

Correlation between VO2max Capacity and Movement Skills in the Standard Single Form of Pencak Silat Athletes

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Abstract

This study aimed to examine the relationship between VO2max capacity and motor skill performance in the pencak silat standard single form (jurus tunggal baku) among athletes of Perguruan Empat Banding Budi Air Tawar Timur, Padang, Indonesia. A quantitative correlational design was used, involving 20 athletes (8 adolescents, 12 adults) selected through purposive sampling. VO2max was measured using the Multistage Fitness Test (Léger Bleep Test), while motor skill was assessed with the official 2026 Indonesian Pencak Silat Association (IPSI) standard single-form scoring sheet, covering correctness and steadiness aspects. Data were analyzed descriptively, tested for normality (Shapiro-Wilk) and linearity, and then examined using Pearson product-moment correlation and simple linear regression in Jamovi. The average VO2max was 34.67 ± 5.19 ml/kg/min and the average skill score was 9.844 ± 0.044 . Both variables were normally distributed ($p > 0.05$) and linearly related ($p = 0.172$). Pearson correlation revealed a strong, significant, positive relationship ($r = 0.846$, $p < 0.001$), with VO2max explaining 71.6% of the variance in skill scores ($R^2 = 0.716$). VO2max capacity is strongly and significantly associated with motor skill performance in the pencak silat standard single form, underscoring the importance of integrating cardiorespiratory endurance training into technical coaching programs.

Keywords VO2max, Motor Skill, Pencak Silat, Tunggal Baku, Correlational Study

1. Introduction

Pencak silat is one of Indonesia's cultural heritages that has developed into a competitive sport contested at regional, national, and international levels [1]. In line with Law of the Republic of Indonesia Number 11 of 2022 concerning Sport, athlete development must be carried out in a planned, systematic, integrated, tiered, and sustainable manner, supported by sport science and technology [2]. Improving pencak silat athletes' achievement therefore requires research that identifies the factors influencing their performance.

Under the 2026 regulations of the Indonesian Pencak Silat Association (IPSI), matches are divided into the sparring (tanding) category and the artistic form (jurus) category [3]. The form category emphasizes an athlete's ability to perform a prescribed sequence of movements correctly and steadily, and the standard single form (jurus tunggal baku) is one of its most demanding events because athletes must perform the complete bare-hand, machete (golok), and staff (toya) sequences accurately and firmly [3]. Judging in this event is based on two main

components: correctness, covering technique, direction, and sequence accuracy, and steadiness, covering movement stability, rhythm, power, stamina, and expressiveness [3]. Athletes are therefore required not only to memorize the sequence but also to sustain movement quality consistently from the beginning to the end of the performance.

Motor skill refers to an athlete's capacity to perform movements accurately, in a coordinated, effective, and consistent manner [4]. Because the standard single form lasts approximately three minutes without interruption, athletes must maintain coordination, balance, rhythm, strength, and concentration throughout; any decline in these components can reduce the judges' scores [5].

One physical factor presumed to relate to motor skill performance is cardiorespiratory endurance, commonly measured through VO2max, which reflects the maximal capacity of the body to take up, transport, and utilize oxygen during physical activity [6]. Athletes with higher VO2max are generally better able to sustain energy supply, delay fatigue, and preserve movement quality until the performance ends.

Optimal performance in the standard single form is

generally understood to depend on the interaction of several biomotor components, including strength, speed, flexibility, balance, and endurance, which together support the technical execution and physical conditioning of an athlete throughout a training cycle [7]. Among these components, cardiorespiratory endurance is considered particularly relevant to events performed continuously over several minutes, because it determines how long an athlete can sustain near-maximal effort before performance quality begins to decline. This theoretical link provides the basis for examining VO₂max specifically in relation to standard single-form motor skill in the present study.

Preliminary observation at Perguruan Empat Bending Budi Air Tawar Timur indicated that, although most athletes performed the early sequence well, a decline in movement quality—reduced power, inconsistent rhythm, less smooth transitions, and weakening balance—became apparent from the machete to the staff sequence. Coaches attributed this pattern to suboptimal cardiorespiratory endurance, as training has traditionally emphasized technical mastery over physical conditioning.

