Associations of lower limb muscle strength and body reaction time with crescent kick performance in competitive pencak silat athletes

Jery Setiawan[1*,A-F], Siti Baitul Mukarromah[1,A,E,F]

[1] Department of Sport Science, Faculty of Sports Science, Universitas Negeri Semarang, Semarang, Indonesia

***Corresponding author:** Jery Setiawan'; Universitas Negeri Semarang, Semarang, Indonesia; email: jerysetiawan2512@students.unnes.ac.id

Received: 2026-06-20
Accepted: 2026-08-08
Published: 2026-08-18

A – Research concept and design
B – Collection and/or assembly of data
C – Data analysis and interpretation
D – Writing the article
E – Critical revision of the article
F – Final approval of article

ABSTRACT

Background: Crescent kick performance is an important technical component of competitive pencak silat and may be associated with physical capacities such as lower limb muscle strength and reaction time. However, evidence regarding the relationships of these physical characteristics with crescent kick performance remains limited.

Objectives: This study aimed to examine the associations of lower limb muscle strength and body reaction time with crescent kick performance among competitive pencak silat athletes.

Methods: This quantitative correlational study involved 30 competitive pencak silat athletes (age: 19.8 ± 2.1 years; height: 168.4 ± 6.3 cm; body mass: 61.7 ± 8.2 kg; body mass index: 21.7 ± 2.3 kg/m²) recruited using total sampling. Lower limb muscle strength was assessed using a leg dynamometer, body reaction time using a reaction timer, and crescent kick performance using a 10-second crescent kick test. Data were analyzed using descriptive statistics, Pearson correlation, and multiple correlation analysis, with statistical significance set at $p < .05$.

Results: Lower limb muscle strength was positively associated with crescent kick performance ($r = 0.734$, $p < .001$), whereas body reaction time was negatively associated with crescent kick performance ($r = -0.739$, $p < .001$), indicating that shorter reaction times were associated with better kick performance. Multiple correlation analysis showed a strong combined association of lower limb muscle strength and body reaction time with crescent kick performance ($R = 0.754$, $R^2 = 0.568$, $p < .001$). Together, these variables accounted for 56.8% of the variance in crescent kick performance.

Conclusions: Greater lower limb muscle strength and shorter body reaction time were associated with better crescent kick performance among competitive pencak silat athletes. These findings highlight the relevance of muscular strength and neuromuscular responsiveness to crescent kick performance and may inform physical conditioning programs for pencak silat athletes. Further studies with larger samples and additional biomechanical, physiological, and technical measures are needed to better understand the factors associated with crescent kick performance.

Keywords: body reaction time; crescent kick; lower limb muscle strength; pencak silat; physical performance.

How to cite this article: Setiawan, J. & Mukarromah, S. B. (2026). Associations of lower limb muscle strength and body reaction time with crescent kick performance in competitive pencak silat athletes. *Physical Education and Sports: Studies and Research*, *5*(2), 208-219. https://doi.org/10.56003/pessr.v5i2.762

INTRODUCTION

Pencak silat is a traditional martial art that has developed into a competitive combat sport characterized by repeated high-intensity offensive and defensive actions. In the fighting category, athletes are required to perform explosive technical actions, including punches, kicks, and takedowns, across repeated competition rounds, placing substantial demands on both physical capacity and technical execution. Kicking techniques are particularly important because they constitute a major component of attacking actions and scoring opportunities in pencak silat. Previous research has indicated that kicking is among the dominant techniques used during competition, emphasizing the importance of developing the physical and motor capacities that support effective kick execution (Subekti et al., 2020). The competitive demands of pencak silat therefore require athletes not only to master kicking techniques but also to generate and repeatedly apply force while responding rapidly to dynamic situations during a bout. More recent evidence also demonstrates that repeated high-intensity technical actions place substantial physiological and performance demands on pencak silat athletes (Subekti et al., 2025).

