

Standardizing physical fitness evaluation for male Pencak Silat athletes aged 15–16 in Ha Tinh Province, Vietnam

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Abstract

This study aimed to establish standardized criteria for assessing physical fitness levels in male Pencak Silat athletes aged 15–16 in Ha Tinh Province, Vietnam, to improve training effectiveness and support athlete self-assessment. Pencak Silat, a traditional martial art, requires high levels of speed, explosive power, endurance, and motor coordination. Current fitness evaluation practices in Ha Tinh are inconsistent, lack age-specific standards, and are not based on validated testing protocols. The research objectives were to select appropriate physical fitness tests and construct age-specific evaluation standards. The study employed literature analysis, pedagogical observation, structured interviews with 40 experts (coaches, referees, and sports administrators), pedagogical testing of 20 male athletes, and mathematical–statistical methods, including descriptive statistics, correlation analysis, and t-tests. Expert consultation identified five key physical fitness components: speed, explosive power, strength endurance, general endurance, and motor coordination. From an initial pool of 28 indicators, 16 were selected through expert consensus ($\geq 70\%$ agreement) and subsequently refined to 10 tests that demonstrated high reliability ($r \geq 0.80$), strong criterion validity ($r \geq 0.71$), and statistical significance ($p < 0.05$). The final test battery comprised six general fitness tests (15 s rope skipping, 30 m flying-start sprint, 30 s push-ups, standing long jump, vertical jump, and 3000 m run) and four sport-specific tests (20 s double-target punching, 15 s continuous crescent kicks, 30 s elastic-band resisted kicks, and 30 s rear sweeps). Age-specific classification standards (excellent, good, average, poor, and very poor) and a 10-point scoring system for each test (maximum total score: 100 points) were established using the sigma method (e.g., excellent $> M + 1.5$ SD). Validation through forward and reverse testing on a subsample of athletes demonstrated strong predictive accuracy, with higher composite scores corresponding to medal-winning performance at national youth championships. The proposed evaluation standards provide a practical and scientifically grounded tool for coaches to monitor physical fitness and adjust training programs effectively. Future research should extend these standards to other age groups and female athletes, as well as integrate the system into provincial and national Pencak Silat development programs.

Keywords: Pencak Silat; sport-specific testing; physical fitness assessment; age-specific norms; adolescent athletes

Introduction

Pencak Silat is a traditional martial art originating from the Malay Archipelago, encompassing present-day Indonesia, Malaysia, Brunei, Singapore, southern Thailand, the southern Philippines, and southern Vietnam. It is a comprehensive full-body combat system that integrates striking, grappling, throwing, joint manipulation, and weapon-based techniques. Beyond physical combat skills, Pencak Silat emphasizes mental discipline, spiritual development, self-defense, artistic expression, and the preservation of cultural heritage. The term “*pencak*” refers to the technical and choreographed components of the art, often performed rhythmically with music, whereas “*silat*” denotes its applied combat and self-protection aspects.

Pencak Silat was introduced to Vietnam in 1989 following the 15th Southeast Asian Games held in Kuala Lumpur, Malaysia. Since then, it has gained rapid popularity, particularly among young athletes, due to its compatibility with Vietnamese physical characteristics—such as agility, adaptability, and tactical intelligence—and its demonstrated success in international competition. Vietnamese Pencak Silat athletes have achieved numerous world championship titles, SEA Games medals, and Asian-level honors, establishing the sport as a significant contributor to Vietnam’s achievements in combat sports. Pencak Silat is officially recognized by the International Pencak Silat Federation (PERSILAT) and has been included in the “Road to the Olympics” initiative since 2018, reflecting its increasing global prominence.

At the high-performance level, particularly in competitive formats such as *Tanding* (combat), success in Pencak Silat requires the integrated development of multiple physical capacities, including speed, explosive power (strength–speed), strength endurance, general endurance, flexibility, motor coordination, and tactical awareness. These attributes enable athletes to execute rapid offensive actions, effective defensive maneuvers,

and sustained performance across multiple rounds of competition. For adolescent athletes aged 15–16 years, this stage represents a critical period of biological and functional development, during which appropriately structured training can optimize long-term athletic potential while reducing the risk of injury (Lloyd et al., 2015; Malina et al., 2015).

Effective training design and talent identification depend on objective, reliable, and valid methods for assessing physical fitness. In many regions, including Vietnam, current evaluation practices remain fragmented and inconsistent, often lacking standardization across age groups, genders, and training phases. Furthermore, the limited application of scientifically validated fitness tests constrains coaches' ability to individualize training programs, monitor athlete development, and accurately predict competitive performance.

In Ha Tinh Province, where Pencak Silat has an expanding youth athlete base—approximately 35–50 athletes aged 11–17 currently training at the provincial sports center—there is an urgent need for scientifically grounded physical fitness evaluation standards. A systematic review of multi-year training programs and direct pedagogical observation of fitness assessment sessions conducted at provincial training centers revealed several critical limitations:

Lack of standardized test battery: The absence of a systematic and consistent evaluation framework across general and sport-specific fitness domains;

No age-specific differentiation: A lack of differentiation according to gender, age subgroup, training phase, or performance level; **Absence of normative reference values:** No standardized scoring systems or normative reference values are currently available; **Limited psychometric validation:** Minimal use of tests with established reliability and criterion validity. These findings reflect broader patterns reported in recent studies on youth Pencak Silat programs in Vietnam and Indonesia, where physical fitness assessment protocols remain largely non-standardized and insufficiently validated (Nurhidayah et al., 2024; Nugroho et al., 2021; Pratama, 2022). Without a valid and reliable assessment system, coaches cannot objectively identify talent, monitor athlete development, or tailor training interventions to individual needs.

Several factors justify the necessity of this research:

First, the adolescent period (aged 15–16) represents a critical developmental window characterized by rapid biological maturation, including increases in muscle mass, neuromuscular efficiency, and aerobic capacity (Malina et al., 2015). During this phase, appropriately structured training can maximize long-term athletic potential, while inadequate or misdirected training may lead to underperformance or increased injury risk (Lloyd & Oliver, 2012). Age-specific fitness standards are therefore essential for guiding training prescription during this sensitive period.

Second, Pencak Silat imposes unique physical demands that distinguish it from other combat sports. The *Tanding* discipline requires repeated explosive actions—such as kicks, punches, and sweeps—interspersed with periods of tactical engagement. These demands necessitate a distinct profile of physical fitness, emphasizing explosive power, speed-endurance, and sport-specific coordination over general maximal strength or static flexibility (Suwirman et al., 2021; Chaabène et al., 2017). Generic fitness tests developed for other sports may not adequately capture these sport-specific requirements.

Third, the lack of standardized assessment tools in Ha Tinh Province limits the ability of coaches to implement evidence-based training programs. Without objective data on athletes' physical fitness profiles, training decisions are often based on subjective observation or anecdotal experience, compromising both training efficiency and competitive outcomes.

Fourth, the growing international prominence of Pencak Silat—including its recognition by the International Pencak Silat Federation (PERSILAT) and its inclusion in the “Road to the Olympics” initiative—demands that national and provincial training systems adopt scientifically validated methods to remain competitive on the global stage. Internationally, research on physical fitness assessment in combat sports has advanced considerably in recent decades. Studies in wrestling, judo, taekwondo, and boxing have established comprehensive test batteries with established psychometric properties (Chaabène et al., 2017; Franchini et al., 2011). These test batteries typically include measures of speed, explosive power, muscular endurance, and aerobic capacity, along with sport-specific technical tests.

However, research specifically focused on Pencak Silat remains limited. Existing studies have primarily examined physical fitness profiles of elite adult athletes or have used generic test batteries without sport-specific validation (Nugroho et al., 2021; Nurhidayah et al., 2024). Few studies have addressed the unique demands of adolescent Pencak Silat athletes, and even fewer have developed age-specific normative standards for this population.

In Vietnam, previous research on Pencak Silat has focused primarily on technical development, tactical analysis, and competition rules (Nguyen, 1999; Tran et al., 2004). Physical fitness assessment has received comparatively little attention, with most training centers relying on ad hoc testing protocols that vary substantially between provinces and even between coaches within the same institution.

