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Establishing a Standardized Professional Endurance Assessment Framework for U19 Male Basketball Athletes in Da Nang, Vietnam

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Abstract:

This study presents the development and empirical validation of a multidimensional professional endurance (PE) assessment model tailored for U19 male basketball athletes in Da Nang, Vietnam. Twenty competitive players (17–18 years) completed five basketball specific field tests—20 m multi stage shuttle run (Beep Test), 4 × 28 m dribbling shuttle, 30 s continuous jump, 5 × 27 m dribblelayup sprints, and a five-position jump-shoot sequence—selected via Delphi consensus with 26 national experts (agreement ≥ 80%). Concurrently, direct physiological indices (VO2max, $HR2_{ax}$, VO_2/HR ratio, and minute ventilation) were measured using a Cosmed K4b2 gas analyzer. Raw performance and physiological data were standardized through Z-score transformation to construct a unified 1–10 C-scale, subsequently stratified into six performance tiers from "Poor" to "Excellent." Descriptive statistics characterized cohort norms; Wilcoxon signed-rank tests profiled distributional properties; and Pearson correlation coefficients quantified concordance between indirect and direct VO_2max measures ($\alpha = 0.05$).

Results indicated a mean composite C-score of 5.3 ± 2.3 (out of 10), aligning with an "Average" endurance classification. Indirect VO_2max (Beep Test) averaged 47.9 ± 1.3 ml·kg^{-1}·min^{-1}, while direct measures yielded 48.2 ± 1.2 ml·kg^{-1}·min^{-1}—both falling short of the 52–56 ml·kg^{-1}·min^{-1} elite threshold. Test reliability was high (coefficients of variation: 2.4–14.9%), and indirect–direct VO_2max concordance was robust ($r = 0.98$, $p < 0.001$).

Conclusion: The proposed C-scale assessment framework demonstrates strong validity, reliability, and practical utility for profiling endurance capacities in youth basketball athletes. Coaches and sport scientists can employ this evidence-based tool to inform individualized training interventions—particularly high-intensity interval protocols—to bridge the gap toward elite aerobic performance standards.

Keywords: Professional endurance, U19 basketball, VO2 max, Beep Test, Cosmed K4b2, assessment scale, sports training.

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INTRODUCTION

In professional sports, technical endurance is a core factor that determines performance, especially in sports that require continuous high-intensity movements such as basketball. Professional endurance not only reflects the ability to maintain physical strength throughout the match but also directly affects the athlete's technique, tactics and recovery ability in real competition situations.For the U19 age group – an important transitional stage between youth training and professional competition – assessing and improving passing endurance has great theoretical and practical significance, supporting talent selection, building scientific training plans, and optimizing competition performance.

In Vietnam, basketball is growing, especially in big cities like Da Nang, where the local sports industry is implementing the "Da Nang Sports Development Plan under Action Program No. 09– CTr/TUimplementing resolution no. 08– NQ/TW of Ministry of Politburo (2007). This plan emphasizes the selection and training of talents for key sports of type 1, in which basketball is identified as Da Nang's strength thanks to its tradition and available potential.However, the reality of training young basketball players here is facing many challenges.Training is mainly based on traditional experience, lacking scientific evaluation criteria suitable for specific age groups and sports.This has led to the recent unstable performance of Da Nang U19 athletes, especially in regional and national tournaments.

Worldwide, research on professional endurance in basketball has made great progress, with the widespread use of modern measurement tools such as Cosmed K4b2 and standardized tests such as the Beep Test(Castagna et al., 2010; Léger et al., 1988). These methods allow accurate assessment of physiological indices such asVO2 max, Hrmax, VO2/HR and VE, from which to build personalized training programs, improving competition efficiency. However, in Vietnam, research on PE in basketball is still limited, mainly focusing on technical aspects or general fitness, not paying attention to developing a comprehensive assessment system for each age group and specific sport.

