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Original Article

Validity and Reliability of the Fundamental Motor Skills in Sports (FUS) Test for Iranian Children and Adolescents

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Abstract

Background: Confident and proficient participation in physical activities throughout life relies on mastering Fundamental Motor Skills. Given the need for more effective solutions in assessing fundamental basic skills in both children and adolescents, the present study aimed to evaluate the validity and reliability of the Fundamental Motor Skills test in sports (FUS) among Iranian children and adolescents.
Methods: This was a descriptive-correlation study with a cross-sectional design. A total number of 1500 children (750 girls and 750 boys) aged 7 to 14 with an average age of 10.63±2.54 were selected from eleven districts of Shiraz, Iran in the academic year of 2023-2024 through cluster sampling technique. For data collection, FUS test was used. The test was translated into Persian using an independent double-reverse translation method prior to its use. The content validity of the translated test was carefully verified and confirmed. Before testing each skill, the students were provided with a brief explanation about the importance and how to implement the skill. To analyze the data, Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), Pearson intraclass correlation coefficient, and One-sample t-test were employed. A significance level of α=0.05 was applied and the data were analyzed using SPSS version 23.
Results: The results of the confirmatory factor analysis indicated that all fit indices, except for Comparative Fit Index (GFI), exceed the threshold of 0.90. The results of the impact score revealed that all subscales achieved a score of 1.5 or higher, indicating satisfactory face validity. The results of the Content Validity Ratio (CVR) demonstrated that all subscales of the FUS test met or exceeded the threshold specified by the Lawshe Table (0.62). The results of the Content Validity Index (CVI) similarly revealed that all subscales of the FUS test attained a CVI score exceeding 0.79. Both inter-rater (0.96-0.97) and intra-rater (exceeding 0.96) reliability demonstrated considerable to nearly complete agreement. Detective agreements for FUS assignments ranged from 79.6% to 94.5%. A moderate positive correlation was noted between the Ball bouncing task and both the Forward roll (r=0.35; P=0.004) and Throwing & Catching tasks (r=0.39; P=0.002). Other relationships were either below average. Intraclass correlation coefficient (ICC) values, ranging between 0.93 and 0.98, affirm outstanding test-retest reliability.
Conclusions: The results of our study demonstrated that the FUS test is both feasible and effective for use in school settings. Therefore, the FUS test holds promise in facilitating the enhancement of motor proficiency by offering a standardized and systematic means of evaluating Fundamental Motor Skills in school-age children and adults.

Keywords: Reliability and validity, Face validity, Motor skills, Adolescent, Children

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1. Introduction

A primary objective of physical education is to cultivate individuals who are both healthy and possess a good level of physical literacy, enabling them to reap the benefits of engaging in physical activities. Thus, physical education programs ought to prioritize enhancing motor skills and acquiring proficiency in a range of fundamental physical activities (1).

Fundamental Motor Skills (FMS) encompass foundational abilities like jumping, striking, and kicking, which lay the groundwork for mastering more intricate and specialized skills used in both organized and informal sports and games (1). FMS are commonly grouped into locomotor skills (such as running and jumping), manipulation skills (including throwing and kicking), and stability skills (such as single-leg balance and rolling) (2). Children possessing proficient Fundamental Motor Skills can confidently engage in a diverse array of physical activities (2, 3). The advantages related to high degrees of FMS in children are numerous, the most important of which include improved cardiorespiratory fitness (4, 5), greater participation in physical activity (6, 7), and lower degrees of obesity (3, 6). Yet, it is important to recognize that the connection between Fundamental Motor Skills and physical activity remains inadequately understood. Although Stodden and colleagues suggested that motor competency may result in more physical activity among 8 to 12 years old children (8); Robinson and colleagues found that there were few studies to investigate the correlation between FMS motor competency and physical activity among adults (3). Indeed, in numerous countries, there has been a lack of assessment regarding Fundamental Motor Skills among school-age children, and many nations indicate a low prevalence of children who have mastered such skills (9, 10).

Typically, Fundamental Motor Skills are assessed through tests that focus on either outcomes or processes. The outcome-oriented method concentrates on quantitatively analyzing an individual's motor performance, while the process-oriented assessment is qualitative and pertains to the manner in which movements are executed during a task (2). Because qualitative evaluation is more intricate, it is commonly understood that effectively managing process-oriented assessment often demands greater expertise and training (11), and its evaluation becomes more accurate as the experience and mentality of the evaluator increases (12). However, certain researchers proposed that employing both methods simultaneously could offer a more comprehensive assessment of Fundamental Motor Skills (12, 13).

One of the most commonly used instruments for evaluating the progression of Fundamental Motor Skills is the Test of Gross Motor Development (TGMD), which combines elements of both process-oriented and product-oriented assessments (14). TGMD-3 has shown a high level of validity and trustworthiness (14). Other assessments have approved a comparable construction, such as the Get Skilled Get Active (GSGA) Manual in Australia, and the basic Motor Skills: A Manual study for Classroom Teachers of Victoria (15, 16). Since TGMD-3, GSGA and other FMS assessments often measure single skills (15), newer tests such as the Canadian Agility and Motor Skills Assessment (CAMSA) (17) and the Dragon Challenge (DC) (18) emerged, drawing attention on a dynamic approach and valid ecological theory perspectives.