Prior research supports the relevance of VO₂max to pencak silat performance. Mardius [8] reported that VO₂max, together with agility, contributed to single-form skill among athletes in Padang City, although that study combined VO₂max with another physical variable and did not isolate its relationship with skill under the current 2026 IPSI regulations. Other studies have examined physical condition and technique in pencak silat athletes [9] and analyzed single-form performance more broadly [10], yet a specific study on the relationship between VO₂max and standard single-form motor skill under the newest competition regulation at Perguruan Empat Bending Budi Air Tawar Timur has not been found, indicating a research gap that warrants further investigation.

This study therefore aimed to examine (1) the VO₂max capacity, (2) the motor skill level in the standard single form, and (3) the relationship between VO₂max capacity and motor skill among athletes of Perguruan Empat Bending Budi Air Tawar Timur. The findings are expected to provide coaches with empirical evidence for designing training programs that balance technical and physical conditioning components, while enriching the sport science literature on pencak silat.

2. Materials and Methods

2.1. Research Design

This study employed a quantitative correlational design [11], which aims to determine whether a relationship exists, and how strong that relationship is, between two variables without administering any treatment to the subjects [12]. No intervention was given to the athletes; the researcher only measured VO₂max capacity and standard single-form motor skill, and then analyzed the relationship between the two variables. Conceptually, the design can be depicted as $X \rightarrow Y$, where X denotes VO₂max capacity (the independent variable) and Y denotes standard single-form motor skill (the dependent

variable).

2.2. Place and Time

The study was conducted in July 2026 at Perguruan Empat Bending Budi Air Tawar Timur, Padang City, West Sumatra, Indonesia. This site was selected because the institution actively develops athletes and regularly participates in pencak silat championships, particularly in the form category, and because preliminary observation revealed variation in single-form motor skill presumably related to athletes' physical condition.

2.3. Population and Sample

The population comprised 30 single-form pencak silat athletes training at the institution. Using a purposive sampling technique [13], 20 athletes who actively practiced the standard single form were selected as the sample, consisting of 8 adolescent athletes (14–16 years) and 12 adult athletes (17–45 years).

2.4. Research Variables and Instruments

Two variables were examined: VO₂max capacity as the independent variable (X) and standard single-form motor skill as the dependent variable (Y). VO₂max was measured using the Multistage Fitness Test (MFT), also known as the Bleep Test, developed by Léger et al. [14] and recommended by the American College of Sports Medicine as a valid field test for cardiorespiratory fitness [15]. The test required athletes to perform 20-metre shuttle runs at a progressively increasing pace dictated by an audio signal until volitional exhaustion; the final completed level and shuttle were converted into VO₂max scores (ml/kg/min) using the standard Léger conversion table.

Motor skill in the standard single form was assessed using the official 2026 IPSI standard single-form scoring sheet [3], administered by certified judges. The instrument evaluates two components: correctness (movement sequence, bare-hand technique, machete technique, staff technique, and movement direction) and steadiness (stability, balance, power, stamina, rhythm, and expressiveness). The sum of both components constituted each athlete's skill score. Both instruments are officially standardized tools with established validity and reliability: the MFT shows a strong correlation with laboratory-based VO₂max measurement [14,15], while the IPSI scoring sheet possesses content validity as the officially mandated national judging instrument [3].

2.5. Instrument Validity and Reliability

Both instruments used in this study have established validity and reliability. The MFT developed by Léger et al. [14] demonstrates strong criterion validity because its results correlate highly with laboratory-based VO₂max measurement using gas-analyzer methods, and the American College of Sports Medicine recommends it as a valid field test for cardiorespiratory fitness assessment [15]. Its reliability is maintained when the standard protocol is followed consistently, including the use of a 20-metre track, identical audio pacing, uniform instructions, and comparable testing conditions [14,15].

