another. Contemporary developmental theories emphasize that motor development is not an isolated physical process; rather, it serves as a foundational mechanism through which children explore the environment, regulate behavior, acquire cognitive competencies, and develop social participation skills. In this regard, movement experiences during early childhood significantly influence later learning outcomes, including artistic and musical development (Madhurasinghe Mudiyanselage & Hikkaduwa Liyanage, 2025; Rico-Gonzalez, 2025). Research has demonstrated that children's opportunities for coordinated movement, sensory integration, and motor exploration contribute substantially to the maturation of executive functioning, attentional control, and adaptive learning behaviors (Baikulova et al., 2026; Hsiao et al., 2025). Consequently, developmental readiness for structured educational experiences should be evaluated not solely through chronological age or observable interest, but also through the child's underlying neuromuscular and psychomotor capacities.

Within this developmental context, music education occupies a particularly unique position because it simultaneously engages sensory, motor, emotional, cognitive, and social systems. Learning to play a musical instrument requires children to coordinate complex patterns of movement while integrating auditory perception, visual attention, timing precision, bilateral coordination, and emotional expression. Instrumental performance depends heavily on fine motor control, postural stability, muscle endurance, and visual–motor integration, particularly during the early phases of skill acquisition (Jurinic et al., 2025). Biomechanical investigations of piano and instrumental performance indicate that even beginner-level musical tasks impose substantial demands on upper-limb coordination, joint stability, muscular regulation, and motor sequencing. Such findings suggest that successful musical training depends not only on musical aptitude but also on adequate muscular–motor readiness. If these motor prerequisites are insufficiently developed, children may experience frustration, inefficient learning patterns, physical discomfort, or even anxiety associated with musical performance (Kenny, 2026).

Despite the recognized complexity of musical performance, traditional approaches to early music education have often focused predominantly on auditory sensitivity, rhythmic perception, or cognitive aptitude, while comparatively neglecting the importance of motor readiness. However, recent scholarship increasingly emphasizes that readiness for instrumental learning is multidimensional and should include physical and neuromotor developmental indicators alongside musical competencies (Respati & Hamzah, 2026; Zavalko & Khalilova, 2018). In particular, preschool children display considerable variability in postural control, hand strength, proprioceptive awareness, balance, coordination, and motor planning, even among typically developing populations (Gogola et al., 2026; Zhang et al., 2025). Such developmental differences may substantially affect the child's ability to manipulate instruments effectively, sustain attention during practice, or execute repetitive movement patterns required for musical learning.

The growing literature on motor skill development further supports the importance of early assessment and intervention in educational contexts. Studies examining play-based learning, movement-centered curricula, and adapted physical education programs demonstrate that structured motor activities can significantly enhance coordination, self-regulation, and learning engagement in children (Favazza et al., 2023; Roth et al., 2025). Cooperative movement programs, rhythmic motor entrainment, and multisensory educational interventions have been associated with improvements in both motor proficiency and psychosocial functioning (Celaya, 2022; Kuspratiwi et al., 2026). Such findings are particularly relevant to music education because instrumental performance inherently combines rhythmic timing, sensory integration, and coordinated movement execution.

Rhythm and auditory stimulation also appear to play an influential role in neuromuscular activation and motor regulation. Research investigating auditory stimulation and rhythmic movement training has shown that sound-based interventions may enhance muscular strength, timing coordination, and physiological regulation (Safari et al., 2026). Similarly, studies examining dance-based and movement-oriented educational programs indicate that physically expressive activities contribute not only to physical fitness but also to aesthetic development, coordination, and emotional engagement (Yu et al., 2025).

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These findings collectively suggest that musical and motor systems are deeply interconnected and mutually reinforcing during childhood development.

The relationship between motor development and learning becomes even more significant when considering children with developmental vulnerabilities or special educational needs. Research on developmental coordination difficulties and psychomotor delays demonstrates that deficits in proprioception, force regulation, balance, and joint control may interfere with children's participation in educational and recreational activities (Gogola et al., 2026). Similarly, children born preterm or those with developmental challenges may experience persistent psychomotor differences that affect later functional performance and learning capacities (Kozakiewicz et al., 2025). Inclusive educational frameworks therefore emphasize the necessity of developmentally appropriate and individualized assessment procedures capable of identifying strengths and limitations before intensive training begins (Basaran & Soylemez, 2026; Mulyaningrum et al., 2026). In music education, this issue becomes especially important because early negative experiences related to physical strain or repeated failure may influence children's long-term attitudes toward artistic participation.

Contemporary educational models increasingly advocate holistic approaches that integrate movement, creativity, and sensory experiences within early learning environments. STEAM-based pedagogical frameworks, for example, emphasize hands-on engagement, creative exploration, and fine motor activity as essential components of developmental learning (Hsiao et al., 2025). Digital interactive educational games and multisensory instructional strategies have similarly been shown to improve children's cognitive engagement and behavioral participation (Baikulova et al., 2026). These approaches reinforce the notion that motor readiness is deeply intertwined with broader developmental functioning and should therefore be considered an essential element in educational planning.