Developing Fundamental Movement Skills (FMS) should be a top concern for public wellness, but there are several obstacles hindering their effective cultivation both within and beyond physical education settings (2, 4, 16). Baghurst and co-workers discovered that while most faculty members involved in academic programs for physical education teacher education (PETE) recognized the importance of skill mastery for PETE students, only 46 percent of programs included motor skills testing as a component, and 59 percent assessed physical fitness. They also noted the absence of a standardized or consistent approach for evaluating Fundamental Movement Skills (FMS) and particular sports abilities (19). Other research identified challenges in evaluating Fundamental Movement Skills (FMS) at schools, including the perception that hiring a separate teacher is necessary for motor skills assessment and concerns about elevated workload stress (20), lack of validity and reliability of assessment tools (21), and time limitation and lack of focus on quality movement evaluation (22).

Makaruk and colleagues introduced a novel developmental assessment called the Fundamental Motor Skills in Sport (FUS) designed to measure Fundamental Motor Skills specifically within sports contexts (23). The FUS test allows evaluators to gauge students' Fundamental Motor Skills through examination of six distinct motor (sports) tasks, encompassing hurdling, rope jumping, forward rolling, ball bouncing, throwing and catching, and kicking and stopping a ball. Makaruk and colleagues found that the FUS test is acceptable, reliable and practicable to be implemented in school settings. Thus, this assessment tool has the capacity to facilitate deliberate practice and enhance motor proficiency by offering a standardized and organized method for evaluating fundamental movement skills among Polish schoolchildren and adolescents (23). In contrast to other developmental assessments, the FUS test not only evaluates Fundamental Motor Skills but also integrates a commitment to fostering deliberate practice, with tasks tailored to align closely with the motor requirements of students. Furthermore, factors such as the prevalence of sports in a particular nation, along with the universality and relevance of specific motor skills to lifelong physical activity, should serve as the foundation for creating new fundamental movement skills. The FUS test thoroughly offers the potential for authentic, valid, and dependable assessment of these skills.

Overall, given the significance of Fundamental Movement Skills (FMS) in sports and the limited physical activity levels among children and adolescents, there is an immediate requirement to create a developmental assessment tailored to individuals' sports backgrounds, similar to the FUS test. Therefore, as the validity and reliability of this test have not been assessed in Iran, the researchers sought to examine its validity and reliability among children and adolescents in this study.

2. Methods

2.1. Participants

This was a descriptive-correlational study utilized with a cross-sectional design. Data were collected at a single point in time within a specific timeframe. The participants included 1500 people (750 boys and 750 girls) with an average age of 10.63±2.54. The participants were selected through cluster sampling technique from children and adolescents aged 7-14 years in 11 districts of Shiraz, Iran. The study excluded children and adolescents with neurological and skeletal-muscular injuries. It assessed various aspects of validity, including content, face, and construct validity, as well as multiple reliability criteria such as inter-rater, intra-rater, test-retest reliability, and stability, following the COSMIN classification of measurement properties (24). Approval was secured from the research assistant at the General Department of Education and Culture of Fars before conducting the test. The present study adhered to the Helsinki principles, and its protocol has been sanctioned by the Ethics Committee of Kharazmi University-Research Institute of Movement Sciences (IR-KHU.KRC.1000.182). All parents and children provided a written consent form before participating in the study.

2.2. Assessment Tool

The FUS test serves as a research instrument that evaluates students' Fundamental Motor Skills through six distinct motor (sport) tasks, which encompass hurdling, rope jumping, forward rolling, ball bouncing, throwing and catching, and kicking and stopping a ball. Assessing a skill relies on the accurate execution of its five components. The student's level of proficiency is determined by the test in which they achieve the highest score, and if the scores are equal in both tests, the result from the initial test is considered final. Assignment evaluation (i.e. awarding points) is completed after finishing the test. Evaluation is performed using a video player software or an application, and the recorded videos should be played at a normal speed. If there is any doubt, slow motion analysis can be performed, and must be reported in the evaluation sheet (23). An overview of FUS test tasks is presented in Figure 1.