Among the kicking techniques used in pencak silat, the crescent or sickle kick is an important offensive action characterized by a semicircular trajectory toward the opponent. Successful execution requires coordinated lower-limb movement, postural control, and the ability to perform the technique rapidly and repeatedly. Nugroho (2017) identified the crescent kick as a frequently used technique and emphasized that its execution is supported by physical characteristics such as leg muscle strength and movement coordination. Evidence from pencak silat studies further suggests that kicking performance is multidimensional. For example, Subekti et al. (2020) found that eye-foot coordination and movement speed were significantly associated with sickle-kick ability, while the combined contribution of coordination, speed, and limb-length characteristics accounted for a substantial proportion of kicking performance. Similarly, Ihsan et al. (2022) reported that leg muscle explosive power, agility, and self-confidence were associated with sickle-kick performance, with the three variables collectively accounting for 70.2% of the outcome. These findings indicate that effective crescent-kick performance cannot be explained by technical skill or a single physical characteristic alone.

Lower limb muscle strength represents one potentially important physical characteristic because kicking requires the production and control of force through both the supporting and kicking limbs. Although maximal strength and explosive power are distinct physical qualities, research in pencak silat consistently demonstrates the relevance of lower-extremity force-producing capacity to kicking performance. Ihsan et al. (2022) identified leg muscle explosive power as an important component associated with sickle-kick performance. Experimental evidence also supports the responsiveness of kicking performance to lower-limb conditioning. Lubis et al. (2024) reported significant improvements in force, peak power, jump height, and left-leg kicking speed following six weeks of combined plyometric, functional, and interval training in male university pencak silat athletes. Resistance-band training has likewise been reported to improve performance in a 10-second front-kick test among adolescent female pencak silat athletes (Ilahi et al., 2023), while repetition training increased crescent-kick performance by approximately 15% in a small sample of trained athletes (Nugroho, 2017).

Collectively, this evidence supports the relevance of lower-limb physical capacity to repeated kicking performance, although the existing literature has predominantly emphasized explosive power, training responses, or specific kick-speed outcomes rather than directly examining lower limb maximal strength.

Body reaction time represents a complementary neuromuscular characteristic that may also be relevant to technical performance in combat sports. Reaction time reflects the interval required to detect a stimulus, process the relevant information, select an appropriate response, and initiate the corresponding motor action. Cano et al. (2024) demonstrated that these processes involve both central decision-making and peripheral neuromuscular components and found that athletes performed motor reaction tasks approximately 30% faster than non-athlete controls. Faster reaction time has also been associated with better physical and sport-skill performance, supporting its relevance as a performance-related characteristic in athletes. In striking combat sports, this capacity is particularly important because athletes must continuously perceive an opponent's actions and rapidly initiate an appropriate offensive, defensive, or counterattacking response. Faro et al. (2025) further demonstrated that reaction time can be assessed reliably using a striking-specific perceptual-motor task in professional combat-sport athletes, highlighting the functional relevance of reaction-related capacities within striking performance. At the same time, their findings emphasize that reaction-time assessment should be interpreted within the context of the task because generic laboratory tests may not fully reproduce the perceptual and environmental demands of real competition.

Despite growing evidence regarding the physical characteristics associated with pencak silat kicking performance, the literature remains fragmented. Previous studies have examined leg explosive power, agility, coordination, speed, anthropometric characteristics, and responses to different conditioning interventions (Ihsan et al., 2022; Ilahi et al., 2023; Lubis et al., 2024; Subekti et al., 2020). For instance, explosive power and agility have been examined together in relation to sickle-kick performance, while coordination and movement speed have also been investigated as correlates of kicking ability. However, within the evidence identified for the present study, considerably less attention has been given to the combined association of maximal lower limb muscle strength and body reaction time with repeated crescent-kick performance. These two characteristics represent complementary domains: muscle strength reflects force-generating capacity, whereas reaction time reflects the efficiency with which an athlete initiates a motor response following a stimulus. Examining them simultaneously may therefore provide a more integrated understanding of the physical and neuromuscular characteristics associated with crescent-kick performance than examining either characteristic in isolation.