The educational significance of motor readiness extends beyond technical skill acquisition and also influences emotional development and identity formation. Studies on music learning and child development indicate that positive early musical experiences contribute to children's self-confidence, motivation, artistic identity, and emotional expression (Garcia-Bender, 2025). Conversely, developmental mismatches between instructional demands and children's readiness levels may contribute to stress, reduced motivation, or negative self-perceptions regarding musical ability (Kenny, 2026). Research on beginner-level music pedagogy further suggests that individualized and developmentally sensitive instructional approaches improve children's engagement and long-term learning outcomes (Kenduzler & Akkas, 2025). Therefore, assessing muscular–motor readiness prior to the initiation of formal instrumental training may help educators establish more supportive and effective learning pathways.

Another important consideration involves the embodied nature of musical performance itself. Music learning requires sustained interaction between perception and movement, including finger isolation, bilateral coordination, timing precision, postural alignment, and muscular endurance. These capacities emerge gradually during early childhood and may vary considerably between individuals (Rico-Gonzalez, 2025). Research on adapted physical education and motor learning consistently demonstrates that developmentally appropriate movement experiences enhance children's capacity for coordinated action and sustained task engagement (Favazza et al., 2023; Roth et al., 2025). Such evidence underscores the necessity of evaluating physical readiness alongside cognitive and auditory competencies when preparing children for instrumental instruction.

Furthermore, recent developments in clinical and developmental assessment research highlight the importance of reliable and valid measurement tools capable of capturing subtle variations in motor functioning. Studies focused on neuromuscular disorders and developmental coordination emphasize that accurate assessment procedures are essential for identifying developmental needs and guiding intervention planning (Gogola et al., 2026; Osman et al., 2025). Nevertheless, despite substantial advances in pediatric motor assessment, there remains a notable lack of specialized tools specifically designed to evaluate muscular–motor readiness for musical instrument learning in early childhood. Existing developmental assessments primarily focus on general motor competence rather than the specific neuromotor demands associated with instrumental performance (Zhang et al., 2025). Consequently, music educators and parents often rely on subjective judgment or age-based assumptions when deciding whether a child is prepared to begin formal instrument training.

This gap in the literature is particularly important because early childhood represents a period of heightened neuroplasticity and developmental sensitivity. During this stage, supportive educational experiences may significantly strengthen long-term developmental trajectories, whereas

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inappropriate instructional demands may contribute to maladaptive patterns of learning or emotional disengagement (Madhurasinghe Mudiyanselage & Hikkaduwa Liyanage, 2025). Research involving music-based reinforcement and movement-oriented interventions further indicates that synchronized auditory–motor activities can positively influence functional performance and behavioral engagement (Walker et al., 2025). These findings collectively support the argument that muscular–motor readiness constitutes a fundamental prerequisite for healthy and successful participation in specialized musical instruction.

Although previous studies have examined isolated aspects of motor development, music pedagogy, physical education, and psychomotor functioning, an integrated developmental framework specifically targeting readiness for instrumental learning remains underdeveloped. Existing literature highlights the importance of movement competence, sensory integration, rhythm, and motor coordination in children's educational participation, yet few studies have attempted to synthesize these dimensions into a comprehensive assessment instrument applicable to music education contexts (Jurinic et al., 2025; Respati & Hamzah, 2026). The absence of such tools limits educators' ability to make evidence-based decisions regarding the timing, intensity, and appropriateness of early instrument instruction.

Accordingly, the present study aims to examine the construct validity and reliability of a researcher-made muscular–motor readiness assessment tool designed to evaluate the preparedness of children aged 3–7 years for specialized musical instrument training.

2. Methods and Materials

2.1. Study Design and Participants

This methodological study was carried out in 2025 in the city of Mashhad, with the aim of developing and validating a comprehensive instrument for assessing muscular–motor readiness in early music education contexts. The study employed a multi stage cluster sampling procedure to obtain a representative sample of young children enrolled in music education centers across the city. In the first stage, urban districts were randomly selected; in the second stage, music education institutions within each district were identified; and in the final stage, children meeting the inclusion criteria were randomly selected from the available class rosters. This sampling strategy ensured adequate coverage of the diverse socioeconomic and educational backgrounds present within the city.

The sample size was determined using standard guidelines for scale development and factor analytic research, which recommend a minimum ratio of 5–10 participants per item and not fewer than 200 participants for stable factor solutions. Based on these criteria and the anticipated dimensionality of the new instrument, a target of at least 250 participants was calculated. Ultimately, 251 children aged 3 to 7 years were included in the study, providing sufficient statistical power for both exploratory and confirmatory factor analyses.

Eligibility criteria required that children be within the specified age range (3–7 years), enrolled in a music education or preparatory program, and have no diagnosed neurological, sensory, or severe developmental disorders that might prevent participation in motor performance assessments. Children whose parents declined informed consent, those unable to complete the motor based tasks, or those with incomplete assessment data were excluded from the final analyses.

The instrument developed for this study—a researcher constructed muscular–motor readiness assessment tool—was grounded in an integrated framework drawing from three established developmental and motor assessments: the Denver II, the Movement Assessment Battery for Children – Second Edition (MABC 2), and the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT 2). Items were designed to capture fine and gross motor coordination, motor control, timing, postural stability, and developmental indicators that are theoretically relevant to the demands of early music training. The administration procedure involved individual assessment sessions in which the researcher completed the new instrument alongside the standardized tools, enabling both comparative evaluation and external validation.