Regarding scoring, participants will receive one

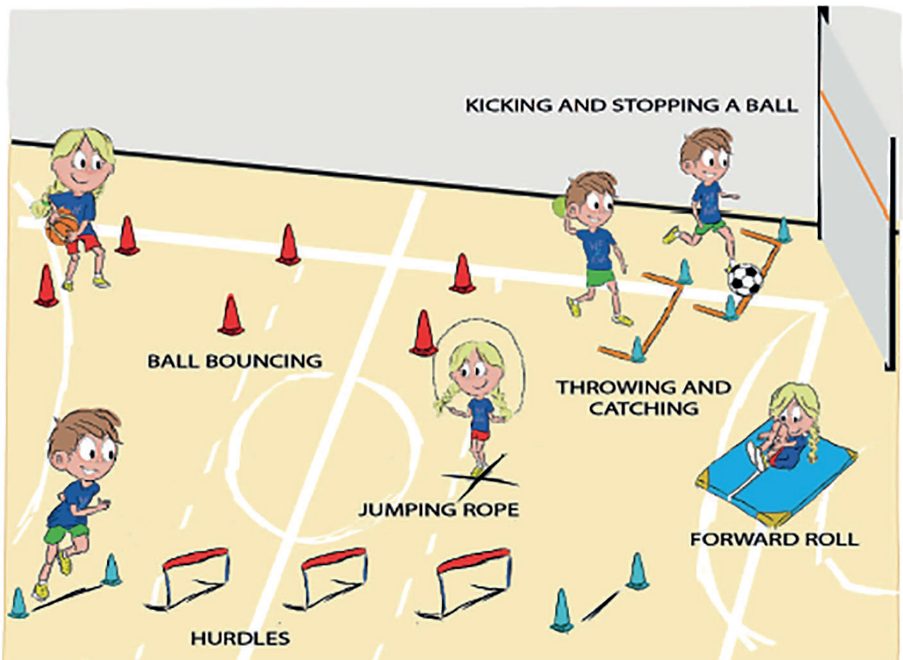

Figure 1: The figure shows an overview of all of the performed skills.

point for each criterion they fulfill and zero points if they do not meet the criterion. Points are only awarded when the criteria are clearly demonstrated. Each task will be performed twice, and the scores from the attempts with the highest scores will be used for subsequent analysis. Like previous studies (23, 24), four levels of mastery were created for each of these skills:

1. Complete proficiency is achieved when the student executes all components of the skill in accordance with the predetermined criteria (5 points). 2. Near proficiency is attained when the student completes all components according to the established criteria, with the exception of one (4 points). 3. Partial proficiency is achieved when the student completes three skill components according to the established criteria (3 points). 4. Poor proficiency is indicated when the student fails to perform more than two skill components correctly according to the established criteria (2 points or less).

Following this, the combined scores for all six FUS skills serve as the basis to assess total mastery in fundamental movement skills across four levels. Exemplary proficiency in fundamental movement skills is attained when the student demonstrates full proficiency in all evaluated skills (5 points were obtained for each skill) or achieves proficiency in all but one skill at the “Near Proficient” level (receiving 4 points for the skill). Acceptable proficiency in fundamental movement skills is attained when the pupil achieves at least the “Near Proficiency” level for each evaluated skill (scoring a minimum of 4 points for each skill) and does not reach the criteria for “Full FMS Proficiency”. Initial proficiency in fundamental movement skills is reached when a student’s scores are at the “Partial Proficiency” level (minimum of 3 points for each skill) for each assessed skill and does not meet the criteria for “Full FMS Proficiency” or “Good FMS Proficiency”. Finally, insufficient mastery in fundamental movement skills occurs when the skill performance fails to meet the standards set for the levels of “Full FMS Proficiency,” “Good FMS Proficiency,” and “Preliminary FMS Proficiency “ (23).

2.3. Tool Translation Process

The test needed to be translated into Persian before it could be used. To do so, the independent double-inverse translation method was used (17), where four bilingual translators collaborated to translate the scoring form. Two translators worked separately to translate FUS items from English to Persian, while two other translators independently translated the Persian versions back into English. The translations included skill names, performance criteria, and FUS implementation instructions. Having completed four independent translations, the translators and the researcher compared the translations with the original version. The Persian adaptation of FUS underwent review and revision, and the final translated version approved through consensus, was used.

Before using the Persian version, its content validity underwent assessment through both quantitative and qualitative methods. Five experts in the field of physical education and sports sciences were invited to provide written feedback on the validity of the tool after conducting a thorough examination. Experts were instructed to consider grammar, word choice, significance of subscales, their appropriate placement, and the completion time of the test during the qualitative assessment of content validity. After collecting expert opinions, potential changes to the tool were taken into consideration. To quantitatively assess content validity and ensure the selection of the most crucial and accurate test content, the Content Validity Ratio (CVR) was employed. Additionally, the Content Validity Index (CVI) was used to ensure optimal design of tool subscales for measuring the content effectively.

To ascertain the quantitative content validity of the FUS test, it was distributed to 15 experts in physical education and sports science. They were asked to assess each subscale of the tool and categorize it as “essential,” “not essential but beneficial,” or “not essential” for inclusion. Responses were evaluated using CVR and aligned with Lawshe Table, where values exceeding 0.59 were deemed acceptable (25).