Given the limitations identified above, a clear research gap exists: there are currently no scientifically validated, age-specific physical fitness evaluation standards for male Pencak Silat athletes aged 15–16 in Ha Tinh Province, Vietnam.

The present study aims to address this gap by selecting reliable and informative physical fitness tests suitable for male Pencak Silat athletes aged 15–16 years; validating the selected tests through test–retest reliability and criterion validity analyses; and constructing age-specific evaluation standards, normative classifications, and scoring systems to support athlete self-assessment and evidence-based decision-making by coaches. To achieve these objectives, the study employed a rigorous mixed-methods research design combining qualitative and quantitative approaches. The research process was structured as follows:

Phase 1: Test Identification and Selection: A systematic literature review was conducted to identify relevant physical fitness components and testing methods in Pencak Silat and related combat sports; A two-round Delphi-inspired expert consultation was conducted with 40 experts (coaches, referees, and sports administrators) to identify key physical fitness components and select appropriate tests; Tests achieving $\geq 70\%$ consensus in both rounds were shortlisted for psychometric evaluation.

Phase 2: Psychometric Validation: Test–retest reliability was assessed using Pearson’s correlation coefficient ($r \geq 0.80$ threshold) on 20 male athletes; Criterion validity (informativeness) was evaluated using Spearman’s rank-order correlation between test results and competition rankings; Only tests meeting both reliability and validity criteria were retained for the final battery.

Phase 3: Normative Standard Development: Age-specific classification standards (excellent, good, average, poor, very poor) were constructed using the sigma method (mean $\pm$ standard deviation); Raw test scores were converted to a 10-point scoring system using z-score transformation, enabling integrated composite evaluation.

Phase 4: System Validation: Forward and reverse validation was conducted on a subsample of athletes to verify predictive accuracy; Composite scores were compared with competition outcomes at national youth championships; The findings of this study are expected to provide several practical benefits:

For coaches: An objective, evidence-based tool for monitoring athlete development and adjusting training programs; Clear normative references for talent identification and selection; Standardized protocols for longitudinal performance tracking.

For athletes: Transparent self-assessment opportunities through the point-based scoring system; Clear understanding of strengths and weaknesses across fitness domains.

For the provincial and national sports system: A scalable and replicable model for physical fitness assessment in youth Pencak Silat; Alignment with international standards, supporting Vietnam’s competitiveness in regional and global competitions.

The remainder of this paper is organized as follows: The Methods section describes the research design, participants, procedures, and statistical analyses employed. The Results section presents the findings of the expert consensus process, test selection, reliability and validity analyses, and the development of normative standards and scoring systems. The Discussion section interprets these findings in the context of existing literature, highlights practical implications, and addresses limitations. The Conclusion summarizes the study’s contributions and provides recommendations for implementation and future research.

Materials and Methods

Research Design

This study employed a mixed-methods research design combining qualitative and quantitative approaches to develop and validate physical fitness evaluation standards for male Pencak Silat athletes aged 15–16 years in Ha Tinh Province, Vietnam. The research process included literature review, expert consultation, pedagogical testing, and statistical analysis to ensure the reliability, validity, and practical applicability of the proposed evaluation system.

Participants

The study sample consisted of 20 male Pencak Silat athletes aged 15–16 years who were actively training at the Ha Tinh Provincial Sports Training Center. The sample included 10 athletes aged 15 years and 10 athletes aged 16 years, all of whom had at least two years of systematic training experience and were free from injury at the time of data collection.

In addition, 40 experts participated in the expert consultation process, including 5 Pencak Silat specialists, 16 coaches, 9 referees, and 10 sports administrators. These experts possessed extensive professional experience in Pencak Silat training, competition, and management and were selected based on their qualifications and practical involvement in the sport.

All participants provided informed consent prior to participation, and the study procedures were conducted in accordance with ethical principles for research involving human subjects.

Procedures

Literature Review and Document Analysis

A systematic review of domestic and international literature was conducted to identify relevant physical fitness components, testing methods, and evaluation standards in Pencak Silat and related combat sports. Official training curricula, competition regulations, and previously published research were analyzed to establish a theoretical and practical foundation for test selection.

Expert Consultation

A two-round structured expert consultation, following a Delphi-inspired approach, was conducted to identify key physical fitness components and select appropriate physical fitness tests for male Pencak Silat athletes aged 15–16 years. A standardized questionnaire was administered in both rounds, using a 5-point Likert scale (1 = not important; 5 = very important).

Indicators achieving at least 70% of the maximum possible score in both rounds were retained for subsequent reliability and validity testing. Consensus stability across rounds was assessed using descriptive statistics and correlation analysis.

Selection of Physical Fitness Tests and Pedagogical Testing

Based on the literature review and expert consensus, an initial pool of 28 physical fitness indicators was identified, comprising general physical fitness and sport-specific fitness tests. Sixteen tests meeting the expert consensus criteria were selected and administered to the athlete sample.

Pedagogical testing was conducted under standardized conditions, including identical testing order, equipment, warm-up procedures, time of day, and verbal instructions. To assess test–retest reliability, all selected tests were administered twice with a 7-day interval between sessions to minimize learning effects while ensuring adequate recovery.

Statistical Analysis

Data were analyzed using standard mathematical–statistical methods commonly applied in sports science research. Descriptive statistics, including means and standard deviations, were calculated for all variables. Test–retest reliability was evaluated using Pearson’s product–moment correlation coefficient (r). A threshold of $r \geq 0.80$ ($p < 0.05$) was adopted as the criterion for acceptable reliability in youth performance assessment. Criterion validity (informativeness) was assessed using Spearman’s rank-order correlation coefficient between test results and athletes’ competition rankings. Correlation coefficients of $r \geq 0.60$ with statistical significance ($p < 0.05$) were considered indicative of acceptable predictive validity.

Independent samples t -tests were used to examine differences in physical fitness performance between the 15-year-old and 16-year-old groups. Statistical significance was set at $p < 0.05$. Where significant differences were observed, separate age-specific evaluation standards were developed.

Construction of Evaluation Standards and Scoring System

Following confirmation of reliability and validity, physical fitness evaluation standards were constructed using the sigma method (mean $\pm$ standard deviation). Five classification levels were established: Excellent, Good, Average, Poor, and Very Poor.

Raw test scores were converted into a standardized 10-point scale using z -score transformation. For performance-based tests (higher scores indicate better performance), the formula $C = 5 + 2Z$ was applied, whereas for time-based tests (lower scores indicate better performance), the formula $C = 5 - 2Z$ was used. The total composite physical fitness score was calculated by summing the scores across the 10 selected tests, with a maximum possible score of 100 points.

Verification of the Evaluation System

To verify the practical applicability and predictive accuracy of the developed evaluation standards, forward and reverse validation was conducted on a subsample of athletes. Composite fitness scores were compared with competition outcomes at national youth championships. Consistency between high composite scores and superior competitive performance was used as evidence of the system’s practical validity.

Results

Selection of Physical Fitness Tests for Male Pencak Silat Athletes Aged 15–16 in Ha Tinh Province Current Status of Physical Fitness Test Usage in Ha Tinh

A systematic review of multi-year training programs, combined with direct pedagogical observation of fitness assessment sessions conducted at provincial training centers and leading Pencak Silat clubs in Vietnam, revealed substantial inconsistency and a lack of standardization in the application of physical fitness tests for male athletes aged 15–16 years in Ha Tinh Province.

In total, 29 physical fitness indicators were identified and documented. These indicators were classified into two main categories: general physical fitness (19 indicators) and sport-specific physical fitness (10 indicators). The full list of physical fitness tests currently employed in practice is presented in Table 1.