Based on the above situation and the urgent needs of the Da Nang sports industry, this study aims to build a system of standards and a scale to evaluate PE for Da Nang U19 male basketball athletes. Through the application of scientific testing methods and data standardization, the study not only provides a tool to support coaches in assessing physical fitness levels but also contributes to the sustainable development orientation for local basketball, in line with the national strategy on physical education and sports until 2030 and beyond.

METHODOLOGY

The study was conducted on 20 male athletes of the Da Nang U19 basketball team (age 17 – 18), using quantitative methods combined with statistical analysis. The two main tools are Beep Test (20m shuttle run) and Cosmed K4b2 (direct measurement on Treadmill) are applied to evaluate Professional endurance through indicatorsVO2 max, Hrmax, VO2/HR and VE. The process includes: (1) Interviewing 26 experts to select 5 tests (reaching >80% consensus); (2) Experimental testing on 20 athletes; (3) Standardizing data using Z-score, building a C scale (1-10) and classification criteria (Poor, Weak, Average, Fair, Good); (4) Statistical analysis (Mean, SD, Cv%, Wilcoxon, Pearson) using SPSS software. Data was collected in March 2024 at the Da Nang Sports Training Center.

RESULTS

1. Standard system and scale for evaluatingprofessional endurance

Based on expert interviews and the Wilcoxon test (Z = -1.657, Sig. = 0.325 > 0.05), five tests were selected: Beep Test, 28m x 4 Dribbling, 30s Jump, 5 x 27mDribbling and Layup, and 5-position Jump Shot. The classification criteria and C-score scale were constructed based on experimental data (Table 1, Table 2).

Table 1. Classification standards for professional endurance for male athletes U19 Da Nang

Test content	Weak	Average	Fair	Good	Excellent
Beep test (laps)	<74.89	74.89-76.00	76.00-80.22	80.22–81.33	>81.33
28m x 4 dribbling (s)	>29.42	28.75-29.42	27.65-28.75	26.76–27.65	<26.76
30s jumpwith table (times)	<20.74	20.74-24.58	24.58-28.42	28.42–32.26	>32.26
5 x 27mdribbling and layup(s)	>33.75	32.72-33.75	31.70-32.72	30.67–31.70	<30.67
5 - position jump shot (s)	>64.82	63.58-64.82	62.34-63.58	61.10–62.34	<61.10

Table 2. C-score scale (1-10) evaluate professional endurance

Test content	1	2	3	4	5	6	7	8	9	10
Beep test (lap)	<73.83	73.83	74.89	75.94	78.05	79.11	80.16	81.22	82.27	>82.27
28m x 4 dribbling (s)	>29.42	29.42	28.98	28.54	28.09	27.65	27.20	26.76	26.31	<26.31
30s jumpwith table (times)	<20.74	20.74	22.66	24.58	26.50	28.42	30.34	32.26	34.18	>34.18
5 x 27mdribbling and layup (s)	>33.75	33.75	33.24	32.72	32.21	31.70	31.18	30.67	30.15	<30.15
5-position jump shot (s)	>64.82	64.82	64.20	63.58	62.96	62.34	61.72	61.10	60.48	<60.48

The composite score (Table 3) classifies PE into 5 levels:Good (≥45), Fair (35-44), Average (25-34), Weak (20-24), Poor (≤19).

Table 3. Classification of the total score of professional endurance

Classify	Score
Excellent	≥45
Good	35–44
Fair	25–34
Average	20–24
Weak	≤19

2. Current status of the professional endurance of the male U19 Da Nang team

The test results of 20 athletes (Table 4) showed that professional endurance was at an average level, with uniformity but not outstanding.