The standard single-form scoring sheet is the officially mandated instrument used in national and international

pencak silat competitions and therefore possesses strong content validity, as it was developed and ratified by the national governing body based on the correctness and steadiness criteria applied in actual competition [3]. Its reliability is supported by the use of certified judges who apply the same standardized scoring guidelines, reducing subjectivity in the assessment of athletes' performance.

2.6. Data Analysis Technique

Data were analyzed with Jamovi software [16] through three stages. First, descriptive statistics (N, minimum, maximum, mean, and standard deviation) were computed for both variables. Second, prerequisite tests were performed, comprising the Shapiro-Wilk normality test [17] and a linearity test based on the deviation-from-linearity F statistic [18]. Third, hypothesis testing was conducted using Pearson product-moment correlation, followed by simple linear regression to determine the coefficient of determination (R^2) and the regression equation. The decision criterion for both the correlation and regression analyses was a significance level of $p < 0.05$.

3. Results and Discussion

3.1. Descriptive Statistics

Data were obtained from 20 athletes. VO2max ranged from 21.2 to 43.6 ml/kg/min, with a mean of 34.67 (SD=5.19), while motor skill scores ranged from 9.715 to 9.915, with a mean of 9.844 (SD=0.044), as shown in Table 1. The comparatively small variation in skill scores relative to VO2max suggests a narrow but potentially meaningful performance range among the sampled athletes.

Table 1. Descriptive Statistics of VO2max and Motor Skill (N=20)

Variable	N	Min	Max	Mean	SD
VO2max	20	21.2	43.6	34.67	5.19
Motor Skill	20	9.715	9.915	9.844	0.044

Source: Research data processed with Jamovi.

Grouping the VO2max scores into five intervals (Table 2) showed that the highest frequency occurred in the 36–40 ml/kg/min interval (9 athletes, 45%), while the lowest occurred in the 21–25 ml/kg/min interval (1 athlete, 5%), indicating that most athletes possessed moderate-to-good cardiorespiratory endurance.

Table 2. Frequency Distribution of VO2max

Interval (ml/kg/min)	f	%
21–25	1	5
26–30	4	20
31–35	3	15
36–40	9	45
41–45	3	15
Total	20	100

Source: Research data.

3.2. Prerequisite Tests

The Shapiro-Wilk test indicated that both VO2max ($W=0.945$, $p=0.294$) and motor skill ($W=0.915$, $p=0.080$) were normally distributed ($p > 0.05$), while the linearity test showed no significant deviation from linearity ($F=2.070$,

$p=0.172$), confirming that the relationship between the two variables met the linear assumption required for Pearson correlation (Table 3).

Table 3. Normality and Linearity Test Results

Test	Statistic	p	Conclusion
Shapiro-Wilk (VO2max)	$W=0.945$	0.294	Normal
Shapiro-Wilk (Motor Skill)	$W=0.915$	0.080	Normal
Linearity (Lack of Fit)	$F=2.070$	0.172	Linear

Source: Research data processed with Jamovi.

3.3. Hypothesis Testing

Pearson correlation analysis revealed a strong, significant, positive relationship between VO2max and motor skill ($r=0.846$, $p < 0.001$), leading to the rejection of H_0 and the acceptance of H_a (Table 4). Simple linear regression produced $R^2=0.716$, indicating that variation in VO2max accounted for approximately 71.6% of the variance in motor skill scores, with the regression equation $Y = 9.598 + 0.0071X$, where Y denotes motor skill and X denotes VO2max.

Table 4. Pearson Correlation and Simple Linear Regression Results

N	r	R^2	p
20	0.846	0.716	<0.001

Source: Research data processed with Jamovi.

3.4. Discussion

The results confirm a strong positive relationship between VO2max capacity and standard single-form motor skill, consistent with the notion that cardiorespiratory endurance underlies an athlete's capacity to sustain movement quality throughout a demanding routine [6]. The standard single form requires athletes to execute a continuous sequence of bare-hand, machete, and staff techniques for approximately three minutes without pause, drawing heavily on stamina, balance, coordination, and strength [3]. A higher VO2max enables more efficient oxygen uptake, transport, and utilization, supporting sustained energy production and delaying the onset of fatigue [6]. As fatigue accumulates, athletes commonly experience declines in stance stability, hand-foot coordination, movement power, and rhythm—precisely the components judged under the steadiness criterion of the IPSI scoring system [3]. The present findings are consistent with Mardius [8], who similarly found VO2max to be associated with single-form skill among athletes in Padang City, and extend that work by isolating VO2max as a standalone predictor under the newest competition regulation.