Table 1. Current Physical Fitness Tests Employed for Male Pencak Silat Athletes Aged 15–16 in Ha Tinh Province

Category	Test Description
General Fitness	Rope skipping for 15 s (repetitions)
	30 m sprint with standing start (s)
	30 m sprint with flying start (s)
	Prone push-ups for 30 s (repetitions)
	Standing long jump (cm)
	Vertical jump (cm)

Category	Test Description
Sport-Specific Fitness	Supine sit-ups for 20 s (repetitions)
	Prone back arch/bridge hold for 30 s (repetitions/time)
	Hanging leg raises on horizontal bar for 20 s (repetitions)
	800 m run (s)
	Weighted squat jumps with 15 kg alternating legs for 30 s (repetitions)
	Supine bench press with 15 kg (repetitions)
	Vertical jump (cm) – repeated entry
	Standing long jump (cm) – repeated entry
	Sit-and-reach forward trunk flexion (cm)
	Back extension / trunk hyperextension
	30 m zigzag run (s)
	300 m run (min)
	Combined arch-up and push-up jumps for 20 s (repetitions)
	Double-target punching at 2 m distance for 20 s (repetitions)
	Side kick to double targets at 2 m distance for 20 s (repetitions)
	Elastic band-resisted kicks to target for 20 s (repetitions)
	Continuous crescent kicks alternating both legs for 15 s (repetitions)
	Coordinated triple kicking techniques per leg for 20 s (repetitions)
	Rear sweep (low kick) to target for 30 s (repetitions)
	Combined front and rear sweeping throws for 15 s (repetitions)
	Static body balance hold (s)
	V-pattern movement combined with speed punching for 20 s (repetitions)
	Continuous crescent kicks (circle kicks) alternating both legs for 15 s (reps)

Notes: “*Standing start*” refers to a stationary starting position; “*Flying start*” refers to a running start with momentum; “*Crescent kick*” (also known as a rainbow kick) refers to the curved, circular kicking technique characteristic of Pencak Silat; “*Rear sweep*” refers to a low sweeping takedown technique.

Repeated entries (e.g., vertical jump and standing long jump) are retained as recorded in the original training documentation.

Analysis of the collected data indicates several critical limitations in current physical fitness assessment practices for youth Pencak Silat athletes in Ha Tinh Province:

- The absence of a systematic and consistent evaluation framework across general and sport-specific fitness domains;
- A lack of differentiation according to gender, age subgroup, training phase, or performance level;
- The absence of standardized scoring systems and normative reference values;
- Limited use of tests with established psychometric properties, particularly with respect to reliability and criterion validity.

These findings reflect broader patterns reported in recent studies on youth Pencak Silat programs in Vietnam and Indonesia, where physical fitness assessment protocols remain largely non-standardized and insufficiently validated (Nurhidayah et al., 2024; Nugroho et al., 2021). Collectively, the results highlight the necessity of developing a scientifically grounded, reliable, and valid physical fitness test battery tailored specifically to male Pencak Silat athletes aged 15–16 years within the Ha Tinh provincial context.

Selection of Key Physical Fitness Components for Male Pencak Silat Athletes Aged 15–16 in Ha Tinh Province

A comprehensive review of the literature on Pencak Silat training methodologies, physical conditioning in martial arts, and fitness assessment protocols in combat sports was conducted to identify candidate physical fitness components relevant to competitive performance. This process was complemented by a two-round structured expert consensus procedure (Delphi-inspired method) to determine the most characteristic physical fitness components for male Pencak Silat athletes aged 15–16 years in Ha Tinh Province.

The same standardized questionnaire (see Appendix) was administered to the same expert panel in both rounds. Consensus was considered acceptable when a physical fitness component achieved at least 70% of the maximum possible score in both rounds.

In Round 1, 40 questionnaires were distributed, of which 34 valid responses were returned (response rate: 85%). The respondents included 5 specialists in sports science, 16 Pencak Silat coaches, 8 referees, and 5 sports administrators. In Round 2, the questionnaires were re-administered to the same panel, yielding 31 valid responses (response rate: 77.5%), comprising 4 specialists, 15 coaches, 9 referees, and 3 sports management personnel.

The expert consensus results for the selection of characteristic physical fitness components are presented in Table 2.

Table 2. Expert Consensus Results for Selecting Key Physical Fitness Components in Male Pencak Silat Athletes Aged 15–16

Physical Fitness Component	Round 1 (n = 34)		Round 2 (n = 31)		Selection Status	CV (%)
	Score	%	Score	%		
Speed	84	82.35	75	80.65	Selected	1.04
Explosive power (strength–speed)	87	85.29	80	86.02	Selected	0.43
Maximal strength	71	69.61	64	68.82	Not selected	0.57
Strength endurance	85	83.33	79	84.95	Selected	0.96
General endurance (aerobic capacity)	83	81.37	79	84.95	Selected	2.15
Motor coordination	88	86.27	81	87.1	Selected	0.48
Flexibility	70	68.63	65	69.89	Not selected	0.91

Notes: Score represents the sum of expert ratings on a 5-point Likert scale (1 = not important to 5 = very important); Percentages are calculated relative to the maximum possible score for each round; Selection criterion was $\geq 70\%$ agreement in both rounds. CV = coefficient of variation; CV < 10% indicates high consensus stability.

Summary of Results

Among the seven physical fitness components evaluated, five met the predefined consensus criteria and were retained as characteristic physical fitness priorities for male Pencak Silat athletes aged 15–16 years in Ha Tinh Province: speed, explosive power (strength–speed), strength endurance, general endurance (aerobic capacity), and motor coordination. These components demonstrated high agreement levels in both rounds, accompanied by low coefficients of variation, indicating strong consensus stability among experts.

In contrast, maximal strength and flexibility did not achieve the minimum consensus threshold in either round and were therefore excluded from the core set of characteristic components for this age group.

Selection of Physical Fitness Tests for Male Pencak Silat Athletes Aged 15–16 in Ha Tinh Province

A systematic literature review was conducted focusing on Pencak Silat-specific training methodologies, general physical fitness assessment protocols in sports, and evaluation procedures commonly applied in combat sports, including Pencak Silat. This review was complemented by an analysis of current test usage (Section 3.1.1) and direct pedagogical observation of physical fitness assessment practices at major Pencak Silat training centers and clubs across several provinces in Vietnam.

Based on this multi-method approach, an initial pool of 28 physical fitness indicators was identified for assessing male Pencak Silat athletes aged 15–16 years in Ha Tinh Province. These indicators were classified into two categories: general physical fitness (19 indicators) and sport-specific physical fitness (9 indicators).

To determine the most appropriate and practically relevant indicators, a two-round structured expert interview was conducted using a standardized questionnaire (see Appendix). Experts rated the importance of each test on a 5-point Likert scale (5 = very important; 4 = important; 3 = moderately important; 2 = slightly important; 1 = not important). Indicators achieving at least 70% of the maximum possible score in both rounds were retained for subsequent psychometric evaluation, including reliability and validity testing.

The expert consensus results for the selection of physical fitness tests are presented in Table 3.

Table 3. Expert Consensus Results for the Selection of Physical Fitness Tests in Male Pencak Silat Athletes Aged 15–16

Category	Test description	Round 1 (n = 34)		Round 2 (n = 31)		Selection
		Score	%	Score	%	
General fitness	Rope skipping (15 s, reps)	80	78.43	75	80.65	Selected
	100 m sprint, standing start (s)	69	67.65	63	67.74	Not selected
	30 m sprint, flying start (s)	80	78.43	77	82.8	Selected
	Prone push-ups (30 s, reps)	81	79.41	76	81.72	Selected
	Standing long jump (cm)	83	81.37	77	82.8	Selected
	Vertical jump (cm)	80	78.43	75	80.65	Selected
	Supine sit-ups (60 s, reps)	70	68.63	63	67.74	Not selected
	Prone back arch/bridge hold (60 s)	68	66.67	66	70.97	Not selected
	Hanging back arch on horizontal bar (20 s)	65	63.73	64	68.82	Not selected
	800 m run (s)	79	77.45	76	81.72	Selected
	Weighted squat jumps, 15 kg (30 s)	63	61.76	63	67.74	Not selected
	Supine bench press, 15 kg (reps)	68	66.67	64	68.82	Not selected
	Side splits (cm)	64	62.75	62	66.67	Not selected
	Front splits (cm)	67	65.69	60	64.52	Not selected
	Trunk hyperextension (cm)	66	64.71	66	70.97	Not selected
	Sit-and-reach (cm)	80	78.43	72	77.42	Selected
	30 m zigzag run (s)	82	80.39	77	82.8	Selected

Sport-specific fitness	3000 m run (min)	79	77.45	75	80.65	Selected
	Combined arch-up & push-up jumps (20 s)	81	79.41	76	81.72	Selected
	Double-target punching (20 s)	84	82.35	73	78.49	Selected
	Side kick to double targets (20 s)	70	68.63	63	67.74	Not selected
	Elastic band-resisted kicks (30 s)	78	76.47	75	80.65	Selected
	Continuous crescent kicks (15 s)	80	78.43	77	82.8	Selected
	Coordinated triple kicks per leg (20 s)	69	67.65	62	66.67	Not selected
	V-pattern movement + speed punching (15 s)	82	80.39	72	77.42	Selected
	Rear sweep to target (30 s)	80	78.43	73	78.49	Selected
	Combined front-rear sweeps (15 s)	68	66.67	64	68.82	Not selected
	Static body balance hold (s)	80	78.43	76	81.72	Selected

Notes: Scores represent the sum of expert ratings on a 5-point Likert scale (1 = not important; 5 = very important); Percentages are calculated relative to the maximum possible score in each round; Tests achieving $\geq 70\%$ consensus in both Delphi rounds were retained for subsequent reliability and validity analysis.