Following the determination and computation of CVR, CVI was examined using content validity index by Waltz and Basel (26). To do so, the test was once more administered to the same 15 experts, who were then instructed to evaluate each subscale based on three criteria—relevance, simplicity, and clarity—using a four-point Likert scale (1: irrelevant, 2: partially relevant, 3: relevant, and 4: highly relevant). To achieve this, the CVI score was determined by summing up favorable ratings for each item that received the 3rd and 4th ranks (indicating the highest level of agreement) across all participants. In this study, the content validity index was computed using the CVI formula. Subscales were considered acceptable when their CVI score exceeded 0.79 (27). The CVR results showed that all subscales of the FUS test met or exceeded the threshold value specified in the Lawshe Table (0.62). These findings suggested that the tool included essential and significant subscales. The CVI findings showed that every subscale of the FUS test had a CVI score above 0.79, indicating their suitability. After assessing the content validity index across all scoring criteria, the FUS test was employed to assess the fundamental motor skills in 7 to 14 year-old children and adolescents.

2.4. Design

Prior to assessing each skill, a trained model delivered verbal instructions and presented an evident verification of the whole task. Participants received standard instructions aimed at directing external attention to enhance movement automaticity (28). For instance, the forward rolling instruction in the FUS entails fostering the use of external attention by directing the contributor to execute a forward part along a designated line. One practice for each task should be done for preparing each participant, and two formal tests were then done. During and after each attempt, there was no verbal feedback provided regarding performance. All steps were recorded by means of either a video camera or a smartphone. The method of recording, along with the distance and angles of the camera for each task, were as follows: In the hurdling task, the camera or supervisor was placed in a position vertical to the running line and at a distance of 6 meters from the second hurdle. In the jumping rope task, the camera or the observer was facing the student doing the task, at a distance of 4 meters from the center of X on the ground. For the forward rolling task, the camera or observer was situated at a 45-degree angle to the left or right of the student executing the task. The camera was placed at a distance of 3 meters from the closest corner of the mattress. For the ball bouncing (dribbling) task, the camera or observer was positioned perpendicular to the running line, 15 meters from the starting line and 5 meters from the side of the line marked by the cones near the camera. During the 20-meter test, the camera should track the student's movement continuously. For the throwing and catching task, the camera or observer should be positioned at a 45-degree angle either to the left or right side of the student performing the task. The throw should be filmed or observed from a distance of 5 meters from the center of the baseline indicated on the ground. For the kicking and stopping a ball task, the camera or observer should be positioned behind the student performing the task, angled 45 degrees to the left or right, and situated 5 meters away from the midpoint of a marked line on the ground (23).

2.5. Data Analysis

Descriptive statistics, including mean and standard deviation, were employed. The Persian version of FUS test was evaluated for its content validity using the CVI questionnaire before being put into practice. Confirmatory factor analysis (CFA) was employed to evaluate the construct validity of the FUS test, while face validity was assessed using the impact score for each item. Additionally, both inter-rater and intra-rater reliability were assessed independently by the raters, with a two-week interval, using the intraclass correlation coefficient (ICC). The interpretation of Cohen's kappa coefficients followed the categorization suggested by Landis and Koch, and the amount of detected agreements was computed (29). Furthermore, confidence intervals at the 95% level were computed for each of the reliability metrics. Pearson's correlation was employed to examine the association between variables, while the stability of the FUS test was evaluated through ICC analysis. The Limits of agreement (LOA) were established as the average disparity±1.96 times the standard deviation of the disparity. A one-sample t-test was used to evaluate systematic bias, whereas Pearson's correlation was computed to assess proportional bias. Statistical calculations were conducted with a significance level set at $\alpha=0.05$. The data were analyzed using SPSS version 23.

3. Results

A total number of 750 girls and 750 boys within the age group of 7 to 14 years from different areas of Shiraz, Iran participated in this study. The inclusion criteria were: lack of movement and cognitive problems, and participation in all evaluation stages. Those absent in the evaluation sessions, and unwilling to continue were excluded from the study. Table 1 shows demographic characteristics of the participants, including mean age and standard

Table 1: Demographic information of participants based on age groups

Age	Mean and SD Age	Boy		Girl		Dominant Hand (Frequency)		Dominant Leg (Frequency)	
		Frequency	Relative Frequency	Frequency	Relative Frequency	Right	Left	Right	Left
7	7.08±0.02	100	13.33	100	13.33	185	15	187	13
8	8.05±0.04	100	13.33	120	16	195	25	198	22
9	9.07±0.03	100	13.33	100	13.33	180	20	184	16
10	10.05±0.02	80	10.66	120	16	180	20	188	12
11	11.07±0.01	100	13.33	80	10.66	165	15	167	13
12	12.05±0.04	70	9.33	100	13.33	157	13	159	11
13	13.06±0.02	100	13.33	60	8	149	11	154	8
14	14.03±0.01	100	13.33	70	9.33	162	8	165	5
Total	10.55±2.34	750	50	750	50	1373	127	1400	100

SD: Standard Deviation

Table 2: Mean±SD score of mastery of individual FMS in the FUS test tasks among students

Task (sub-test)	Score (Mean±SD)
Hurdles	2.45±1.67
Jumping rope	2.39±1.66
Forward roll	3.23±1.65
Ball bouncing	3.25±1.40
Throwing and catching	2.41±1.19
Kicking and stopping a ball	3.37±1.10

SD: Standard Deviation, FMS: Fundamental Motor Skills, FUS: Fundamental Motor Skills in Sports

deviation, frequency and percentage distribution, and the prevalence of hand and foot dominance across age categories.