2.2. Measures

PDMS-2 (Peabody Developmental Motor Scales – Second Edition): The Movement Assessment Battery for Children – Second Edition (MABC 2) is one of the most widely used and well established standardized instruments for evaluating motor skills in children and for identifying Developmental Coordination Disorder (DCD). Developed by Henderson, Sugden, and Barnett, the assessment is designed for children between 3 and 16 years of age and is extensively applied in both clinical and research contexts. In practice, it is commonly used for developmental screening, diagnostic evaluation, and determining the severity of motor coordination difficulties.

The MABC 2 evaluates motor performance across three interconnected domains that together provide a comprehensive picture of a child's motor functioning. Manual dexterity focuses on fine motor control and examines the child's speed, accuracy, and eye–hand coordination during tasks that require precise hand and finger movements, such as manipulating small objects or tracing pathways. Aiming and catching assesses coordination in dynamic interactions with moving objects and reflects the child's ability to integrate visual information with timed motor responses during activities such as throwing and catching a ball; these tasks rely heavily on bilateral coordination, motor timing, and effective motor planning. Balance, the third domain, evaluates both static and dynamic postural control, capturing the child's capacity to maintain body stability, regulate posture, and shift weight efficiently during movement. Together, these domains allow clinicians and researchers to detect subtle difficulties in motor control that may reflect underlying neuromotor challenges.

Performance on the MABC 2 is quantified through a scoring system that converts raw task scores into standardized scores and normative percentiles, enabling comparison with age based norms. Based on these scores, children can be categorized into three interpretive ranges—typical performance, at risk of motor difficulties, or significant motor impairment—which makes the instrument particularly useful for both early screening and clinical diagnosis.

Within the framework of the present study, the MABC 2 served as a central assessment tool for identifying and quantifying the severity of motor coordination difficulties. In methodological terms, it functioned as an intermediate link between initial developmental screening and more detailed analysis of motor performance. The information obtained from this assessment provided a structured basis for a broader evaluation of children's motor abilities and contributed to the development of a music based muscular–motor assessment framework, thereby connecting conventional motor assessment indices with an innovative evaluative approach.

BOT-2 (Bruininks–Oseretsky Test of Motor Proficiency – Second Edition): The Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT 2) is one of the most widely recognized standardized instruments for assessing both fine and gross motor skills in children and adolescents. Originally developed by Robert H. Bruininks, the first edition was published in 1978, and the second edition (BOT 2) was comprehensively revised and updated in 2005 by Robert Bruininks and Deborah Bruininks. Designed specifically for individuals aged 4 to 21 years, the BOT 2 is extensively used across rehabilitation settings, developmental assessments, physical education programs, growth and motor development research, and studies focusing on the interaction between music, movement, and motor performance.

The BOT 2 provides a broad evaluation of motor proficiency through eight motor subtests that collectively represent the domains of fine and gross motor functioning. The fine motor domain includes Fine Motor Precision, assessing accuracy in tasks such as drawing lines, cutting, or connecting dots, and Fine Motor Integration, which measures visual–motor integration through geometric drawing or pattern imitation. The manual coordination domain evaluates Manual Dexterity, reflecting speed and efficiency in manipulating small objects such as beads or buttons, as well as Upper Limb Coordination, which captures eye–hand coordination in throwing, catching, or striking tasks. The body coordination domain encompasses Bilateral Coordination, focusing on coordinated two sided movements such as synchronous jumping or symmetrical limb actions, and Balance, which assesses static and dynamic postural stability across different positions. Finally, the strength and agility domain includes Running Speed and Agility, measuring rapid directional changes and quick locomotor movements, along with Strength, which evaluates upper and lower body muscular power through tasks such as sit ups or push ups.

The test is available in both a complete form and a short form. The complete form consists of approximately 53 items and requires about 45 to 60 minutes to administer, whereas the short form contains 14 items and can be completed in 15 to 20 minutes, making it suitable for rapid screening. Each item is scored on a 0–3 or 0–2 scale depending on performance quality. Raw scores are converted to scaled scores, percentile ranks, and a set of composite indices: Fine Manual Control (FMC), Manual Coordination (MC), Body Coordination (BC), and Strength and Agility (SA), culminating in the Total Motor Composite (TMC), which represents the child's overall motor proficiency level.

Psychometric evaluations based on a U.S. standardization sample of more than 1,500 participants indicate excellent reliability and validity. Reported indices include test–retest

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reliability ranging from 0.80 to 0.90, inter rater reliability between 0.97 and 0.99, and internal consistency (Cronbach's alpha) between 0.88 and 0.98. The BOT 2 demonstrates strong concurrent validity through substantial correlations with established measures such as the Peabody Developmental Motor Scales–Second Edition (PDMS 2), with reported coefficients between r = 0.65 and 0.83, and demonstrates robust discriminant validity in its ability to distinguish children with Developmental Coordination Disorder (DCD) from typically developing peers.

Denver II (Denver Developmental Screening Test): The Denver Developmental Screening Test – Second Edition (DDST II), commonly referred to as Denver II, is one of the most widely used and well established screening instruments for evaluating overall developmental progress in early childhood. The test assesses children from birth to six years of age (0–72 months) and was revised and republished in 1992 with updated normative data and clearer administration procedures. Its primary purpose is the early identification of developmental delays, allowing children who may require further diagnostic evaluation or early intervention services to be referred promptly for more comprehensive assessment.