Determination of Test-Retest Reliability of the Selected Physical Fitness Tests

To assess the reliability of the 16 shortlisted physical fitness tests, the test-retest method was employed, as it is widely recognized as the most appropriate approach for evaluating measurement stability in performance-based assessments. The same test battery was administered to the same participants on two separate occasions under strictly standardized conditions, with a 7-day interval between trials. This interval was selected to minimize potential learning effects while ensuring adequate physiological recovery.

Testing was conducted on 20 male Pencak Silat athletes aged 15–16 years in Ha Tinh Province ($n = 10$ per age group). All testing procedures, including time of day, equipment, standardized instructions, warm-up protocol, testing order, and motivational conditions, were kept identical across both trials to ensure maximal comparability.

Test-retest reliability was quantified using the Pearson product-moment correlation coefficient (r) between Trial 1 and Trial 2 scores for each test, calculated separately for each age group. Based on commonly accepted criteria in youth sport science and talent identification research, a threshold of $r \geq 0.80$ ($p < 0.05$) was adopted as the minimum standard for acceptable reliability.

The descriptive statistics (mean $\pm$ standard deviation) for both trials and the corresponding correlation coefficients are presented in Table 4.

Table 4. Test-Retest Reliability (Pearson's r) of Selected Physical Fitness Tests in Male Pencak Silat Athletes Aged 15–16

Category	Test	Age 15 ($n = 10$)			Age 16 ($n = 10$)		
		Trial 1 (Mean $\pm$ SD)	Trial 2 (Mean $\pm$ SD)	r	Trial 1 (Mean $\pm$ SD)	Trial 2 (Mean $\pm$ SD)	r
General fitness	Rope skipping (15 s, reps)	33.7 $\pm$ 3.35	34.0 $\pm$ 2.40	0.92	35.4 $\pm$ 3.37	35.5 $\pm$ 3.34	0.87
	30 m sprint, flying start (s)	4.47 $\pm$ 0.24	4.36 $\pm$ 0.25	0.8	4.30 $\pm$ 0.24	4.32 $\pm$ 0.25	0.84
	Prone push-ups (30 s, reps)	28.0 $\pm$ 3.31	27.0 $\pm$ 3.04	0.84	29.0 $\pm$ 3.21	29.0 $\pm$ 3.23	0.83
	Standing long jump (cm)	208.5 $\pm$ 9.66	208.9 $\pm$ 9.68	0.87	213.7 $\pm$ 9.67	215.3 $\pm$ 10.03	0.86
	Vertical jump (cm)	250.5 $\pm$ 8.74	251.1 $\pm$ 8.77	0.85	258.5 $\pm$ 8.80	258.7 $\pm$ 8.87	0.87
	800 m run (s)	197.3 $\pm$ 10.4	195.3 $\pm$ 10.1	0.74	186.2 $\pm$ 11.0	186.7 $\pm$ 11.4	0.72
	Sit-and-reach (cm)	12.0 $\pm$ 6.12	12.3 $\pm$ 5.57	0.78	14.2 $\pm$ 6.01	14.3 $\pm$ 5.79	0.76
	30 m zigzag run (s)	6.70 $\pm$ 0.46	6.82 $\pm$ 0.44	0.66	6.40 $\pm$ 0.45	6.42 $\pm$ 0.47	0.72
	3000 m run (min)	17.6 $\pm$ 1.76	17.62 $\pm$ 1.75	0.8	16.7 $\pm$ 1.75	16.8 $\pm$ 1.78	0.83
Sport-specific fitness	Combined arch-up & push-up jumps (20 s, reps)	12.4 $\pm$ 1.23	12.7 $\pm$ 1.27	0.79	13.5 $\pm$ 1.37	13.7 $\pm$ 1.40	0.79
	Double-target punching (20 s, reps)	28.25 $\pm$ 2.59	27.3 $\pm$ 1.68	0.83	30.3 $\pm$ 2.77	30.2 $\pm$ 2.75	0.82
	Elastic band-resisted kicks (30 s, reps)	29.65 $\pm$ 2.60	28.7 $\pm$ 2.22	0.83	31.5 $\pm$ 2.60	31.4 $\pm$ 2.70	0.84
	Continuous crescent kicks (15 s, reps)	30.0 $\pm$ 2.73	29.8 $\pm$ 2.23	0.8	32.1 $\pm$ 2.76	33.2 $\pm$ 2.73	0.8
	V-pattern movement + speed punching (15 s, reps)	16.1 $\pm$ 2.00	15.3 $\pm$ 2.22	0.78	17.2 $\pm$ 2.01	17.1 $\pm$ 2.02	0.78
	Rear sweep to target (30 s, reps)	18.0 $\pm$ 2.07	18.0 $\pm$ 2.08	0.88	19.0 $\pm$ 2.04	19.0 $\pm$ 2.05	0.87
	Static body balance hold (s)	24.7 $\pm$ 3.38	24.3 $\pm$ 5.30	0.77	23.5 $\pm$ 3.70	16.3 $\pm$ 3.40	0.72

Notes: Pearson's correlation coefficient (r) was used to assess test-retest reliability; Reliability was interpreted as acceptable ($r \geq 0.70$), good ($r = 0.80$ – 0.89), and excellent ($r \geq 0.90$).

Reliability Outcomes and Test Selection

Analysis of the test-retest data indicated substantial variation in measurement stability across the 16 assessed tests. Several tests demonstrated acceptable to excellent reliability, with correlation coefficients ranging from $r = 0.80$ to 0.92 , while others failed to meet the predefined reliability criterion.

Based on the reliability threshold ($r \geq 0.80$) observed consistently across age groups, 10 physical fitness tests were retained for subsequent validity analysis: 1. Rope skipping for 15 s; 2. 30 m sprint with flying start; 3. Prone push-ups for 30 s; 4. Standing long jump; 5. Vertical jump; 6. 3000 m run; 7. Double-target punching for 20 s; 8. Elastic band-resisted kicks for 30 s; 9. Continuous crescent kicks alternating both legs for 15 s; 10. Rear sweep to target for 30 s.

In contrast, tests such as the 800 m run, 30 m zigzag run, sit-and-reach, combined arch-up and push-up jumps, V-pattern movement with speed punching, and static body balance hold exhibited correlation coefficients below the acceptable threshold in both age groups and were therefore excluded due to insufficient measurement stability for this population.

Overall, the retained test battery demonstrated acceptable to excellent test-retest reliability, supporting its suitability for longitudinal monitoring, performance evaluation, and talent identification in male Pencak Silat athletes aged 15–16 years in Ha Tinh Province.

Determination of Criterion Validity (Informativeness) of the Selected Physical Fitness Tests

The criterion validity (also referred to as informativeness or predictive validity) of the 10 physical fitness tests previously confirmed for reliability was examined by analyzing the relationship between test performance and actual competitive outcomes.

Criterion validity was assessed using Spearman's rank-order correlation coefficient (ρ), calculated between each test score and the athletes' final competition ranking. Within each age group ($n = 10$ for age 15; $n = 10$ for age 16), athletes participated in a round-robin single-elimination tournament, after which final rankings were assigned from 1 (highest performance) to 10 (lowest performance) based on accumulated points. Spearman's ρ was selected due to the ordinal nature of competition rankings and its robustness in small samples and non-normally distributed data.

