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A 2d kinematic analysis of front kick speed in pencak silat athletes from south lampung regency

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ABSTRACT
This study aimed to describe the kinematic characteristics of front kick speed in regional level Pencak Silat athletes from South Lampung Regency preparing for the 10th Lampung Provincial Sports Week (PORPROV X) in 2026. A quantitative descriptive approach was employed involving ten athletes (six males and four females) who were actively participating in a centralized training program. Front kick performance was recorded using a high-speed Fujifilm X-T4 camera at 240 frames per second with a 50 mm focal length lens to minimize perspective distortion. The recorded videos were analyzed using Kinovea 2025.1.1 software through two-dimensional kinematic analysis. The measured variables included kick displacement, execution time, and average kick speed. The results showed that male athletes achieved higher average front kick speeds (2.75 m/s) than female athletes (2.33 m/s), primarily due to shorter execution times rather than greater displacement. Overall, performance was characterized by adequate movement range but lower temporal efficiency compared to values reported in elite athletes, indicating that execution time is a key determinant of front kick speed at the regional level. This study contributes to the biomechanics of Pencak Silat by providing empirical kinematic data at the provincial level and identifying execution time as a primary performance-limiting factor. These findings offer a biomechanical basis for targeted training interventions focusing on neuromuscular coordination, explosive strength, and movement acceleration. It can be concluded that improving temporal efficiency is critical to enhancing front kick performance. Future studies should incorporate larger samples and three-dimensional analysis for a more comprehensive understanding.
Keywords: biomechanics; pencak silat; kick; speed; kinematic

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INTRODUCTION

Pencak Silat is a combat sport that relies heavily on effective attacking and defensive techniques, where scoring opportunities are often determined within very short time windows during sparring exchanges (Nugroho, 2020; Soni et al., 2022). In match situations, scoring opportunities occur within very brief temporal windows, where successful attacks must be executed before the opponent can perceive, process, and respond to the stimulus. Human reaction time to visual stimuli typically ranges between ~200–300 ms (Schimdt & Lee, 2014), meaning that faster kicking actions can exceed the opponent's response capacity and increase scoring probability. Among the various kicking techniques, the front kick is frequently used due to its direct trajectory, rapid execution, and effectiveness in reaching the target while maintaining postural stability (Jamal et al., 2024). Successful execution of this technique therefore depends not only on technical accuracy but also on the ability to generate high movement velocity within a short time interval, as higher kick speed reduces interception likelihood, limits defensive counteractions, and enhances scoring efficiency. Consequently, kick speed represents a critical performance indicator in competitive Pencak Silat (Ahmad et al., 2024; Febrianta et al., 2025).

From a biomechanical perspective, movement performance in Pencak Silat can be systematically analyzed using kinematic approaches, which describe motion characteristics such as displacement, time, and velocity without considering the underlying forces (Coman, 2020; Irawan et al., 2021). Kinematic analysis of kicking techniques has been shown to provide objective indicators of movement efficiency and technical quality, particularly in striking-based sports (Doewes et al., 2022). The increasing use of two-dimensional (2D) video-based motion analysis offers a practical and cost-effective method for evaluating athletic performance in applied training environments (Hölbling et al., 2020).

Previous studies examining front kick kinematics in Pencak Silat have predominantly focused on elite or international-level athletes (Doewes et al., 2022; Irawan et al., 2021; Syaifullah & Maghribi, 2023). These studies consistently report that higher-level athletes exhibit more efficient movement patterns and optimized execution timing, contributing to superior kick speed. However, these findings present a limitation in practical application, as they may not accurately reflect the biomechanical characteristics of athletes at lower competitive levels. The direct adoption of elite-based benchmarks for regional athletes risks creating unrealistic performance targets and less effective training interventions.

Despite the growing body of research on kinematic analysis in Pencak Silat, there is a noticeable gap in studies that focuses on regional-level athletes who are actively preparing for provincial competitions. Athletes at this level often represent a critical developmental stage, where biomechanical evaluation can play a strategic role in performance enhancement and injury prevention. Furthermore, limited research has documented front kick kinematic parameters in training center environments, where standardized training programs are implemented over extended preparation periods. Addressing this gap is essential to provide empirical data that is contextually relevant for coaches and practitioners working at the provincial level. Biomechanical data obtained from regional-level athletes is therefore needed to establish realistic performance benchmarks and to support the development of evidence-based training interventions tailored to provincial competition demands.