Table 4. Professional endurance test results (n=20)

Test	Mean	SD	Cv%
Beep test (laps)	77.93	2.04	2.62
28m x 4 dribbling (s)	27.97	1.17	4.18
30s jumpwith table (times)	27.74	4.13	14.89
5 x 27mdribbling and layup (s)	32.08	1.35	4.21
5 - position jump shot (s)	62.67	1.53	2.44

Comments: The mean values ranged from "Fair" to "Good" according to Table 1. The coefficient of variation (Cv%) was low (2.44%-4.21%) in most tests, indicating uniformity among athletes, except for the 30s Jump (Cv% = 14.89%) reflecting large differences in continuous jumping ability, possibly due to individual technique or fitness**.**

Table 5. Total score distribution of professional endurance

Classify	Score	Athletes	(%)
Classify	≥45	2	10
Excellent	35–44	5	25
Good	25–34	8	40
Fair	20–24	2	10
Average	≤19	3	15
Average total score: 26.25 (SD = 11.45, Range: 7-46)			

Comments: The average total score of 26.25 is in the "Average" range, with 40% of athletes at this level, reflecting a stable but not outstanding foundation. The "Good" (10%) and "Fair" (25%) groups have potential for development, while the 15% "Poor" need significant improvement. The large standard deviation (11.45) shows a clear differentiation between athletes.

3. VO2 max status of male basketball players U19 da nang

Table 6. VO2 max from Beep Test and Cosmed K4b2

Parameters	Beep Test	Cosmed K4b2
Mean (ml/kg/min)	47.9	48.2
SD	1.3	1.2
Range	45.9-49.6	45.9-49.5
Hrmax (bpm)	-	204 (200-208)
VO2/HR	-	0.235 (0.225-0.241)
VE (L/min)	-	146.9 (136-157)

The evaluation results using Beep Test and Cosmed K4b2 showed that:

Beep Test (47.9 ml/kg/min):

The average value of 47.9 ml/kg/min is in the "Average" range (45-52 ml/kg/min) according to The Movement System (2021), 4-8 units lower than the "Excellent" threshold (52-56 ml/kg/min). Compared to the NBA professional basketball player standard (50-60 ml/kg/min) (Hoffman, 2006), the team is 2-12 units lower, showing that aerobic endurance does not meet the requirements of high-intensity competition.

The average speed of 13.3 km/h (Level 11-12) is suitable for basketball activities (sprinting, changing direction), but the maximum is only 13.8 km/h, lower than the professional threshold (>14 km/h) (Léger et al., 1988). The small standard deviation (1.3 ml/kg/min) and Cv% 2.62% reflect uniformity, but the maximum value (49.6 ml/kg/min) is still below 50 ml/kg/min, lacking outstanding individuals. The VO2 max threshold achieved is sufficient for average movements, but does not ensure the ability to recover quickly after sprinting or maintain performance at the end of the match, consistent with the record of inconsistent performance (Brooks et al., 2005).

Cosmed K4b2 (48.2 ml/kg/min):

VO2 max 48.2 ml/kg/min is 0.3 units higher than Beep Test, still in the "Average" range, lower than "Excellent" (52-56 ml/kg/min) and NBA athletes (50-60 ml/kg/min) (Hoffman, 2006). The range of 45.9-49.5 ml/kg/min shows that no athlete exceeded the 50 ml/kg/min threshold, similar to Beep Test.

Hrmax (204 bpm): Within the normal range for 17-19 year olds (190-210 bpm) (Åstrand & Rodahl, 2003), reflecting good cardiovascular response to exercise. However, the higher heart rate than professional athletes (190-205 bpm) (Hoffman, 2006) may be due to suboptimal stroke volume, leading to limited oxygen transport efficiency.

VO2/HR (0.235 ml/bpm/kg): Within the optimal range for young athletes (0.23-0.26 ml/bpm/kg) (The Movement System, 2021), but lower than professional athletes (0.28-0.32 ml/bpm/kg) (Hoffman, 2006). This

indicates that the efficiency of oxygen transport per heartbeat is only average, not well supporting short acceleration phases or rapid recovery

VE (146.9 L/min): Lower than professional athletes (>170 L/min) (Hoffman, 2006) and within the range of young athletes (130-160 L/min) (The Movement System, 2021). The range of 136-157 L/min indicates that the respiratory capacity is not fully developed, limiting oxygen supply in continuous exercise situations.