Denver II evaluates development across four fundamental domains that together provide a broad picture of a child's developmental functioning. The gross motor domain examines large muscle activities such as sitting, crawling, walking, running, and jumping, reflecting the maturation of postural control and locomotor ability. The fine motor–adaptive domain focuses on more precise hand and finger movements as well as visual–motor coordination, including activities such as grasping objects, drawing shapes, or building block towers. The language domain assesses both receptive and expressive communication abilities, encompassing the understanding of words, the use of vocabulary, sentence formation, and verbal responses to social interaction. Finally, the personal–social domain evaluates the child's ability to interact with others and to perform age appropriate self care behaviors, including social play, feeding, and independent dressing.

The administration of the Denver II is organized around an age based developmental chart in which each test item is positioned along a horizontal timeline representing the age range at which most children typically acquire that skill. During the assessment, the examiner identifies the child's exact age in months on the chart and selects the relevant items accordingly. Each task is then scored according to the child's performance, typically categorized as Pass, Fail, Refusal, or No Opportunity. These outcomes are interpreted by comparing the child's performance with the expected developmental range indicated by the normative chart. Based on this comparison, performance may be interpreted as normal, caution, or delay, depending on whether the child demonstrates skills within the expected age range, shows borderline performance on a specific item, or exhibits clear delays across one or more developmental indicators. The overall screening outcome is generally reported as pass, suspect, or fail, with children demonstrating delays in multiple areas typically referred for further developmental evaluation.

Psychometric studies of the Denver II indicate strong reliability and acceptable validity for developmental screening purposes. Reported inter rater reliability ranges from approximately 0.90 to 0.99, while test–retest reliability has been reported between 0.80 and 0.95. The instrument's content validity has been supported by panels of pediatric and developmental experts, and its convergent validity is demonstrated through positive correlations with other established developmental assessments, including the Bayley Scales of Infant Development and the Gesell Developmental Schedules. In practical settings, the test is relatively quick to administer, typically requiring 15 to 25 minutes, which contributes to its popularity in clinical and community screening contexts.

In both clinical practice and research, Denver II is widely used as a general developmental screening tool in pediatric clinics, early childhood centers, and preschool environments. Within interdisciplinary research contexts—particularly studies examining the developmental effects of music education, rhythmic movement, and play based interventions—the instrument is often employed to monitor broader developmental outcomes. In such studies, domains related to gross motor development and personal–social interaction are especially relevant, as group musical activities and rhythmic movement exercises frequently engage these aspects of child development.

2.3. Data Analysis

Data collection occurred in controlled assessment rooms within the selected institutions, and all evaluations were conducted by trained examiners following standardized protocols. Subsequent analyses included exploratory factor analysis (EFA) to identify the underlying structure of the instrument and confirmatory factor analysis (CFA) to verify model fit. Reliability indices, including Cronbach's alpha and composite reliability (CR), were calculated to assess

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internal consistency. All statistical procedures adhered to established methodological standards for test development and validation. Moreover, confirmatory factor analysis in this study was performed using SmartPLS-4 software.

3. Findings and Results

A total of 251 children aged 3 to 7 years participated in this study. In terms of age distribution, 80 participants (31.9%) were in the 3–5-year age group, 48 participants (19.1%) were in the 5–6-year age group, and 123 participants (49.0%) were in the 6–7-year age group, with the largest proportion belonging to the 6–7-year group. Regarding gender distribution, 180 participants (71.7%) were boys and 71 participants (28.3%) were girls.

Table 1

Descriptive statistics of the variables

Variables	Groups	Frequency	Percent	Total	Mode
Gender	Boy	180	71.7	251	1
	Girl	71	28.3		
Age	3–5	80	31.9	251	3
	5–6	48	19.1		
	6–7	123	49.0		

Table 2

Description of the research variables

Variables	N	Mean	SD	Median	Min	Max	Skewness	Kurtosis
Gross Motor Stability	251	1.689	0.686	2.000	0	2	-1.904	1.869
Proximal Stability	251	1.725	0.651	2.000	0	2	-2.107	2.721
Bimanual Coordination	251	1.586	0.648	2.000	0	2	-1.301	0.480
Sustained hold	251	1.741	0.633	2.000	0	2	-2.207	3.185
Tripod Grasp Development	251	1.713	0.618	2.000	0	2	-1.986	2.544
Intrinsic Hand Strength	251	1.108	0.858	1.000	0	2	-0.209	-1.614
Finger Isolation	251	0.892	0.721	1.000	0	2	0.164	-1.062
Asymmetrical Hand Use	251	1.414	0.576	1.000	0	2	-0.357	-0.755
Wrist Mobility and Rotation	251	1.518	0.582	2.000	0	2	-0.745	-0.424
Visual Targeting	251	1.367	0.545	1.000	0	2	-0.051	-0.874
Smooth Visual Tracking	251	1.697	0.548	2.000	0	2	-1.642	1.772
Oculomotor-Manual Integration	251	1.733	0.636	2.000	0	2	-2.151	2.973
Midline Orientation	251	1.753	0.615	2.000	0	2	-2.284	3.588
Motor Sequencing & Endurance	251	1.637	0.573	2.000	0	2	-1.327	0.783
Muscle Tone Assessment	251	1.749	0.604	2.000	0	2	-2.240	3.513
Total Score	251	23.323	4.572	24.000	8	30	-0.750	0.081

Step 1: Exploratory Factor Analysis (EFA)

At this stage, exploratory factor analysis (EFA) was conducted to reduce the number of items in the instrument and to examine the consistency and alignment between the questionnaire items and their underlying factors. EFA groups and classifies related variables in order to summarize and organize the data structure. The analysis was performed on 251 completed questionnaires. Prior to conducting factor analysis, it was necessary to determine whether the data were suitable for factor analysis. Therefore, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were applied.