The coefficient of determination ($R^2=0.716$) indicates that VO2max accounts for a substantial share of skill variance, yet approximately 28.4% remains attributable to other factors not examined in this study, such as technical mastery, coordination, flexibility, strength, speed, training experience, concentration, and psychological readiness [9]. This finding should not be interpreted causally, given the correlational design employed; rather, it indicates that VO2max is one of several interrelated components contributing to overall performance quality [4].

From a practical standpoint, these results suggest that technical training in the standard single form should be

complemented by structured cardiorespiratory conditioning. Training modalities such as interval training, fartlek, and circuit training [7] may be incorporated into coaching programs, tailored to the roughly three-minute performance duration characteristic of the event, to help athletes preserve technical quality throughout their routines.

This study has several limitations. The sample was limited to 20 athletes from a single local institution, which may constrain the generalizability of the findings to other pencak silat organizations. Psychological factors such as anxiety and motivation during testing were not controlled, and the physical condition variable was restricted to VO₂max, excluding other biomotor components such as flexibility, balance, and agility that may also influence single-form performance.

Taken together, these findings carry practical implications for coaching management at Perguruan Empat Bending Budi Air Tawar Timur and similar institutions. Coaches are encouraged to schedule periodic cardiorespiratory evaluation, for instance every one to two months using the MFT, so that endurance development can be monitored alongside technical progress before athletes are entered into official championships. At the same time, athletes themselves are encouraged to take ownership of their physical conditioning, recognizing that precise and expressive technique cannot be sustained through the closing moments of a routine without adequate cardiorespiratory reserve. For sport science research, the findings reinforce the value of examining physical-condition components alongside technical skill when evaluating performance in artistic pencak silat categories.

4. Conclusion

Based on the results and discussion, it can be concluded that (1) the athletes' average VO₂max capacity was 34.67 ml/kg/min, classified within a moderate-to-good range; (2) the average standard single-form motor skill score was 9.844, indicating a generally high level of skill among the sampled athletes; and (3) VO₂max capacity has a strong, significant, and positive relationship with standard single-form motor skill ($r=0.846$, $p<0.001$), accounting for approximately 71.6% of its variance ($R^2=0.716$). These findings underscore the importance of integrating cardiorespiratory endurance training into the technical coaching of pencak silat athletes, particularly for the standard single-form event, to help them sustain movement quality throughout the performance. Future research is recommended to involve larger and more diverse samples and to incorporate additional biomotor and psychological variables to provide a more comprehensive understanding of the determinants of single-form motor skill.

Recommendations

Based on the conclusions above, several recommendations are proposed for coaches, athletes, and future researchers. Coaches at Perguruan Empat Bending

Budi Air Tawar Timur are advised to design a more structured physical training program aimed at improving athletes' VO₂max, for example through interval training, fartlek, or circuit training adapted to the roughly three-minute duration of the standard single-form performance, and to conduct periodic physical evaluation using the MFT at least once every one to two months to monitor athletes' endurance development before they compete in official championships.

Athletes are encouraged to build greater awareness of the importance of independent physical conditioning, particularly in maintaining and improving cardiorespiratory endurance, because refined and precise technique cannot be executed to its full potential in the closing moments of a routine without adequate VO₂max-supported stamina.

Future researchers are encouraged to expand the scope of this study, given that VO₂max explained approximately 71.6% of the variance in motor skill while roughly 28.4% remained attributable to other factors. Subsequent studies could examine additional biomotor components such as flexibility, dynamic balance, and muscular strength, as well as psychological factors such as competitive anxiety, and could involve larger and more diverse samples spanning multiple pencak silat institutions to strengthen the generalizability of the findings.

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