Accordingly, the present study extends previous research by examining lower limb muscle strength and body reaction time within the same correlational framework in competitive pencak silat athletes. Rather than treating either characteristic as a causal determinant or predictor, the study evaluates their individual and combined associations with performance on a 10-second crescent-kick test. This distinction is important because the outcome represents repeated crescent-kick performance, rather than direct biomechanical kick velocity. The findings are expected to contribute to the emerging evidence on physical correlates of pencak silat performance and to provide coaches and strength-and-conditioning practitioners with empirical

information that may assist in identifying relevant physical training priorities. Therefore, this study aimed to examine the individual and combined associations of lower limb muscle strength and body reaction time with crescent kick performance among competitive pencak silat athletes.

METHODS

Study Design and Participants

This study employed a quantitative correlational design to examine the individual and combined associations of lower limb muscle strength and body reaction time with crescent kick performance among competitive pencak silat athletes. The study was conducted at Kuningan Terate Sport Center, Indonesia. Because the study was observational, no experimental manipulation or training intervention was applied.

The target population consisted of 35 registered and actively training pencak silat athletes at the center. All athletes were screened for eligibility, and 30 participants met the inclusion criteria and completed all testing procedures. Five athletes were excluded because they did not meet the eligibility criteria or were unavailable during the data collection period. The inclusion criteria were: (1) active participation in regular pencak silat training; (2) at least six months of continuous training experience; (3) age between 15 and 25 years; (4) no current musculoskeletal injury affecting lower-extremity performance; and (5) willingness to participate in the study.

The final sample consisted of 30 competitive pencak silat athletes with a mean age of 19.8 ± 2.1 years, mean height of 168.4 ± 6.3 cm, mean body mass of 61.7 ± 8.2 kg, and mean body mass index of 21.7 ± 2.3 kg/m².

Ethical approval statement

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The research protocol received an ethical exemption determination from the Health Research Ethics Committee, Faculty of Medicine, Universitas Negeri Semarang, Indonesia (No. 514/KEPK/FK/KLE/2026). Before data collection, all participants received information regarding the study objectives, procedures, potential risks, expected benefits, confidentiality, and their right to withdraw from the study. Written informed consent was obtained from all participants. For participants younger than 18 years, written assent was obtained from the participants together with written informed consent from their parents or legal guardians.

Research Instruments

Three assessments were used to measure lower limb muscle strength, body reaction time, and crescent kick performance. Lower limb muscle strength was assessed using a leg dynamometer. Participants stood on the dynamometer platform with the knees slightly flexed and performed a maximal pulling effort according to the standardized testing procedure. Two trials were completed, with an appropriate recovery interval between trials, and the highest recorded value, expressed in kilograms, was used for analysis. Body reaction time was assessed using a reaction timer. Participants were instructed to respond as quickly as possible to a visual stimulus generated by the device. Three trials were performed, and the fastest reaction time, expressed in seconds, was used for analysis. Crescent kick performance

was assessed using a 10-second Crescent Kick Test. Participants were instructed to perform as many valid crescent kicks as possible within 10 seconds according to the standardized testing procedure. Two trials were performed, and the highest number of valid kicks was recorded as the final performance score.

All participants received standardized instructions and familiarization with the testing procedures before formal measurement. Testing procedures, assessor instructions, equipment setup, and environmental conditions were kept consistent across participants to minimize measurement variability. The same assessors administered each test throughout the study.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics were calculated to summarize participant characteristics and study variables and are presented as minimum values, maximum values, means, and standard deviations. The Kolmogorov–Smirnov test was used to assess data distribution, and linearity was examined before correlation analysis. Pearson product–moment correlation coefficients were calculated to examine the associations between lower limb muscle strength and crescent kick performance and between body reaction time and crescent kick performance. Multiple correlation analysis was subsequently performed to evaluate the combined association of lower limb muscle strength and body reaction time with crescent kick performance. The multiple correlation coefficient (R) and coefficient of determination (R^2) were reported. Statistical significance was set at $p < .05$.