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Table 3

KMO and Bartlett's Test

Assumption			Result
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.77	confirmation
Bartlett's Test of Sphericity	Approx. Chi-Square	4257.031	confirmation
	df	105	
	p	< .001	

As shown in Table 3, Bartlett's test of sphericity was statistically significant, indicating that the correlation matrix was appropriate for factor analysis. In addition, the KMO value was 0.77, confirming that the sample size was adequate for conducting factor analysis. Using the Varimax rotation method, four main factors were extracted. The eigenvalues of all extracted factors were greater than 1. Together, these four factors explained 79.7% of the total variance.

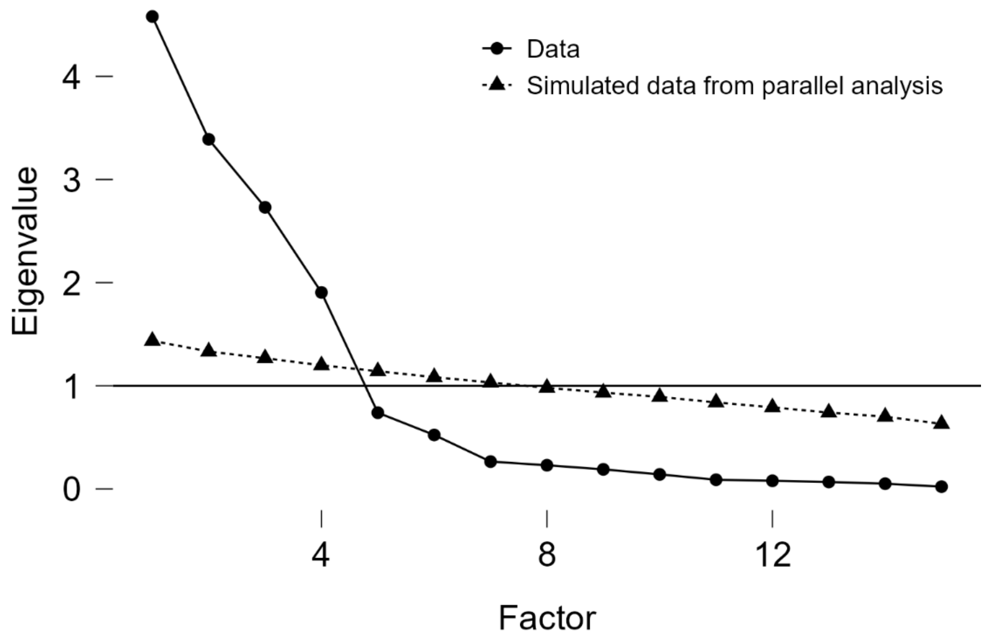
Table 4

Results of exploratory factor analysis

Factor	Eigenvalues	Cumulative %
Factor 1	4.580	0.293
Factor 2	3.389	0.484
Factor 3	2.730	0.657
Factor 4	1.905	0.797

Figure 1

Scree plot



The presence of four factors was also confirmed by the Scree plot. Furthermore, the factor loadings of each item were examined.

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Table 5

Factor Loadings (Structure Matrix)

	Factor 1	Factor 2	Factor 3	Factor 4
Q1	0.844			
Q2	0.913			
Q4	0.964			
Q12	0.953			
Q13	0.996			
Q3			0.823	
Q5			0.950	
Q15			0.993	
Q6		0.996		
Q7		0.883		
Q8		0.852		
Q9		0.521		
Q10				0.408
Q11				0.995
Q14				0.896

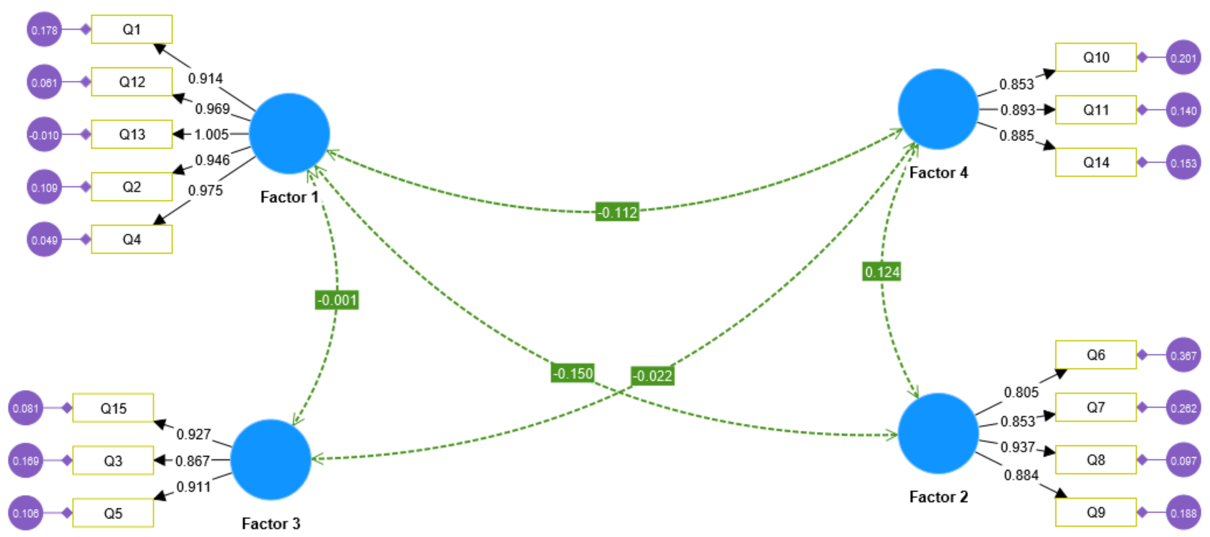
The EFA results based on the structural matrix indicated that the questionnaire consisted of four main factors. In the first factor, items Q1, Q2, Q4, Q12, and Q13 showed high factor loadings of 0.844, 0.913, 0.964, 0.953, and 0.996, respectively. The second factor included items Q6, Q7, Q8, and Q9 with factor loadings of 0.996, 0.883, 0.852, and 0.521, respectively. The third factor comprised items Q3, Q5, and Q15 with factor loadings of 0.823, 0.950, and 0.993. Finally, the fourth factor included items Q10, Q11, and Q14 with factor loadings of 0.408, 0.995, and 0.896. Overall, the results indicated that all items had acceptable factor loadings on their respective factors, supporting the four-factor structure of the instrument