The lowest score was related to Jumping Rope and Throwing and Catching tasks; while the highest score was related to the task of Kicking and Stopping a ball (Table 2). Each FMS task yielded an average score of ≤4. Consequently, a significant majority of students, comprising 55%, demonstrated a basic level of proficiency in FMS. A quarter of children exhibited inadequate FMS skills, while 7% demonstrated proficient FMS abilities.

The construct validity of the FUS test was assessed through both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). Prior to executing EFA, the Kaiser-Mayer-Olkin (KMO) measure and Bartlett's Test of Sphericity were administered. The KMO test yielded a coefficient of 0.83, showing that the sample size is acceptable for factor analysis. Moreover, Bartlett's test of sphericity achieved significance at the 0.01 level, suggesting that the factor analysis approach is appropriate for discerning the structure factor of the model. To ascertain the factors within the FUS test, Very Simple Structure (VSS), Parallel Analysis Scree Plots, eigenvalues, and variance explained by each factor were employed. In summary, the proposal of a three-factor model aligned entirely with the original structure of the test. The factor analysis of the FUS test used the maximum likelihood along with Promax rotation. The obtained fit indices (TLI: 0.89, RMSEA: 0.06, RMSR: 0.03) indicated the appropriate fit of the data with the model. Analysis of the results revealed that the first two factors possess eigenvalues surpassing one, with 27%, 22% and 18% of the variance explained by the first, the second, and the third factor, respectively. Altogether, these factors explain 67% of the total variance. After rotating the factors, the results of analysis indicated that all item factor loadings exceeded 0.60, demonstrating highly satisfactory values. Following the data examination using the EFA method, the resulting structure underwent CFA analysis. Absolute fit indices (SRMR=0.06<0.08, AGFI: O.90>0.91, GFI=0.93>0.90), comparative (CFI=0.94>0.90, NFI=0.91>0.90, NNFI=0.94>0.90) and adjusted fit (χ^2/df=2.53< 3, RMSEA=0.06<0.08) obtained in total shows the appropriate fit of the model with the data and the factorial structure of the FUS test is confirmed.

Both quantitative and qualitative approaches were employed to assess face validity. Qualitative face validity was assessed by a specialized panel of 10 individuals, including experts in physical education and sports science. They evaluated aspects such as level of difficulty, inadequacy, ambiguity of phrases, and semantic sufficiency, incorporating their feedback to make minor adjustments to the test.

For quantitative measure face validity, the impact score for each subscale was computed. Initially, a 5-point Likert scale was used for rating all items of the instrument: “completely agree” (5), “agree” (4), “neutral” (3), “disagree” (2), and “completely disagree” (1). Then, the questionnaire was administered to a group of 20 children ranging from 7 to 14 years old to assess its validity. Face validity of the test related to the target group was assessed using the impact score for each item:

(Impact Score=Frequency (%)×Importance)

The results of the impact score showed that all items achieved a score of 1.5 or higher, thus meeting the acceptable threshold (30).

Given the inter-rater reliability, Cohen’s kappa coefficients surpassed 0.75, suggesting substantial to near-perfect consensus among raters. The percentage of agreement for all FUS skills ranged from 81.3% to 89.7% (Table 3). Strong consensus among raters was verified with elevated values (0.96-0.97), demonstrating outstanding inter-rater reliability across all tasks employed in the FUS test. Substantial inter-rater consensus was established with values ranging from 0.96 to 0.97, signaling exceptional inter-rater reliability across all tasks administered in the FUS test.

The measures of intra-rater reliability demonstrated almost perfect agreement in the scores provided by raters at both time intervals. On the whole, the reliability for the second assessment

Table 3: Inter-rater reliability for skills assessed in FUS test tasks

Task	Percentage of observed agreements (%)	Cohen’s kappa (95% CI)	Agreement	ICC (95% CI)	Strength of ICC
Hurdle	84.6	0.79 (0.76-0.82)	Substantial	0.97 (0.96–0.97)	Excellent
Jumping rope	87.4	0.84 (0.80-0.88)	Almost perfect	0.98 (0.98–0.99)	Excellent
Forward roll	86.8	0.82 (0.79-0.85)	Almost perfect	0.98 (0.98–0.99)	Excellent
Ball bouncing	81.3	0.76 (0.73-0.79)	Substantial	0.97 (0.96–0.97)	Excellent
Throwing and Catching	89.7	0.86 (0.84-0.89)	Almost perfect	0.98 (0.98–0.99)	Excellent
Kicking and stopping a ball	84.7	0.80 (0.77-0.83)	Substantial	0.97 (0.96–0.97)	Excellent