The novelty of this study lies in its focus on regional-level athletes within a real training camp environment, providing context-specific kinematic data that has been largely underreported in the

literature. By generating empirical benchmarks based on provincial-level competitors, this study offers more applicable references for coaches and practitioners compared to elite-centered data.

Therefore, this study aims to describe the kinematic characteristics of front kick speed in regional-level Pencak Silat athletes from South Lampung Regency who are preparing for the 10th Lampung Provincial Sports Week (PORPROV X) in 2026. Specifically, this research seeks to quantify front kick displacement, execution time, and resulting speed using two-dimensional video-based motion analysis. The findings are expected to contribute baseline kinematic data for provincial-level athletes and support evidence-based coaching practices in Pencak Silat training programs.

METHOD

This research uses a quantitative descriptive method. The subjects of this study were 10 regional-level Pencak Silat athletes from South Lampung Regency who were undergoing a centralized training program (training center) in preparation for the 10th Lampung Provincial Sports Week (Pekan Olahraga Provinsi X Lampung) in 2026. The sample included 6 male athletes and 4 female athletes. A purposive sampling technique was employed, in which participants were intentionally selected based on specific criteria relevant to the objectives of the study**.** Inclusion criteria required athletes to be actively training, free from lower-extremity injuries, and officially registered as members of the South Lampung Pencak Silat contingent. This research was conducted at the South Lampung Pencak Silat Training Center, South Lampung.

Research Instruments

The primary instrument in this study was a high-speed digital video recording system. Motion data were captured using a Fujifilm X-T4 camera capable of recording at 240 frames per second. This high frame rate was selected to allow precise identification of temporal events during the execution of the front kick movement. The camera was equipped with a 50 mm focal length lens to reduce perspective distortion and maintain consistent spatial scaling across the movement plane (Rimmasch, 2017).

The recorded videos were subsequently processed and analyzed using Kinovea software version 2025.1.1. A two-dimensional (2D) kinematic analysis approach was applied, in which the athlete's movement was projected onto a single observation plane. This approach is commonly employed in biomechanical studies to quantify linear motion variables when the movement predominantly occurs within a defined plane, as adopted in previous front kick kinematic analyses. The specifications and functions of the research instruments used in this study are summarized in Table 1.

Table 1. Specifications and Functions of Research Instruments

No.	Instrument	Technical Specifications	Function	Data Output
1	Fujifilm X-T4 Camera	240 fps, 50 mm lens	Capture front kick motion with high temporal resolution	High-speed video (frame-by-frame)
2	Tripod	Fixed and stable position	Maintain camera stability and consistent angle	Stable recording
3	Kinovea Software (v2025.1.1)	2D motion analysis	Analyze kinematic variables from recorded video	Time, displacement, velocity data

Test Process

Prior to data collection, all participants performed a standardized warm-up for approximately 15 minutes, consisting of general mobility exercises and dynamic movements relevant to Pencak Silat kicking techniques. After the warm-up session, each athlete was positioned in a predetermined stance within the prepared testing area.

Participants were instructed to execute the front kick technique using their dominant leg, aiming at a fixed target positioned at a consistent height. Each athlete performed two valid front kick trials with maximal effort, executed individually to avoid interference or visual obstruction. Adequate rest was provided between trials to minimize the effects of fatigue.

The camera was positioned perpendicular to the plane of motion at a fixed distance from the athlete to ensure consistent video capture conditions across all subjects. This procedure followed the same experimental logic as previous kinematic front kick studies (Syaifullah & Maghribi, 2023), while adapting the execution to the regional-level athlete population involved in this research.

Motion Kinematics Parameters

Kinematic analysis focused on linear motion parameters of the front kick. Video calibration was performed by converting pixel displacement into real-world distance units using a known reference length within the recording area (Kinovea, 2021).

The displacement of the kicking foot was measured from the initial position at the start of the kicking phase to the point of maximal extension at impact. Kick duration was determined by identifying the time interval between the initiation of foot movement and the moment of target contact.