Step 2 Confirmatory Factor Analysis (CFA)

To further evaluate the measurement model, confirmatory factor analysis (CFA) was conducted using SmartPLS version 4. The research model was first specified and then its model fit was examined. Factor loadings of all items on their respective constructs were assessed.

Figure 2

Research model



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Factor loadings are calculated based on the correlation between the indicators of a construct and the construct itself. A loading of 0.70 or higher indicates that the variance shared between the construct and its indicators exceeds the measurement error variance, suggesting acceptable reliability of the measurement model. In addition, the statistical significance of all items was evaluated and confirmed. t-values greater than 1.96 at the 0.05 significance level indicate that the factor loadings are statistically significant.

Table 6

The significance of the questionnaire items

	Sample mean (M)	Standard deviation (STDEV)	T-value	P values
Q1 <- Factor 1	0.895	0.038	24.348	p<0.001
Q10 <- Factor 4	0.790	0.056	15.210	p<0.001
Q11 <- Factor 4	0.897	0.046	19.577	p<0.001
Q12 <- Factor 1	0.959	0.024	41.090	p<0.001
Q13 <- Factor 1	0.999	0.013	79.654	p<0.001
Q14 <- Factor 4	0.886	0.049	18.161	p<0.001
Q15 <- Factor 3	0.944	0.050	18.559	p<0.001
Q2 <- Factor 1	0.934	0.031	30.606	p<0.001
Q3 <- Factor 3	0.846	0.031	27.528	p<0.001
Q4 <- Factor 1	0.966	0.021	45.926	p<0.001
Q5 <- Factor 3	0.921	0.042	21.459	p<0.001
Q6 <- Factor 2	0.760	0.044	18.506	p<0.001
Q7 <- Factor 2	0.814	0.037	22.964	p<0.001
Q8 <- Factor 2	0.938	0.032	29.304	p<0.001
Q9 <- Factor 2	0.832	0.050	17.826	p<0.001

The reliability and validity of the model were evaluated using Cronbach's alpha, composite reliability (CR), and convergent validity through the Average Variance Extracted (AVE) index. The results are presented in Table 7.

Table 7

Reliability and validity of the model

Factor	Cronbach's alpha	Composite reliability		AVE
Factor 1	0.971	0.984		0.926
Factor 2	0.888	0.923		0.759
Factor 3	0.943	0.928		0.814
Factor 4	0.805	0.909		0.769
Fornell and Larker index				
	1	2	3	4
Factor 1	0.962			
Factor 2	-0.150	0.871		
Factor 3	-0.001	0.٣٣١	0.902	
Factor 4	-0.112	0.124	-0.022	0.877
Heterotrait-monotrait ratio (HTMT)				
	1	2	3	4
Factor 1				
Factor 2	0.084			
Factor 3	0.034	0.049		
Factor 4	0.063	0.326	0.069	

For reliability assessment, both Cronbach's alpha and composite reliability were calculated. Cronbach's alpha values for the first to fourth factors were 0.971, 0.888, 0.943, and 0.805, respectively, all of which exceeded the acceptable threshold of 0.70, indicating satisfactory reliability of the constructs. Similarly, composite reliability values for the four factors were 0.984, 0.923, 0.928, and 0.909,

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demonstrating strong internal consistency among the indicators of each construct.

Convergent validity was assessed using the Average Variance Extracted (AVE). The AVE values for the four factors were 0.926, 0.759, 0.814, and 0.769, respectively, all of which were above the recommended threshold of 0.50, confirming adequate convergent validity.

Discriminant validity was examined using the Fornell–Larcker criterion and the Heterotrait–Monotrait ratio (HTMT). According to the Fornell–Larcker criterion, the square root of the AVE for each construct was greater than its correlations with other constructs, indicating adequate distinction between the constructs. Furthermore, the HTMT values between constructs were all below the threshold of 0.85, providing additional support for discriminant validity.

Overall, the results indicate that the measurement model demonstrates satisfactory reliability and validity.