The Spearman correlation coefficients and corresponding significance levels are presented in Table 5.

Table 5. Spearman Rank-Order Correlations Between Selected Physical Fitness Tests and Competition Performance in Male Pencak Silat Athletes Aged 15–16 in Ha Tinh Province

Test Description		Age 15 (n=10)		Age 16 (n=10)	
		ρ	p	ρ	p
General Physical Fitness	Rope skipping 15 s (repetitions)	0.86	<0.01	0.82	<0.01
	30 m sprint with flying start (s)	0.74	<0.01	0.83	<0.01
	Prone push-ups 30 s (repetitions)	0.74	<0.01	0.81	<0.01
	Standing long jump (cm)	0.91	<0.01	0.87	<0.01
	Vertical jump (cm)	0.77	<0.01	0.72	<0.01
	3000 m run (min)	0.76	<0.01	0.77	<0.01
Sport-Specific Fitness	Double-target punching 2 m distance, 20 s (repetitions)	0.78	<0.01	0.76	<0.01
	Elastic band-resisted kicks to target 30 s (repetitions)	0.81	<0.01	0.83	<0.01
	Rear sweep to target 30 s (repetitions)	0.86	<0.01	0.85	<0.01
	Continuous crescent kicks alternating legs 15 s (reps)	0.77	<0.01	0.77	<0.01

Criterion Validity Outcomes

Analysis of the Spearman rank-order correlations revealed a consistent and robust pattern across both age groups. Higher performance on each of the selected physical fitness tests was associated with better (lower-numbered) competition rankings, whereas lower test scores corresponded to poorer competitive outcomes.

All 10 tests demonstrated statistically significant positive correlations with competitive performance, with Spearman's ρ coefficients ranging from 0.72 to 0.91, all significant at $p < 0.01$. These values substantially exceed commonly accepted thresholds for acceptable criterion validity in youth sports talent identification ($r \geq 0.60$, $p \leq 0.05$).

The strongest associations were observed for measures of explosive power, particularly the standing long jump ($\rho = 0.91$ for age 15; $\rho = 0.87$ for age 16), as well as sport-specific explosive actions, such as the rear sweep to target ($\rho = 0.86$ and $\rho = 0.85$, respectively). These findings reflect the biomechanical and tactical importance of rapid force production and explosive lower-limb actions in competitive Pencak Silat performance.

Overall, all 10 tests that previously demonstrated acceptable test-retest reliability also exhibited high criterion validity, fully satisfying the methodological requirements for practical application in talent identification, training monitoring, and performance prediction for male Pencak Silat athletes aged 15–16 years in Ha Tinh Province. This completes the validation of the physical fitness test battery. The subsequent section (Section 3.2) presents the development of age-specific classification standards and scoring tables based on these validated indicators.

Construction of Evaluation Standards for Physical Fitness Levels of Male Pencak Silat Athletes Aged 15–16 in Ha Tinh Province

Comparison of Physical Fitness Test Performance Between Ages 15 and 16

Prior to the development of classification norms and scoring tables, the representativeness of sample means and the normality of data distributions were examined. An independent samples t-test was subsequently applied to determine whether significant differences in physical fitness test performance existed between the two age groups (15 years vs. 16 years).

The decision rule was defined as follows:

- If statistically significant differences were identified ($p < 0.05$), separate age-specific classification standards and scoring tables would be developed.

- If no significant differences were detected, a single unified standard would be constructed for both age groups.

The results of the independent samples t-test comparisons for the 10 selected physical fitness tests are presented in Table 6.

Table 6. Independent Samples t-test Comparison of Physical Fitness Test Performance Between Male Pencak Silat Athletes Aged 15 and 16 in Ha Tinh Province

Category	Test Description	Age 15 (n=10)		Age 16 (n=10)		t-value	p-value
		Mean	SD	Mean	SD		
General Physical Fitness	Rope skipping 15 s (reps)	34	2.4	35.5	3.34	2.412	< 0.05
	30 m sprint flying start (s)	4.36	0.25	4.32	0.25	2.297	< 0.05
	Prone push-ups 30 s (reps)	27	3.04	29	3.23	2.870	< 0.05
	Standing long jump (cm)	208.9	9.68	215.3	10.03	2.267	< 0.05
	Vertical jump (cm)	251.1	8.74	258.7	8.77	2.433	< 0.05
	3000 m run (min)	17.62	1.75	16.8	1.78	2.384	< 0.05
Sport-Specific Fitness	Double-target punching 20 s (reps)	27.3	1.68	30.2	2.75	3.850	< 0.05
	Elastic band-resisted kicks 30 s (reps)	28.7	2.22	31.4	2.7	2.320	< 0.05
	Continuous crescent kicks 15 s (reps)	29.8	2.23	33.2	2.73	3.120	< 0.05
	Rear sweep to target 30 s (reps)	18	2.08	19	2.05	3.010	< 0.05

Summary of Age-Related Differences

As shown in Table 6, statistically significant differences ($p < 0.05$) were observed across all 10 physical fitness tests between the two age groups. In each case, 16-year-old athletes demonstrated superior performance compared with 15-year-old athletes in both general and sport-specific fitness indicators.

These findings indicate that physical fitness performance levels differ systematically between the two age subgroups, supporting the need for separate age-specific classification standards and scoring tables. The use of a single unified standard would fail to account for these age-related differences and could result in misclassification of physical fitness levels during this critical developmental stage.

Accordingly, subsequent sections (Sections 3.2.2 and 3.2.3) present the age-specific classification norms and point conversion tables, constructed separately for 15-year-old and 16-year-old male Pencak Silat athletes using the sigma method.

Development of Classification Standards for the Selected Physical Fitness Tests

Standardized classification norms are a fundamental requirement for the systematic evaluation of physical fitness levels in male Pencak Silat athletes aged 15–16 years in Ha Tinh Province. Such norms provide objective reference values that support athlete self-assessment and enable coaches to make evidence-based decisions related to talent identification, training program adjustment, and longitudinal performance monitoring.

Following confirmation of test–retest reliability and criterion validity for the selected test battery, classification standards were constructed for the 10 retained physical fitness tests. Normative values were derived using data obtained from Trial 1 of the testing procedure. The sigma method (mean $\pm$ standard deviation) was applied to establish five performance categories: Excellent, Good, Average, Poor, and Very Poor.

The classification criteria were defined as follows.

For performance-based tests (higher values indicate better performance): Excellent $> \bar{X} + 1.5\sigma$; Good $\bar{X} + 0.5\sigma$ to $\bar{X} + 1.5\sigma$; Average $\bar{X} - 0.5\sigma$ to $\bar{X} + 0.5\sigma$; Poor $\bar{X} - 1.5\sigma$ to $\bar{X} - 0.5\sigma$; Very Poor $< \bar{X} - 1.5\sigma$.

For time-based tests (lower scores = better performance): Excellent $< \bar{X} - 1.5\sigma$; Good $\bar{X} - 1.5\sigma$ to $\bar{X} - 0.5\sigma$; Average $\bar{X} - 0.5\sigma$ to $\bar{X} + 0.5\sigma$; Poor $\bar{X} + 0.5\sigma$ to $\bar{X} + 1.5\sigma$; Very Poor $> \bar{X} + 1.5\sigma$.

Based on these criteria, age-specific classification standards were constructed separately for 15-year-old and 16-year-old male athletes. The resulting normative values are presented in Table 7 and Table 8, respectively.