FUS: Fundamental Motor Skills in Sports, ICC: Intraclass Correlation Coefficient

Table 4: Intra-rater reliability for skills assessed in FUS test tasks

Task	Percentage of observed agreements (%)	Cohen’s kappa (95% CI)	Agreement	ICC (95% CI)	Strength of ICC
Hurdle			Almost perfect		Excellent
Rater 1	92.3	0.90 (0.85-0.95)		0.99(0.98-0.99)	
Rater 2	89.4	0.87 (0.80-0.93)		0.98(0.98-0.99)	
Jumping rope			Almost perfect		Excellent
Rater 1	86.4	0.81(0.73-0.89)		0.98 (0.97–0.99)	
Rater 2	88.7	0.86 (0.79-0.92)		0.98 (0.97-0.99)	
Forward roll			Almost perfect		Excellent
Rater 1	86.8	0.81(0.74- 0.89)		0.99 (0.98–0.99)	
Rater 2	89.2	0.87 (0.80-0.92)		0.99 (0.980.99)	
Ball bouncing			Substantial		Excellent
Rater 1	85.3	0.80 (0.72-88)		0.98 (0.98-0.99)	
Rater 2	79.6	0.74 (0.65-0.83)		0.97 (0.96–0.98)	
Throwing and Catching			Almost perfect		Excellent
Rater 1	94.5	0.91 (0.85-0.97)		0.99 (0.98–0.99)	
Rater 2	90.3	0.88 (0.81-0.94)		0.99 (0.980.99)	
Kicking and stopping a ball			Almost perfect Substantial		Excellent
Rater 1	85.7	0.82 (0.74-0.89)		0.97 (0.96–0.98)	
Rater 2	79.9	0.77 (0.68- 0.86)		0.96 (0.95-0.97)	

FUS: Fundamental Motor Skills in Sports, ICC: Intraclass Correlation Coefficient of the skill decreased to some degree when using Cohen's kappa measures by the rater, particularly noticeable in the Ball Bouncing task (Table 4). However, all Cohen's Kappa coefficients surpassed 0.70, with agreement percentages ranging from 85.3% to 94.5% and from 79.6% to 90.3% for each rater at both time points, respectively. Exceptional reliability was evident across all tasks of the FUS test, as demonstrated high ICC values (exceeding 0.96) and the 95% confidence interval viewed for both raters.

In order to evaluate the internal consistency of the FUS test, the Intra-Class Correlation Coefficient was applied, which involved estimating the variance using the analysis of variance technique. This approach offers a more precise assessment of error variance compared with Pearson's correlation. The internal consistency of the Fuss test, comprising six subscales, was 0.85, indicating an optimal level of internal consistency for the test.

Outstanding correlations were identified among the outcomes of personal tasks within the FUS test. A moderate and positive association was noted between the Ball Bouncing task and both the Advanced Roll task (r=0.35; P=0.004) and the Throwing & Catching task (r=0.39; P=0.002). Other correlations either fell below the average level (r<0.3) or were not statistically significant.

Table 5 shows the criteria for test-retest reliability of each personal task in the FUS test. No notable systematic bias was detected, as the effective difference between both scores approached zero (ranging from -0.05 to -0.08). Approximately 83% to 98% of the variances fell within the 1.96 standard deviation range of agreement, suggesting a lower degree of variability for the forward roll task and slightly higher variability for the Ball Bouncing task.

No notable correlation was found between either the average or the difference of both scores across all tasks (ranging from 0.03 to 0.37; p-values between 0.42 and 0.97), indicating the lack of proportional bias in the dataset. Furthermore, the computed ICC values for all tasks were notably elevated, varying from 0.93 to 0.98, suggesting robust test-retest reliability.

4. Discussion

The present study aimed to examine the psychometric characteristics of FUS test in sports among Iranian children and adolescents. The results of content validity showed that all the skill items had an agreement coefficient of 0.85 to 1, and the content validity of the test was assigned. The results of CFA and EFA indicated acceptable construct validity. After the test was completed by the target group, the face validity using the impact score formula showed that all subscales have a score ≥ than 1.5. The results also showed inter-rater (0.97-0.96) and intra-rater (more than 0.96) reliability coefficients with satisfactory values in the subscales of the FUS test. A moderate positive correlation was observed between the Ball Bouncing task and both the Forward Roll (r=0.35; P=0.004) and Throwing & Catching (r=0.39; P=0.002). Other relationships were below average. ICC values ranging between 0.93 and 0.98 confirm excellent test-retest reliability. The findings of this study were in line with the results reported by Makaruk and colleagues (23).