4. Discussion and Conclusion

The present study aimed to evaluate the construct validity and reliability of a researcher-made muscular–motor readiness assessment tool designed for children aged 3–7 years prior to specialized musical instrument training. The findings demonstrated that the developed instrument possessed a strong and theoretically coherent four-factor structure, with the extracted factors collectively explaining 79.7% of the total variance. Additionally, the results of exploratory and confirmatory factor analyses supported the structural integrity of the model, while the reliability analyses revealed high levels of internal consistency across all dimensions of the instrument. Cronbach's alpha coefficients ranged from 0.805 to 0.971, composite reliability indices exceeded recommended thresholds, and average variance extracted values confirmed acceptable convergent validity. Furthermore, discriminant validity was supported through the Fornell–Larcker criterion and HTMT ratios. Collectively, these findings indicate that the developed assessment tool provides a psychometrically sound framework for evaluating muscular–motor readiness related to instrumental music learning in early childhood.

One of the most important findings of this study was the emergence of a four-factor structure representing distinct yet interconnected domains of muscular–motor readiness. This multidimensional structure aligns with contemporary developmental theories emphasizing that motor functioning in childhood consists of integrated systems involving coordination, postural stability, motor planning, visual–motor integration, and neuromuscular regulation (Rico-Gonzalez, 2025; Zhang et al., 2025). The factors extracted in the present study correspond closely with the developmental demands associated with musical instrument learning, particularly regarding fine motor precision, bilateral coordination, sustained movement control, and postural endurance. These findings support the perspective that readiness for instrumental education should not be conceptualized solely as musical aptitude, but rather as a broader developmental construct integrating physical and cognitive preparedness (Respati & Hamzah, 2026; Zavalko & Khalilova, 2018).

The strong psychometric properties observed in this study are also consistent with previous literature emphasizing the importance of reliable developmental assessment tools during early childhood. Research examining fine motor assessment instruments has demonstrated that valid and standardized measures are essential for identifying developmental strengths and limitations in preschool-aged children (Zhang et al., 2025). Similarly, studies focusing on neuromuscular and coordination-related evaluations have highlighted the necessity of precise observational frameworks capable of capturing subtle variations in movement control and proprioceptive functioning (Gogola et al., 2026; Osman et al., 2025). The current study extends this body of knowledge by introducing a specialized instrument specifically designed for the context of early musical instrument training, thereby addressing an important gap within developmental music education research.

The findings also support previous evidence indicating that successful musical learning is deeply dependent on motor and biomechanical readiness. Instrumental performance requires children to sustain controlled postures, regulate muscular force, coordinate bilateral movements, and execute precise finger actions over extended periods of time. Biomechanical studies of piano performance and instrumental execution demonstrate that even beginner-level music activities involve complex kinematic and neuromuscular processes (Jurinic et al., 2025). Consequently, children who lack sufficient postural control, coordination, or muscular endurance may encounter substantial difficulty during early instruction. The present assessment tool appears capable of identifying these developmental dimensions, thereby enabling more informed educational decisions regarding the initiation of formal music training.

Another important aspect of the findings relates to the role of movement experiences in broader educational and

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developmental functioning. Research in adapted physical education and early childhood pedagogy consistently demonstrates that motor competence contributes not only to physical performance but also to attentional regulation, behavioral engagement, social interaction, and cognitive flexibility (Favazza et al., 2023; Roth et al., 2025). Studies investigating movement-centered educational interventions further indicate that structured motor experiences improve children's self-regulation, learning participation, and confidence in skill acquisition (Celaya, 2022; Kuspratiwi et al., 2026). The present study aligns with these findings by emphasizing that muscular–motor readiness should be considered a foundational prerequisite for effective participation in specialized learning contexts such as instrumental music education.

The high reliability coefficients obtained in this study further suggest that the developed instrument provides stable and internally coherent measurements of readiness-related constructs. Such consistency is particularly important in early childhood assessments, where developmental variability is naturally high and observational precision becomes essential. Previous research on developmental coordination and psychomotor functioning has emphasized that reliable assessment procedures are critical for distinguishing typical developmental differences from clinically or educationally meaningful delays (Gogola et al., 2026; Kozakiewicz et al., 2025). The current findings indicate that the researcher-made instrument possesses sufficient measurement stability to support its application in educational and developmental screening settings.

The significance of muscular–motor readiness becomes even more apparent when considering the psychological dimensions of music learning. Studies examining music performance anxiety and emotional development suggest that children who encounter repeated difficulty or frustration during early instrumental learning may develop negative emotional associations with musical participation (Kenny, 2026). Conversely, developmentally appropriate educational experiences contribute positively to motivation, confidence, and long-term musical identity formation (Garcia-Bender, 2025). The present findings therefore support the idea that early readiness assessment may help reduce unnecessary stress and facilitate more positive educational trajectories by ensuring that instructional demands align with children's developmental capacities.

The role of sensory and rhythmic stimulation in motor functioning also provides theoretical support for the current findings. Research investigating auditory stimulation and rhythmic motor activities has demonstrated that sound-based interventions can positively influence muscle activation, movement timing, and physiological coordination (Safari et al., 2026). Similarly, movement-oriented and dance-based educational programs have been associated with improvements in physical fitness, coordination, and aesthetic skill development (Yu et al., 2025). Such evidence reinforces the conceptual relationship between movement systems and musical performance, suggesting that the constructs assessed in the present tool are directly relevant to the functional demands of early instrumental training.