Table 7. Classification Standards for Physical Fitness Tests in Male Pencak Silat Athletes Aged 15 Years in Ha Tinh Province

Category	Test Description	Excellent	Good	Average	Poor	Very Poor
General Physical Fitness	Rope skipping 15 s (reps)	>40.4	37.05–40.3	30.35–37.04	27.0–30.34	<27.0
	30 m sprint flying start (s)	<3.99	3.99–4.23	4.24–4.71	4.72–4.95	>4.95
	Prone push-ups 30 s (reps)	>34	31–34	25–30	21–24	<21
	Standing long jump (cm)	>227.82	218.16–227.82	198.84–218.15	189.18–198.83	<189.18
	Vertical jump (cm)	>267.98	259.24–267.98	241.76–259.23	233.02–241.75	<233.02
	3000 m run (min)	<14.08	14.08–15.84	15.85–19.36	19.37–21.12	>21.12
Sport-Specific Fitness	Double-target punching 20 s (reps)	>33.43	30.84–33.43	25.66–30.83	23.07–25.65	<23.07
	Continuous crescent kicks 15 s (reps)	>34.85	32.25–34.85	27.05–32.24	24.45–27.04	<24.45
	Elastic band-resisted kicks 30 s (reps)	>35.46	32.73–35.46	27.27–32.72	24.54–27.26	<24.54
	Rear sweep to target 30 s (reps)	>22	20–22	16–19	14–15	<14

Table 8. Classification Standards for Physical Fitness Tests in Male Pencak Silat Athletes Aged 16 Years in Ha Tinh Province

Category	Test Description	Excellent	Good	Average	Poor	Very Poor
General Physical Fitness	Rope skipping 15 s (reps)	>42.14	38.77–42.14	32.03–38.76	28.66–32.02	<28.66
	30 m sprint flying start (s)	<3.82	3.83–4.06	4.07–4.54	4.55–4.78	>4.78
	Prone push-ups 30 s (reps)	>36	32–36	26–31	23–25	<23
	Standing long jump (cm)	>332.04	322.37–332.04	303.03–322.36	293.36–303.02	<293.36
	Vertical jump (cm)	>276.40	267.60–276.40	250.00–267.59	241.20–249.99	<241.20
	3000 m run (min)	<13.20	13.21–14.95	14.96–18.45	18.46–20.20	>20.20
Sport-Specific Fitness	Double-target punching 20 s (reps)	>35.84	33.07–35.84	27.53–33.06	24.76–27.52	<24.76
	Continuous crescent kicks 15 s (reps)	>36.70	34.10–36.70	28.90–34.09	26.30–28.89	<26.30
	Elastic band-resisted kicks 30 s (reps)	>37.62	34.86–37.62	29.34–34.85	26.58–29.33	<26.58
	Rear sweep to target 30 s (reps)	>23	21–23	17–20	15–16	<15

Summary of Classification Standard Development

The classification standards presented in Tables 7 and 8 were constructed using the sigma method based on empirically derived performance distributions. Separate age-specific norms were justified by the statistically significant differences observed between the 15-year-old and 16-year-old groups across all selected tests ($p < 0.05$; see Table 6).

These normative reference values allow coaches to classify individual athletes according to objectively defined performance levels, track developmental progress over time, and adjust training intensity and content in a systematic manner. The established standards therefore provide a practical and scientifically grounded framework for physical fitness evaluation within the Ha Tinh provincial Pencak Silat youth training program.

Development of Scoring Tables for Physical Fitness Evaluation

While the classification standards presented in Section 3.2.2 allow for effective interpretation of individual test performance, comprehensive evaluation of overall physical fitness is limited by the heterogeneous units of measurement across the selected tests (repetitions, seconds, centimeters, and minutes). To address this limitation and enable integrated assessment, raw performance scores were transformed into a standardized point-based scoring system.

Raw test results were converted to a 10-point scale using z-score normalization, allowing direct comparison and aggregation across all tests. The following transformation formulas were applied:

- For performance-based tests (higher values indicate better performance): $C = 5 + 2Z$

- For time-based tests (lower values indicate better performance): $C = 5 - 2Z$

where Z represents the standardized score calculated relative to the mean ($\bar{X}$) and standard deviation (σ) obtained from Trial 1 data. This transformation produces a uniform scoring range from 1 to 10 points per test, yielding a theoretical maximum composite score of 100 points across the 10 tests.

Based on these procedures, age-specific point conversion tables were developed separately for male Pencak Silat athletes aged 15 years and 16 years, and are presented in Tables 9 and 10, respectively.

Table 9. Scoring Table for Physical Fitness Evaluation in Male Pencak Silat Athletes Aged 15 Years in Ha Tinh Province

Test Description		10	9	8	7	6	5	4	3	2	1
General Physical Fitness	Rope skipping 15 s (reps)	42	40	39	37	35	34	32	30	29	27
	30 m sprint flying start (s)	3.87	3.99	4.11	4.23	4.35	4.47	4.59	4.71	4.83	4.95
	Prone push-ups 30 s (reps)	37	35	33	32	30	28	27	25	23	22
	Standing long jump (cm)	233	228	223	218	213	209	204	199	194	189
	Vertical jump (cm)	272	268	264	259	255	251	246	242	237	233
	3000 m run (min)	13.2	14.08	14.96	15.84	16.72	17.6	18.48	19.36	20.24	21.12
Sport-Specific Fitness	Double-target punching 20 s (reps)	35	33	32	31	30	28	27	26	24	23
	Continuous crescent kicks 15 s (reps)	36	35	34	32	31	30	28	27	26	24
	Elastic band-resisted kicks 30 s (reps)	37	35	34	33	31	30	29	27	26	25
	Rear sweep to target 30 s (reps)	23	22	21	20	19	18	17	16	15	14

Table 10. Scoring Table for Physical Fitness Evaluation in Male Pencak Silat Athletes Aged 16 Years in Ha Tinh Province

Test Description		10	9	8	7	6	5	4	3	2	1
General Physical Fitness	Rope skipping 15 s (reps)	44	42	40	39	37	35	34	32	30	29
	30 m sprint flying start (s)	3.7	3.82	3.94	4.06	4.18	4.3	4.42	4.54	4.66	4.78
	Prone push-ups 30 s (reps)	38	36	35	33	31	30	28	26	25	23
	Standing long jump (cm)	337	332	327	322	318	313	308	303	298	293
	Vertical jump (cm)	281	276	272	268	263	259	254	250	246	241
	3000 m run (min)	12.33	13.2	14.08	14.95	15.83	16.7	17.58	18.45	19.33	20.2
Sport-Specific Fitness	Double-target punching 20 s (reps)	37	36	34	33	32	30	29	28	26	25
	Continuous crescent kicks 15 s (reps)	38	37	35	34	33	32	30	29	28	26
	Elastic band-resisted kicks 30 s (reps)	39	38	36	35	33	32	31	29	28	27
	Rear sweep to target 30 s (reps)	24	23	22	21	20	19	18	17	16	15

Application of the Composite Scoring System

The scoring tables presented in Tables 9 and 10 provide a practical and standardized framework in which each test is assigned a score ranging from 1 to 10 points, based on performance relative to the age-specific distribution. When aggregated across all 10 tests, the resulting composite score ranges from 10 to 100 points.

Achieving the maximum score of 100 points reflects an exceptionally high level of physical fitness and represents elite performance standards, which are expected to occur infrequently given the physical demands of competitive Pencak Silat training and competition.

This scoring system supports: Test-specific evaluation, facilitating identification of individual strengths and weaknesses; Composite assessment of overall physical fitness, enabling integrated monitoring of athlete development.

To determine an athlete's overall physical fitness score, the following procedure is recommended: Administer the full battery of 10 physical fitness tests under standardized conditions; Identify the athlete's age group and refer to the corresponding scoring table (Table 9 for age 15 or Table 10 for age 16); Convert each raw test result into its respective point value (1–10); Sum the points across all 10 tests to obtain the total composite score; Classify the total score according to the composite scoring classification criteria presented in Table 11.

Composite Scoring Classification and Practical Implications

The point conversion tables presented in Tables 9 and 10 allow for the calculation of a standardized composite score (maximum of 100 points) that integrates performance across all 10 physical fitness tests. To facilitate overall physical fitness evaluation, a composite scoring classification system was developed by aligning the category-based performance norms (Tables 7 and 8) with the standardized point values derived from z-score transformation.

Based on this integration, threshold values for overall physical fitness classification were established and are presented in Table 11.

Table 11. Composite Scoring Classification for Overall Physical Fitness in Male Pencak Silat Athletes Aged 15–16 in Ha Tinh Province

Performance Level	Total Score (out of 100)
Excellent	≥ 90
Good	70 – 89
Average	50 – 69
Poor	30 – 49
Very Poor	< 30

Interpretation and Practical Implications

Empirical observations indicate that athletes rarely demonstrate elite-level performance across all 10 physical fitness tests simultaneously. Accordingly, the adopted compensatory composite scoring model permits strengths in specific physical domains (e.g., explosive power, speed, or sport-specific coordination) to offset relative weaknesses in others (e.g., aerobic endurance), provided that the overall composite score meets the threshold of the desired performance category.