RESULTS

This study examined the individual and combined associations of lower limb muscle strength and body reaction time with crescent kick performance among competitive pencak silat athletes. Descriptive statistics were first calculated to characterize the distribution of the study variables, followed by assumption testing and correlation analyses.

Table 1. Descriptive statistics of the study variables

Variable	N	Minimum	Maximum	Mean	Standard Deviation
Lower Limb Muscle Strength (kg)	30	110.4	147.5	128.61	10.11
Body Reaction Time (s)	30	0.239	0.314	0.277	0.021
Crescent Kick Performance (kicks/10 s)	30	20	28	23.47	2.08

As shown in Table 1, the athletes demonstrated a mean lower limb muscle strength of 128.61 ± 10.11 kg and a mean body reaction time of 0.277 ± 0.021 s. The mean crescent kick performance was 23.47 ± 2.08 valid kicks within 10 seconds, with individual scores ranging from 20 to 28 kicks.

The Kolmogorov–Smirnov test indicated no statistically significant deviations from normality for lower limb muscle strength, body reaction time, or crescent kick performance (all $p \geq 0.200$) (Table 2). These results supported the use of parametric correlation analyses.

Table 2. Results of the Kolmogorov–Smirnov normality test

Variable	Statistic	Sig.
Lower Limb Muscle Strength (kg)	0.058	0.200
Body Reaction Time (s)	0.061	0.200
Crescent Kick Performance (kicks/10 s)	0.126	0.200

Note. p = 0.200 represents the lower bound of the true significance value reported by SPSS.

Table 3. Results of linearity testing

Relationship	F	Sig.
Lower limb muscle strength × crescent kick performance	3.686	0.008
Body reaction time × crescent kick performance	3.785	0.007

The linearity tests indicated statistically significant linear components for the relationships of lower limb muscle strength and body reaction time with crescent kick performance ($p < .05$) (Table 3).

Table 4. Correlation between lower limb muscle strength and crescent kick performance

Variables	r	p
Lower Limb Muscle Strength – Crescent Kick Performance	0.734	< 0.001

Pearson correlation analysis showed a strong positive association between lower limb muscle strength and crescent kick performance ($r = 0.734$, $p < 0.001$) (Table 4). Athletes with greater lower limb muscle strength tended to perform a greater number of valid crescent kicks during the 10-second test.

Table 5. Correlation between body reaction time and crescent kick performance

Variables	*r*	*p*
Body reaction time × crescent kick performance	-0.739	< 0.001

Body reaction time was strongly and negatively associated with crescent kick performance ($r = -0.739$, $p < 0.001$) (Table 5). Thus, shorter reaction times were associated with a greater number of valid crescent kicks during the 10-second test.

Table 6. Multiple correlation analysis of lower limb muscle strength and body reaction time with crescent kick performance

Statistic	Value
R	0.754
R^2	0.568
Adjusted R^2	0.536
Standard error of the estimate	1.416
F	17.777
p	< 0.001

The multiple correlation analysis showed a strong combined association of lower limb muscle strength and body reaction time with crescent kick performance ($R = .754$, $R^2 = 0.568$, adjusted $R^2 = 0.536$, $F = 17.777$, $p < 0.001$) (Table 6). Collectively, lower limb muscle strength and body reaction time accounted for 56.8% of the variance in crescent kick performance.

DISCUSSION

The present study produced three principal findings regarding the associations of lower limb muscle strength and body reaction time with crescent kick performance among pencak silat athletes at Kuningan Terate Sport Center. First, lower limb

muscle strength was strongly and positively associated with crescent kick performance ($r = 0.734$, $p < 0.001$), indicating that athletes with greater lower limb muscle strength tended to perform a greater number of valid crescent kicks during the 10-second test. Second, body reaction time was strongly and negatively associated with crescent kick performance ($r = -0.739$, $p < 0.001$), indicating that shorter reaction times were associated with better kicking performance. Third, lower limb muscle strength and body reaction time showed a strong combined association with crescent kick performance ($R = 0.754$, $R^2 = 0.568$, $p < .001$), collectively accounting for 56.8% of the variance in the performance outcome. These findings suggest that crescent kick performance is associated with both force-generating capacity and neuromuscular responsiveness and therefore should not be considered solely in relation to a single physical characteristic.