Presently, children encounter reduced chances for developing fundamental movement skills as a result of sedentary behaviors (30). While physical education classes seem suitable for enhancing FMS skills, instructors in this field have deviated from the broader public health objectives aimed at fostering physical competence, encouraging active lifestyles, and promoting overall health among young people (6, 31). As a result, many young school students are less proficient in FMS (32, 33), or their FMS loss are not diagnosed accurately (31). In Iran, a lack of

Table 5: Test-retest for skills assessed in the FUS test

Task	Mean difference (SD)	Limits of agreement	% within limits of agreement	ICC (95% CI)	Strength of ICC
Hurdle	-0.05 (0.54)	-1.10-0.96	87.6%	0.98 (0.96-0.99)	Excellent
Jumping rope	-0.06 (0.63)	-1.23-1.12	94.5%	0.95 (0.91–0.97)	Excellent
Forward roll	-0.05 (0.46)	-0.74-0.83	83.4%	0.93 (0.93–0.96)	Excellent
Ball bouncing	-0.08 (0.65)	-1.29-1.14	98.3%	0.98 (0.95-0.99)	Excellent
Throwing and Catching	-0.08 (0.61)	1.10-0.99	89.7%	0.97 (0.94–0.99)	Excellent
Kicking and stopping a ball	-0.04 (0.47)	-0.93-95	84.2%	0.95 (0.90–0.98)	Excellent

FUS: Fundamental Motor Skills in Sports, ICC: Intraclass Correlation Coefficient organized research and established assessment tools were observed for evaluating FMS in school-age adults, hindering standardization and consistency in assessments. The absence of consistency in this regard presents a difficulty in comparing data across studies and formulating effective interventions aimed at improving FMS skills.

The FUS test assesses students' fundamental movement skills through six distinct motor tasks associated with sports. The first FUS task involves hurdling, demanding a specific degree of coordination, rhythm, balance, and agility, all of which are crucial in numerous sports. According to O'Brien and co-workers, rhythm plays a critical role in motor learning and performance, and activities emphasizing a consistent rhythm can serve as effective preventive measures against detrimental cognitive and emotional states by regulating the movement flow (32). Additionally, rhythm contributes to improved running performance from a physiological standpoint (34). The second FUS task involves mastering the skill of jumping rope, typically involving coordinated consecutive two-way vertical jumps while swinging the rope around the body (35). Research indicated that proficiency in jumping rope offers valuable insights into assessing neuromuscular control during landing, which is crucial in sports like volleyball, basketball, handball, and gymnastics for understanding how to minimize injuries from ground reaction forces (35). From a neural standpoint, jumping rope stimulates neural plasticity by altering the current networks of motor neurons (36). The third FUS task involves executing a Forward Roll, where one rolls backward in a tucked stance, initiating and concluding in a crouched position. This maneuver is commonly employed in gymnastics as well as martial arts like judo and wrestling. Furthermore, in various sports and physical endeavors that entail instances of falling or balance disruption, mastering the skill of controlling ground impacts and sustaining dynamic posture during rolling could potentially contribute to preventing injuries. Moreover, performing forward rolls activates the vestibular system, which plays a crucial role in preserving balance, processing gravitational force feedback, regulating muscle tone, ensuring a stable visual field during head movements, and coordinating motor planning (37). Another FUS item focuses on object manipulation abilities. Proficiency in ball bouncing or dribbling is crucial for achievement in numerous sports, particularly basketball and handball. Additionally, in sports like rugby, American football, tennis, and volleyball, the capacity to handle objects while engaged in locomotion is paramount. As a result, mastering dynamic ball bouncing relies heavily on the coordination of eye movements, dynamic balance, rhythmic timing, and the synchronization of various movements (38). Executing this intricate skill can offer insights into an individual's ability to coordinate movements while simultaneously tracking visually and engaging in physical manipulation of the ball while performing a motor task (38).

The fifth task in the FUS test includes throwing and catching a ball, a fundamental skill applicable in numerous sports, recreational activities, and physical pursuits. The over-the-shoulder throwing technique is used in sports like baseball, cricket, handball, American football, javelin throw, and distance ball throwing. Studies indicated that the motor patterns involved in throwing and striking skills in sports like handball, volleyball spiking, and tennis serving exhibit similarities (32, 38, 39). The throwing technique employed in the FUS test enables the evaluator to assess the coordination of movements during both the approach and throwing phases, along with the range of motion in arm movement and the accuracy of the throw (40). The final task in the FUS test includes kicking and halting a ball, skills utilized in various popular sports like soccer, American football, and rugby. Comparable to throwing and catching, situations requiring extensive leg involvement provide opportunities to evaluate whole-body coordination, motor skills, and visuospatial abilities (40). Kicking and stopping the ball also offer a chance to assess the relationship between the visual system and the lower limbs.