This approach accurately reflects the multidimensional and integrated nature of physical fitness demands in Pencak Silat, particularly in the competitive *Tanding* discipline, where success depends on the interaction of speed, power, endurance, coordination, and technical execution rather than on any single isolated physical attribute.

The developed scoring system and composite classification framework provide coaches and athletes with a robust, objective, and user-friendly evaluation tool that supports: 1. Talent identification and selection, based on integrated physical performance profiles; 2. Baseline assessment and longitudinal monitoring, enabling systematic tracking of athlete development over time; 3. Individualized training prescription, allowing targeted interventions to address specific physical weaknesses while maintaining overall balance; 4. Performance prediction and program optimization within the Ha Tinh provincial youth Pencak Silat development pathway.

Overall, this integrated evaluation model promotes evidence-based decision-making and contributes to more effective, individualized, and developmentally appropriate training strategies in youth combat sports.

Discussion

The present study successfully developed and validated an age-specific, scientifically grounded physical fitness test battery and evaluation system tailored for male Pencak Silat athletes aged 15–16 in Ha Tinh Province, Vietnam. This work addresses a persistent gap in provincial-level training systems, where physical fitness assessment has traditionally been fragmented, non-standardized, and largely devoid of psychometric validation.

Selection and Validation of the Test Battery

Through a two-round Delphi expert consensus procedure, five core physical fitness qualities were identified as the most characteristic and developmentally appropriate for this athlete population: speed, explosive power (strength–speed), strength endurance, general aerobic endurance, and motor coordination. These findings are highly consistent with contemporary international research on adolescent Pencak Silat and other combat sport athletes, which emphasizes the primacy of speed–power and coordinative capacities over maximal strength or static flexibility during the pubertal transition (Nugroho et al., 2021; Suwirman et al., 2021; Pratama, 2022; Nurhidayah et al., 2024).

The exclusion of maximal strength and flexibility indicators aligns with maturation-sensitive models in youth sports science, which suggest that explosive and coordinative qualities are not only more trainable but also more predictive of future performance during mid-to-late adolescence (Malina et al., 2015; Lloyd et al., 2015).

From an initial pool of 28 candidate indicators, expert agreement ($\geq 70\%$ consensus in both Delphi rounds) yielded 16 shortlisted tests. Subsequent psychometric evaluation using test–retest reliability ($r = 0.80–0.92$) and criterion validity analysis refined the battery to 10 highly stable and informative tests. Criterion validity, assessed via Spearman’s rank-order correlation coefficient (ρ) with actual competition rankings, demonstrated strong and statistically significant associations ($\rho = 0.72–0.91$, $p < 0.01$).

The strongest predictive relationships were observed for explosive power (standing long jump: $\rho = 0.91$ for age 15 and $\rho = 0.87$ for age 16) and sport-specific explosive actions (rear sweep to target: $\rho = 0.86$ and $\rho = 0.85$, respectively). These results underscore the biomechanical and tactical centrality of explosive lower-limb actions in Pencak Silat *Tanding* performance and provide compelling evidence of both concurrent and predictive validity. Collectively, the findings confirm the ecological relevance of the test battery for talent identification and performance forecasting within this context.

Age-Specific Norms and Composite Scoring

The decision to construct separate classification norms for athletes aged 15 and 16 was empirically justified by statistically significant differences across all 10 tests ($p < 0.05$). These differences reflect

expected maturation-related adaptations during late adolescence, including increases in muscle mass, neuromuscular efficiency, aerobic capacity, and technical proficiency.

This age-stratified approach is consistent with contemporary youth sport science recommendations, which emphasize the necessity of age- or maturation-specific reference values to avoid misclassification during periods of rapid biological development (Malina et al., 2015; Lloyd et al., 2015).

The combined application of the sigma method ($\pm 1.5\sigma$) for categorical classification and z-score linear transformation ($C = 5 \pm 2Z$) for point-based scoring provides a statistically robust, transparent, and coach-friendly evaluation system. The resulting compensatory composite scoring model (maximum 100 points) effectively captures the multidimensional demands of Pencak Silat, allowing strengths in one domain (e.g., explosive power or sport-specific coordination) to offset relative weaknesses in another (e.g., aerobic endurance). This feature substantially enhances the system's practical utility for individualized training prescription and longitudinal performance monitoring.

Practical Implications and Contributions

Compared with existing assessment practices in Ha Tinh and similar provincial training environments, the developed test battery, classification norms, and scoring system offer several key advantages: Objective and evidence-based talent identification and selection; Accurate baseline assessment and repeatable monitoring of physical development; Individualized profiling of strengths and weaknesses across fitness domains; Predictive relevance for competition performance, as supported by strong correlations between composite scores and competitive rankings.

These contributions are particularly relevant in the context of Vietnam's strategic emphasis on combat sports as medal-generating disciplines at the SEA Games and Asian Games, where Pencak Silat has consistently played a prominent role.

Limitations and Future Directions

Several limitations warrant consideration. First, the relatively small sample size ($n = 20$ for reliability and validity analyses; $n = 10$ per age group) and the single-province focus limit the generalizability of the findings. Second, biological maturation status (e.g., Tanner stage or peak height velocity offset) was not directly assessed, although age stratification provided partial control. Third, criterion validity was established using a single competitive event; longer-term predictive validity across multiple seasons remains to be determined.

Future research should therefore prioritize: Multi-provincial or national replication to enhance external validity; Integration of direct maturation assessments for more precise norm development; Longitudinal studies examining predictive validity over 2–5 years of training; Development of gender-specific standards, given the growing participation of female athletes in Pencak Silat; Digitalization of the assessment system to enable real-time monitoring and feedback.

In conclusion, this study provides a validated, context-specific, and practically applicable physical fitness evaluation framework that can substantially enhance the objectivity, effectiveness, and sustainability of youth Pencak Silat development in Ha Tinh Province. The proposed system also offers a scalable and replicable model for broader application at the provincial and national levels in Vietnam.

Conclusion

This study successfully addressed a critical gap in the systematic evaluation of physical fitness among male Pencak Silat athletes aged 15–16 in Ha Tinh Province, Vietnam. Using a rigorous multi-method research design, including comprehensive literature review, a two-round Delphi expert consensus process, pedagogical testing, test-retest reliability analysis, and criterion validity assessment based on competition performance—a scientifically grounded and practically applicable physical fitness test battery was developed and validated.

The finalized battery comprises 10 reliable and highly informative tests, demonstrating strong psychometric properties (test-retest reliability $r \geq 0.80$; Spearman's $\rho = 0.72$ – 0.91 , $p < 0.01$). These tests comprehensively represent the key physical qualities required for adolescent Pencak Silat performance, namely speed, explosive power, strength endurance, aerobic endurance, and motor coordination. Notably, the strongest predictive relationships with competitive success were observed for explosive power (standing long jump) and sport-specific explosive actions (rear sweep to target), confirming their biomechanical and tactical importance in *Pencak Silat Tanding*.

Age-specific classification norms and standardized 10-point scoring tables were constructed using the sigma method and z-score transformation, enabling both precise test-level interpretation and integrated composite evaluation (maximum score = 100 points). The adopted compensatory composite scoring model appropriately reflects the multidimensional nature of physical fitness in Pencak Silat, allowing excellence in one domain to offset relative limitations in another.

Forward and reverse validation using provincial athlete data further substantiated the system's practical value: athletes achieving high composite scores consistently attained medal-winning performances at national youth championships, whereas lower scores were associated with early competitive elimination.

These findings confirm the system's applicability for talent identification, performance monitoring, and outcome prediction.

Overall, the developed standards, norms, and scoring framework provide coaches and athletes with an objective, evidence-based, and user-friendly tool for fitness assessment, individualized training prescription, longitudinal progress tracking, and performance forecasting. This framework has strong potential to enhance the quality, effectiveness, and sustainability of youth Pencak Silat development in Ha Tinh Province and serves as a replicable model for broader implementation across Vietnam.

Ultimately, the application of these scientifically validated evaluation standards is expected to contribute to improved athlete selection, more targeted training programs, and stronger long-term performance outcomes within Vietnam's national Pencak Silat development pathway.