The present findings additionally align with emerging perspectives emphasizing holistic and interdisciplinary educational models in early childhood. Contemporary pedagogical approaches increasingly integrate movement, creativity, sensory exploration, and interactive learning experiences as interconnected components of child development (Baikulova et al., 2026; Hsiao et al., 2025). STEAM-based instructional models and digital interactive educational strategies have demonstrated positive effects on children's fine motor abilities, engagement, and learning behaviors (Hsiao et al., 2025). The muscular–motor readiness assessment developed in this study complements such approaches by offering a framework capable of evaluating whether children possess the physical and coordinative capacities necessary for successful participation in complex artistic learning environments.

An additional strength of the present study lies in its integration of concepts derived from developmental, educational, and rehabilitative research traditions. Previous literature in inclusive education emphasizes that individualized and developmentally sensitive assessment is essential for supporting diverse learners, including children with motor or developmental challenges (Basaran & Soylemez, 2026; Mulyaningrum et al., 2026). Although the present instrument was designed primarily for typically developing children, its multidimensional structure may also prove useful in identifying readiness-related challenges among children with special educational needs. This possibility is particularly important because inclusive educational frameworks increasingly advocate early identification and supportive intervention rather than delayed recognition of learning difficulties.

The findings further support research emphasizing the embodied nature of artistic learning. Music education is fundamentally rooted in coordinated physical action, sensory feedback, timing regulation, and expressive movement. Studies examining beginner-level solfège

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education and early musical instruction indicate that pedagogical success depends heavily on aligning instructional methods with children's developmental capacities (Kenduzler & Akkas, 2025). In this regard, the present assessment tool may provide educators with a more objective and evidence-based method for determining whether children are physically prepared to begin formal instrumental training.

Moreover, research on music-based reinforcement and synchronized auditory movement demonstrates that rhythmic engagement can positively influence behavioral and functional performance outcomes (Walker et al., 2025). Such findings suggest that motor readiness is not only relevant to technical musical execution but may also contribute to broader behavioral regulation and engagement during learning activities. Consequently, evaluating muscular–motor readiness prior to instrumental training may improve not only skill acquisition but also children's motivation and persistence within educational programs.

The developmental importance of movement experiences during early childhood further strengthens the rationale for the current instrument. Research examining play-based motor development has consistently shown that children acquire foundational movement competencies through active engagement with their physical environment (Madhurasinghe Mudiyanselage & Hikkaduwa Liyanage, 2025). These competencies subsequently influence participation in more specialized activities requiring coordination, precision, and sustained attention. By identifying children's readiness levels before formal instruction begins, the present assessment may help educators design more individualized and developmentally appropriate learning pathways.

Overall, the findings of the present study contribute to the growing body of literature recognizing that musical learning in early childhood is not solely an auditory or cognitive process but a fundamentally embodied developmental activity. The strong validity and reliability indices obtained support the usefulness of the developed instrument as a practical and theoretically grounded assessment tool capable of evaluating muscular–motor readiness for specialized instrument training. In doing so, the study addresses a significant gap within developmental music education research and provides an evidence-based framework for supporting more effective and developmentally sensitive educational decision-making.

One limitation of the present study concerns the geographic and cultural specificity of the sample, as all participants were recruited from music education centers within a single city. Although the sample size was adequate for factor analysis procedures, developmental experiences and educational practices may differ substantially across cultural, socioeconomic, and educational contexts. Therefore, the generalizability of the findings may be somewhat restricted, and caution should be exercised when applying the instrument in populations with different developmental or educational backgrounds. Another limitation involves the cross-sectional nature of the study, which prevented the examination of predictive validity over time. While the instrument demonstrated strong construct validity and reliability, the study did not evaluate whether higher readiness scores actually predict later success in instrumental learning. Additionally, the assessment relied primarily on structured observational scoring procedures, which may still contain a degree of evaluator subjectivity despite standardized criteria.

Future research should investigate the predictive validity of the instrument by examining whether muscular–motor readiness scores are associated with long-term musical achievement, technical performance quality, or sustained participation in music education programs. Longitudinal studies would be particularly valuable for understanding how early motor readiness influences later artistic development and psychological engagement with music learning. Future investigations should also examine the applicability of the assessment tool across different musical instrument families, educational systems, and cultural settings. In addition, further studies could explore the use of digital assessment technologies, motion-tracking systems, or artificial intelligence-based observational tools to increase the precision and objectivity of readiness evaluation procedures. Expanding research to include children with developmental disorders or special educational needs may also provide important insights into the broader applicability of the instrument.

From a practical perspective, the findings of this study highlight the importance of integrating developmental readiness assessment into early music education programs. Music educators, parents, occupational therapists, and developmental specialists may use the instrument as a screening framework to determine whether children possess the foundational motor capacities necessary for successful instrumental learning. The assessment may also support individualized instructional planning by identifying specific motor domains requiring additional development before intensive training begins. Furthermore, early childhood

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education programs may benefit from incorporating movement-based and coordination-enhancing activities into preparatory music curricula in order to strengthen children's readiness for later instrumental participation. Ultimately, the use of developmentally informed assessment approaches may help promote healthier learning experiences, reduce frustration and performance-related stress, and support more positive long-term engagement with music education.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the study and participated in the research with informed consent.

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