Front kick speed was calculated using the ratio of displacement to movement time, expressed in the following equation:

$$v = \frac{s}{t}$$

where v is kicking speed (m/s), s is displacement (m), and t is execution time (s).

For each athlete, the mean values of distance, time, and speed were derived from two trials to represent individual performance characteristics. This analytical framework follows the same kinematic principles applied in earlier studies while being implemented independently within the context of the present sample.

RESULTS

The results of the kinematic analysis of the front kick technique in Pencak Silat athletes from South Lampung Regency are presented based on displacement, execution time, and average speed variables. Data were analyzed separately for male and female athletes to describe performance characteristics.

Front Kick Kinematic Characteristics of Male Athletes

Six male athletes performed two front kick trials each, from which average displacement, time, and speed values were calculated. The average displacement of the male group ranged from 1.70 m to 1.88 m, with a group mean of approximately 1.81 m. The average execution time varied between 0.562 s and 0.762 s, indicating noticeable inter-individual variation in kick duration. Test results in male athletes can be seen in table 2.

Table 2. Kinematic Parameters for Male Participants

No.	Participants	Avg Displacement (m)	Avg Time (s)	Avg Speed (m/s)
1	M1	1.84	0.641	2.87
2	M2	1.70	0.675	2.52
3	M3	1.83	0.595	3.08
4	M4	1.81	0.737	2.46
5	M5	1.88	0.762	2.47
6	M6	1.77	0.562	3.15

The descriptive statistical analysis of male athletes' front kick performance is presented in terms of mean, standard deviation, and distributional measures. The average displacement was 1.805 ± 0.06 m, with values ranging from 1.70 m to 1.88 m, indicating relatively low variability among participants. The interquartile range (Q1 = 1.75 m; Q3 = 1.85 m) further suggests a consistent performance distribution. The average execution time was 0.662 ± 0.08 s, with a minimum of 0.56 s and a maximum of 0.76 s, reflecting moderate variability in movement duration. The median value (0.66 s) indicates a relatively symmetric distribution. Meanwhile, the average front kick speed reached 2.758 ± 0.32 m/s, with a range between 2.46 m/s and 3.15 m/s. The wider spread and interquartile range (Q1 = 2.47 m/s; Q3 = 3.10 m/s) indicate greater inter-individual variability in speed compared to displacement and execution time. A comprehensive summary of the descriptive statistics is presented in Table 3.

Table 3. Summary of the Descriptive Statistics for Male Participants

No.	Variable	N	Mean	Standard Deviation	Min	Q1	Median	Q3	Max
1	Avg Displacement	6	1.805	0.062	1.7	1.752	1.82	1.85	1.88
2	Avg Time	6	0.662	0.078	0.562	0.586	0.658	0.743	0.762
3	Avg Speed	6	2.758	0.315	2.46	2.467	2.695	3.097	3.15

Front Kick Kinematic Characteristics of Female Athletes

Four female athletes were included in the analysis. The average displacement values ranged from 1.63 m to 1.94 m, with an estimated group mean of 1.76 m. Execution time for the female athletes showed values between 0.694 s and 0.795 s, which were generally longer than those observed in the male group. Test results in female athletes can be seen in table 4.

Table 4. Kinematic Parameters for Female Participants

No.	Participants	Avg Displacement (m)	Avg Time (s)	Avg Speed (m/s)
1	F1	1.63	0.795	2.05
2	F2	1.71	0.694	2.46
3	F3	1.94	0.762	2.55
4	F4	1.76	0.783	2.25

The descriptive statistical analysis of female athletes' front kick performance shows that the mean displacement was 1.76 ± 0.13 m, with values ranging from 1.63 m to 1.94 m, indicating greater variability compared to the male group. The interquartile range (Q1 = 1.65 m; Q3 = 1.90 m) suggests a moderate spread distribution. The average execution time was 0.758 ± 0.05 s, with a minimum of

0.69 s and a maximum of 0.80 s, reflecting relatively consistent performance among participants, as also indicated by the narrow interquartile range (Q1 = 0.71 s; Q3 = 0.79 s). Meanwhile, the average front kick speed was 2.327 ± 0.22 m/s, with values ranging from 2.05 m/s to 2.55 m/s. The distribution of speed (Q1 = 2.10 m/s; Q3 = 2.53 m/s) indicates moderate variability among athletes. A comprehensive summary of these descriptive statistics can be seen in Table 5.