The results indicated that the FUS test reflects distinct skills, with each task representing a separate part of the general fundamental movement skill set. Further examination demonstrated that the skills assessed in the FUS test exhibit strong content validity. A notable aspect of the FUS test is its focus on practical skills applicable in sports, highlighting that these abilities are not only fundamental but also directly relevant to different sporting activities. The potential of the FUS test is evident in its applicability for assessing fundamental movement skills across a broad age range (7 to 14 years), and its accuracy in evaluating skill components and performance criteria through a process-oriented method. Other desired aspects underscored include the scoring system, suitability for school settings, and the potential it holds to improve teaching and learning methodologies. FUS adds a distinct value to the current literature on fundamental movement skills by introducing novel assessments for particular sports abilities that were not previously documented in existing fundamental movement skill assessment systems (41). Similarly, both inter-rater and intra-rater reliability assessments of the FUS tasks revealed positive outcomes, affirming the reliability of the fundamental movement skill assessment. Furthermore, the excellent test-retest reliability of skill scores suggested minimal to no significant learning effects. Hence, the evaluation is deemed suitable for tracking performance longitudinally. The present study offers encouraging evidence that the FUS test serves as a dependable assessment instrument, with potential value in tracking the progression of fundamental movement skills in school-age children and adults. It is noteworthy to acknowledge that in this study, the evaluators were researchers specialized in sports, which may limit the applicability of the findings to the target audience of physical education (PE) teachers. PE teachers may be in different levels of experience and knowledge in evaluating FMS (13, 32) in comparison with researchers and sports coaches. Therefore, it is suggested that future work validates the reliability of the fundamental movement skill assessment, specifically among physical education (PE) teachers. Regarding practicality, the FUS test was developed as a tool for assessing fundamental movement skills for both physical education (PE) researchers and teachers. The results of this study offered initial support for the validity and reliability of the FUS test as a tool for evaluating fundamental movement skills. Moreover, our results showed the practicality of managing the test within a school setting during physical education classes.

The primary advantage of the FUS test lies in its evaluation of fundamental movement skills (FMS), crucial for a broad spectrum of physical activities and sports, rendering it a thorough assessment of motor function. Administering and scoring the FUS test is to somehow simple, demanding minimal equipment and training. Furthermore, it is capable of recognizing early-stage deficits in motor skill development and facilitates timely intervention and assistance to enhance optimal motor performance. Employing standardized tasks in the FUS test enables contrasting of outcomes among various populations and environments. Ultimately, the FUS test holds promise as a valuable tool for encouraging physical activity and fostering a healthy lifestyle among school children. By pinpointing areas of weakness and offering tailored interventions, it can effectively enhance the progression of motor skill development.

4.1. Limitations

Relying solely on performance is a drawback of the FUS test, which necessitates an exact level of physical ability and comprehension of the assessed tasks. In whole, children with obvious physical or cognitive impairments may face problems to accurately complete the test, potentially resulting in incomplete documentation of their motor skill development. Additionally, the sample size of this study was small and restricted to a specific geographic region, regardless of gender, age, or socio-cultural factors. Therefore, further research with larger and more diverse samples, ranked by gender and age, is essential to validate the applicability of these findings to broader populations. The study findings and limitations underscored the necessity for further research aimed at refining the assessment of fundamental movement skills in children and adolescents.

5. Conclusions

The significance of FMS in encouraging the development of self-assurance, skilled, and enjoyable engagement in physical activity across the lifespan cannot be overstated. This study examined the validity and reliability of the FUS test, tailored specifically for evaluating athletic skill-based tasks. The FUS test underwent validation among a varied age range of Iranian students, demonstrating outstanding content validity and reliability across inter-rater, intra-rater, and test-retest evaluations. Furthermore, its practicality within school environments suggests its potential as a valuable tool for standard FMS assessment. The FUS test offers a pragmatic resolution to the pressing requirement of enhancing FMS competence among students. Finally, some practical suggestions are provided below:

1. The FUS test offers an appropriate method for assessing and training the motor skills in children and adolescents, enabling coaches to use it for both assessment and purposeful practice.

2. Unlike other developmental assessments, this test does not necessitate sophisticated equipment, making it accessible for sports coaches to evaluate physical education sessions.

3. Given the strong correlation between the subscales of this test and sports-related abilities, it is recommended for use in identifying talented individuals during selection processes.

Ethical Approval

The present study was in accordance with the principles of Helsinki and its protocol was approved by the ethic committee of Kharazmi University-Research Institute of Movement Sciences with the code of IR-KHU.KRC.1000.182. Also, written informed consent was obtained from the parents of children.

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Authors' Contribution

Mohammad Hossein Zamani: Significant contribution to research design, data analysis and interpretation, and drafting of the paper. Ayoub Hashemi: Significant contribution to research design, data analysis and interpretation, and drafting of the paper. Elahe Siavashi: Participation in the design of the work, drafting the work and reviewing it critically for important intellectual content. Razieh Khanmohammadi: Participation in the design of the work, drafting the work and reviewing it critically for important intellectual content. Hamideh Saeidi: Analysis and interpretation of data, and drafting the paper. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, such as the questions related to the accuracy or integrity of any part of the work.

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