Combining VO2 max, Hrmax, VO2/HR and VE showed that the team could maintain average performance, but recovery and end-game endurance were weak, consistent with actual competition (Costill & Wilmore, 2015).

Comparison of the two methods: The mean error of 0.3 ml/kg/min and the correlation coefficient r = 0.98 show high reliability between Beep Test and Cosmed K4b2. Cosmed provides more detailed cardiovascular and respiratory data, but both indicate suboptimal PE.

DISCUSSIONS

Compared to domestic research, Nguyen Van Hung (2018) recorded the average VO2 max of Vietnamese U18 basketball players as 49.5 ml/kg/min (range 47-52 ml/kg/min), 1.3 units higher than the Da Nang U19 team (48.2 ml/kg/min). Tran Quoc Cuong (2020) reported that the VO2 max of male basketball players at Ho Chi Minh City University of Sports and Physical Education was 50.1 ml/kg/min, 1.9 units higher. This shows that the professional endurance of the Da Nang U19 team is lower than the national average, possibly because training in Da Nang has not applied modern methods such as HIIT or direct physiological measurement, which are popular in large centers (Amasuomo & Okoro, 2019).

Internationally, Castagna et al. (2010) measured the average VO2 max of European U19 athletes as 53.5 ml/kg/min (50-57 ml/kg/min) using a method similar to Cosmed, 5-6 units higher than the Da Nang U19 team. Hoffman (2006) reported that the VO2 max of NBA athletes ranged from 50-60 ml/kg/min, 2-12 units higher. Ben Abdelkrim et al. (2007) recorded the VO2 max of Tunisian U19 basketball players as 51.8 ml/kg/min, 3.6 units higher. Other indicators such as the team's VE (146.9 L/min) were lower than those of European athletes (160-180 L/min) (Castagna et al., 2010) and NBA athletes (>170 L/min) (Hoffman, 2006), while VO2/HR (0.235 ml/beat/kg) was lower than that of European athletes (0.25-0.27) and NBA athletes (0.28-0.32). This gap reflects differences in training strategies: developed countries apply high-intensity training and measurement technology early, while Da Nang still relies on traditional experience.

However, the U19 Da Nang team has an advantage in uniformity (SD 1.2-1.3 ml/kg/min), lower than the variation of European athletes (50-57 ml/kg/min) (Castagna et al., 2010) or Tunisia (49-54 ml/kg/min) (Ben Abdelkrim et al., 2007). This creates conditions for synchronous development if science is applied properly. The main causes of limitations may lie in: (1) lack of intensive training (HIIT, interval running) (Hawley, 2000); (2) not optimizing lung capacity and stroke volume through respiratory exercise (Åstrand & Rodahl, 2003); (3) limited facilities and equipment compared to international standards.

To improve, teams need to learn from European training programs (such as Italy, Spain) with HIIT exercises to increase VO2 max to 52-Deprecation53 ml/kg/min (Castagna et al., 2010), or from the US (NBA) with exercises to increase VE and VO2/HR (Hoffman, 2006). Personalizing training based on the C-scale is also a feasible direction, focusing on developing the "Excellent" group and supporting the "Weak" group.

CONCLUSIONS

The study successfully built a standard system and scale to evaluate professional endurance for male basketball athletes U19 Da Nang based on 5 tests (Beep Test, Dribbling 28m x 4, Jumping 30s, 27m x 5Dribbling and Layup, Jumping to shoot 5 positions) and a C scale (1-10) standardized by Z-score.

The results showed that the overall PE was average (total score 26.25/50), with 40% of athletes at "Average", 25% at "Good", and 10% at "Excellent", reflecting a stable but not outstanding foundation. The average VO2 max was

47.9 ml/kg/min (Beep Test) and 48.2 ml/kg/min (Cosmed K4b2), 4-8 units lower than the international standard (52-56 ml/kg/min), indicating that aerobic endurance needs improvement.

It is recommended to use high intensity interval training (HIIT) and deep breathing to increase VO2 max to 52-53 ml/kg/min, which will increase regional competitiveness.

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