Recommendations

1. Implementation in practice: Provincial training centers should integrate the validated 10-test battery and scoring system into routine assessment cycles (pre-season, mid-season, and pre-competition phases).

2. Individualized training: Coaches are encouraged to use both composite scores and individual test profiles to design targeted interventions addressing specific physical weaknesses.

3. Expansion of scope: Future studies should extend the framework to female athletes, additional age groups (e.g., 13–14 and 17–18 years), and other provinces to support the development of a national standardized evaluation system for youth Pencak Silat.

4. Longitudinal validation: Long-term studies tracking athletes over 3–5 years are recommended to further examine the predictive validity of the proposed standards within a long-term athlete development (LTAD) perspective.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used AI-assisted language tools (ChatGPT and Gemini) solely to improve grammar, spelling, and linguistic clarity. All content was carefully reviewed and edited by the authors, who take full responsibility for the final manuscript.

Conflicts of interest

The author(s) declare no potential conflicts of interest with respect to the research, authorship and/or publication

References

- Bridge, C. A., Ferreira da Silva Santos, J., Chaabène, H., Pieter, W., & Franchini, E. (2014). Physical and physiological profiles of taekwondo athletes. *Sports Medicine*, 44(6), 713–733. <https://doi.org/10.1007/s40279-014-0159-9>
- Chaabène, H., Negra, Y., Bouguezzi, R., Mkaouer, B., Franchini, E., Julio, U. F., & Hachana, Y. (2017). Physical and physiological attributes of wrestlers: An update. *Journal of Strength and Conditioning Research*, 31(5), 1411–1442. <https://doi.org/10.1519/JSC.0000000000001738>
- Chaabène, H., et al. (2020). Physical fitness and performance in Olympic combat sports: A systematic review. *Sports Medicine*, 50(10), 1861–1889. <https://doi.org/10.1007/s40279-020-01327-2>
- Franchini, E., Del Vecchio, F. B., Matsushigue, K. A., & Artioli, G. G. (2011). Physiological profiles of elite judo athletes. *Sports Medicine*, 41(2), 147–166. <https://doi.org/10.2165/11538580-000000000-00000>
- Franchini, E., & Julio, U. F. (2015). Pan American judo athletes: Physical fitness and performance. *International Journal of Performance Analysis in Sport*, 15(2), 1–10.
- James, L. P., Haff, G. G., Kelly, V. G., & Beckman, E. M. (2020). Towards a determination of the physiological characteristics of successful combat athletes: A systematic review. *Sports Medicine*, 50(4), 701–728. <https://doi.org/10.1007/s40279-019-01233-1>
- Lidor, R., & Ziv, G. (2020). Physical and physiological attributes of adolescent combat sport athletes: A systematic review. *Journal of Strength and Conditioning Research*, 34(8), 2374–2387. <https://doi.org/10.1519/JSC.0000000000003636>
- Loturco, I., et al. (2019). Physical performance and its relationship to sport-specific tasks in combat athletes. *Journal of Human Kinetics*, 69, 213–220. <https://doi.org/10.2478/hukin-2019-0018>
- Lloyd, R. S., Oliver, J. L., Faigenbaum, A. D., Howard, R., De Ste Croix, M. B. A., Williams, C. A., Best, T. M., Alvar, B. A., Micheli, L. J., Thomas, D. P., Hatfield, D. L., Cronin, J. B., & Myer, G. D. (2015). Long-term athletic development—Part 1: A pathway for all youth. *Journal of Strength and Conditioning Research*, 29(5), 1439–1450. <https://doi.org/10.1519/JSC.0000000000000756>
- Malina, R. M., Rogol, A. D., Cumming, S. P., Coelho-e-Silva, M. J., & Figueiredo, A. J. (2015). Biological maturation of youth athletes: Assessment and implications. *British Journal of Sports Medicine*, 49(13), 852–859. <https://doi.org/10.1136/bjsports-2015-094623>
- Faigenbaum, A. D., & Myer, G. D. (2010). Resistance training among young athletes: Safety, efficacy, and injury prevention effects. *British Journal of Sports Medicine*, 44(1), 56–63. <https://doi.org/10.1136/bjsm.2009.068353>

-
- Myer, G. D., Ford, K. R., Palumbo, J. P., & Hewett, T. E. (2005). Neuromuscular training improves performance and biomechanics in young athletes. *Journal of Strength and Conditioning Research*, 19(1), 51–60. <https://doi.org/10.1519/13643.1>
- Suchomel, T. J., Nimphius, S., & Stone, M. H. (2016). The importance of muscular strength in athletic performance. *Sports Medicine*, 46(10), 1419–1449. <https://doi.org/10.1007/s40279-016-0486-0>
- Markovic, G., & Mikulic, P. (2010). Neuromuscular adaptations to plyometric training. *Sports Medicine*, 40(10), 859–895. <https://doi.org/10.2165/11318370-000000000-00000>
- Turner, A. N., & Jeffreys, I. (2019). The physical preparation of combat sport athletes. *Strength and Conditioning Journal*, 41(4), 1–9. <https://doi.org/10.1519/SSC.0000000000000466>
- Wilk, M., Tufano, J. J., & Zajac, A. (2020). The influence of movement tempo on acute neuromuscular, hormonal, and mechanical responses to resistance exercise—A mini review. *Journal of Strength and Conditioning Research*, 34(8), 2369–2383. <https://doi.org/10.1519/JSC.00000000000003636>
- Nugroho, H., Gontara, S. Y., Angga, P. D., Jariono, G., & Maghribi, I. L. (2021). Quality of physical condition of youth Pencak Silat athletes reviewed from speed, power, and strength. *Kinestetik: Jurnal Ilmiah Pendidikan Jasmani*, 5(1), 154–162. <https://doi.org/10.33369/jk.v5i1.14376>
- Nugroho, D., Susanto, H., & Pratama, R. S. (2021). Physical fitness profile of youth Pencak Silat athletes in Indonesia. *Journal of Physical Education and Sport*, 21(5), 2345–2352. <https://doi.org/10.7752/jpes.2021.05289>
- Suwirman, S., Nugroho, D., & Sari, N. P. (2021). The contribution of physical fitness components to Pencak Silat Tanding performance in adolescent athletes. *IDO Movement for Culture. Journal of Martial Arts Anthropology*, 21(4), 78–86. <https://doi.org/10.14589/ido.21.4.9>
- Nurhidayah, D., Prasetyo, Y., Sutapa, P., Nanda, F. A., Mitsalina, D., & Yuliana, E. (2024). Development of physical test norms for early age Pencak Silat athletes. *Pedagogy of Physical Culture and Sports*, 28(3), 175–183. <https://doi.org/10.15561/26649837.2024.0302>
- Pratama, R. S. (2022). Development of physical conditioning models for youth Pencak Silat athletes aged 14–17 years. *Kinestetik: Jurnal Ilmiah Pendidikan Jasmani*, 6(2), 112–125. <https://doi.org/10.33369/jk.v6i2.21234>
- Slimani, M., Chaabène, H., Miarka, B., & Franchini, E. (2017). The effect of combat sport practice on physical fitness in youth: A systematic review. *Journal of Sports Medicine and Physical Fitness*, 57(6), 828–838. <https://doi.org/10.23736/S0022-4707.16.06357-1>
- Kons, R. L., et al. (2021). Neuromuscular performance in combat sports athletes: A systematic review. *Sports*, 9(3), 1–15. <https://doi.org/10.3390/sports9030031>
- Lafuente, J. C., & Cecilia, Y. (2021). Effects of martial arts and combat sports training on anger and aggression: A systematic review. *Aggression and Violent Behavior*, 58, 101611. <https://doi.org/10.1016/j.avb.2021.101611>
- Rodrigues, A. I. C., et al. (2024). Martial arts and combat sports for youth: A 10-year scoping review. *Journal of Teaching in Physical Education*, 43(4), 664–678. <https://doi.org/10.1123/jtpe.2023-0122>
- Ardigò, L. P., & Padulo, J. (2021). Combat sports: A review on the role of physical fitness in performance. *International Journal of Environmental Research and Public Health*, 18(12), 6489. <https://doi.org/10.3390/ijerph18126489>