Table 5. Summary of the Descriptive Statistics for Female Participants

No.	Variable	N	Mean	Standard Deviation	Min	Q1	Median	Q3	Max
1	Avg Displacement	4	1.76	0.131	1.63	1.65	1.735	1.895	1.94
2	Avg Time	4	0.758	0.045	0.694	0.711	0.772	0.792	0.795
3	Avg Speed	4	2.327	0.223	2.05	2.1	2.355	2.527	2.55

Comparison Between Male and Female Groups

When comparing group averages, male athletes demonstrated a higher mean front kick speed (2.758 ± 0.32 m/s) than female athletes (2.33 ± 0.22 m/s). Male athletes also showed slightly greater displacement (1.805 ± 0.06 m vs. 1.76 ± 0.13 m) and shorter execution times (0.66 ± 0.08 s vs. 0.76 ± 0.05 s). The larger standard deviation observed in male athletes, particularly in speed, indicates greater inter-individual variability compared to female athletes. These results are clearly presented in Table 6.

Table 6. Average Kinematic Parameters for Male & Female Participants

No.	Gender	Avg Displacement (m)	Avg Time (s)	Avg Speed (m/s)
1	Male	1.805 ± 0.06	0.662 ± 0.08	2.758 ± 0.32
2	Female	1.76 ± 0.13	0.759 ± 0.05	2.327 ± 0.22

Figure 1 presents the comparison of mean displacement, execution time, and front kick speed between male and female athletes. Male athletes showed higher mean speed values, while female athletes demonstrated longer execution times.

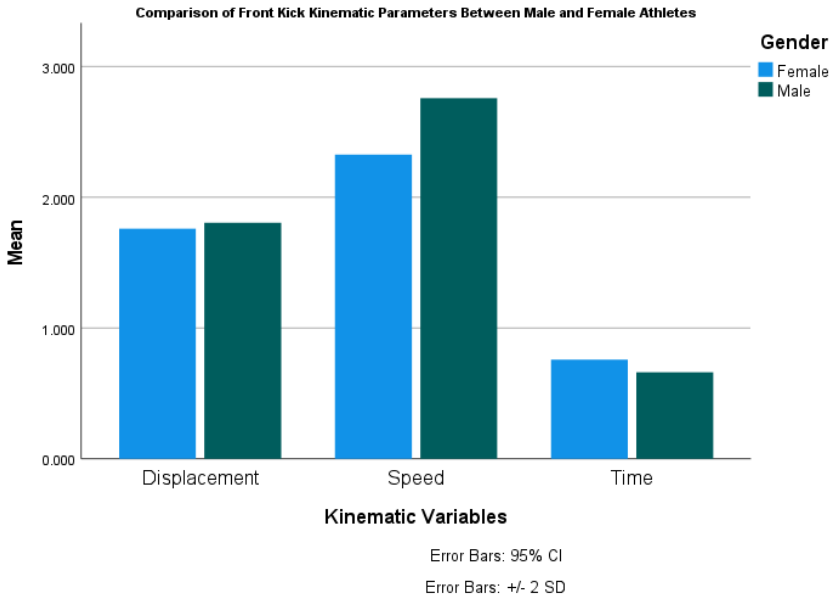

Figure 1. Bar Chart of Average Kinematic Parameters for Male & Female Participants

DISCUSSION

This study examined the kinematic characteristics of the front kick technique in regional level Pencak Silat athletes preparing for provincial competition. The main findings indicate that front kick speed in this athlete group is characterized by moderate displacement values, relatively longer execution times, and lower average speeds compared to values commonly reported in elite-level athletes. In addition, male athletes demonstrated higher front kick speeds than female athletes, primarily associated with differences in execution time rather than displacement.

From a biomechanical perspective, front kick speed is the result of the interaction between movement distance and execution time. The present findings suggest that the relatively lower kick speeds observed in the South Lampung athletes are mainly influenced by longer movement durations, indicating that temporal efficiency plays a more critical role than displacement in determining front kick velocity at the provincial level. This aligns with kinematic principles stating that improvements in striking speed are more strongly associated with reductions in movement time than with increases in movement range (Wąsik et al., 2021).

When compared with previous studies involving world champion and national level Pencak Silat athletes, the front kick speeds observed in this study appear lower (Syaifullah & Maghribi, 2023). Elite athletes have been reported to achieve higher kick velocities through more efficient proximal-to-distal coordination and refined neuromuscular timing (Fuchs et al., 2018; Serrien & Baeyens, 2018). The discrepancy highlights the role of skill level and training background in shaping kinematic performance (Moreno et al., 2023). Athletes at the provincial level may possess sufficient range of motion but have not yet optimized intersegmental coordination and movement sequencing required for maximal speed production.

Gender-related differences observed in this study are consistent with findings from combat sport biomechanics literature (Vannatta & Kernozek, 2021). Male athletes generally exhibit higher kick speeds due to greater muscle strength, faster contraction velocity, and more effective force transmission through the kinetic chain. Female athletes, while demonstrating comparable displacement values, tended to require longer execution times, which consequently reduced average speed (Boyne et al., 2024). These findings suggest that performance enhancement programs for female athletes should emphasize neuromuscular speed and explosive strength rather than increasing movement amplitude.

An important practical implication of this study is its relevance to athlete development at the regional level. Unlike studies focusing on elite performers, the present findings provide context-specific kinematic benchmarks for provincial athletes undergoing centralized training. Such data are particularly valuable for coaches in designing training interventions that target time-related variables, such as reaction speed, leg drive acceleration, and coordination efficiency, rather than solely focusing on technical forms or flexibility (Dos'santos et al., 2021).

It should also be acknowledged that this study employed two-dimensional motion analysis, which assumes that movement occurs primarily within a single plane (Edriss et al., 2025). Although this approach is widely accepted and practical for field-based analysis, it may not fully capture out-of-plane movements inherent in front kick execution (Leporace et al., 2023). Consequently, small measurement biases related to perspective and depth displacement cannot be entirely excluded (Michelini et al., 2020). Future studies may benefit from incorporating multi-camera or three-dimensional motion analysis to provide a more comprehensive understanding of front kick biomechanics (Li et al., 2025). In addition, the integration of mechanical or kinematic feedback systems, such as real-time velocity, joint angle, or acceleration feedback, may also be valuable for

enhancing both measurement accuracy and training effectiveness by enabling athletes and coaches to make immediate, evidence-based technical adjustments (Abdulqader & Naji, 2025; Chang, 2025; Iskandar & Rustanto, 2025; Leinen & Panzer, 2024; Umek et al., 2017; Weakley & García-Ramos, 2025).

In summary, the present study demonstrates that front kick performance in regional level Pencak Silat athletes is primarily limited by temporal execution efficiency rather than movement range. The observed differences between male and female athletes further emphasize the influence of neuromuscular and physiological factors on kick speed. These findings contribute meaningful biomechanical insights for provincial-level training programs and support the use of video-based kinematic analysis as an effective tool for performance evaluation and development.

CONCLUSION

This study concludes that the front kick performance of regional-level Pencak Silat athletes from South Lampung Regency is characterized by moderate kinematic efficiency, where kick speed is predominantly determined by execution time rather than movement displacement. Although athletes generally demonstrate an adequate range of motion, limitations in temporal efficiency during the kicking phase reduce the ability to generate higher kick velocity. Differences in performance were observed between male and female athletes, with male athletes showing superior speed characteristics, likely due to greater neuromuscular capacity and more effective movement coordination rather than differences in technical execution alone.

Practically, these findings provide baseline kinematic reference values for Pencak Silat athletes preparing for provincial-level competitions and underline the importance of optimizing movement timing and acceleration patterns in front kick execution. Coaches and practitioners are advised to implement training interventions focused on explosive strength, neuromuscular coordination, and movement speed to enhance performance. Future studies should involve larger sample sizes, incorporate additional kinematic variables, and employ three-dimensional motion analysis to achieve a more comprehensive understanding of front kick biomechanics in Pencak Silat.

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CONFLICT OF INTEREST

The authors state that there is no conflict of interest in this study.

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