The positive association between lower limb muscle strength and crescent kick performance may be understood from the mechanical demands involved in executing repeated kicking actions. Lower limb muscle strength provides the capacity to generate and control force across the hip, knee, and ankle joints (Suwirman, 2021). During crescent kick execution, the supporting limb contributes to postural stability and force transmission, while the kicking limb must be accelerated rapidly through a coordinated sequence of lower-extremity movements. Greater lower limb strength may therefore provide athletes with a greater capacity to generate and repeatedly apply force while maintaining control of the supporting and kicking limbs. Previous research has similarly emphasized the importance of lower-extremity physical capacity for kicking performance (Kabadayı, 2022). However, because the present study assessed the number of valid kicks completed within 10 seconds rather than biomechanical kick velocity, the findings should be interpreted as evidence of an association between lower limb muscle strength and repeated crescent kick performance rather than direct evidence that stronger athletes produce greater angular or linear kick velocity.

The observed relationship between lower limb muscle strength and crescent kick performance is also consistent with previous literature emphasizing the importance of lower-extremity physical capacity in martial arts and pencak silat. Moreira (2021) reported that leg muscle strength contributes to the physical requirements underlying kicking techniques, while Lubis (2022) emphasized that improvements in lower limb physical capacity may support kicking performance when accompanied by appropriate movement control and flexibility. Similarly, Karo-Karo et al. (2023) highlighted lower-extremity conditioning as an important component of sport-specific movement performance. Although these studies involved different populations, measurements, and training contexts, their findings support the general interpretation that lower limb physical capacity is relevant to successful kicking performance. Nevertheless, the present results extend this evidence by demonstrating a strong association specifically between lower limb muscle strength and the number of valid crescent kicks performed within a standardized 10-second testing period.

Body reaction time demonstrated a similarly strong but inverse association with crescent kick performance. Reaction time reflects the efficiency with which the nervous system detects a stimulus, processes relevant information, selects an appropriate response, and initiates motor action (Ojeda-Aravena, 2023). In combat sports, rapid responses are particularly relevant because athletes operate in dynamic

environments in which offensive and defensive opportunities emerge within short periods. Athletes with shorter reaction times may therefore be better able to initiate movement rapidly following a stimulus and organize subsequent motor actions efficiently. Previous evidence has similarly linked faster reaction-related abilities with technical execution and performance in combat sports (Ervilha et al., 2020). The present finding extends this evidence to competitive pencak silat athletes, showing that shorter body reaction time was associated with a greater number of valid crescent kicks completed during the performance test.

Nevertheless, the relationship between reaction time and crescent kick performance should be interpreted within the context of the measurement procedures used in the present study. The reaction timer assessed a relatively general neuromuscular response, whereas successful kicking during competition involves more complex perceptual processes, including recognition of an opponent's movement, response selection, anticipation, and sport-specific decision-making. Thus, the strong negative correlation observed in this study does not necessarily indicate that general reaction time directly determines competitive kicking effectiveness. Rather, it suggests that faster neuromuscular responsiveness may represent one physical characteristic associated with better performance in a standardized repeated-kicking task. This distinction is important because technical performance during actual competition is influenced by substantially more complex perceptual, tactical, and environmental demands.

The combined analysis further demonstrated that lower limb muscle strength and body reaction time collectively accounted for 56.8% of the variance in crescent kick performance. This finding supports the interpretation that kicking performance is multidimensional and may reflect the integration of mechanical and neuromuscular capacities. Muscular strength provides the physical capacity to generate and control force, whereas reaction-related capacity contributes to the rapid initiation of motor responses. Previous studies have similarly emphasized that physical and neuromuscular characteristics operate together rather than independently in supporting technical performance (Moreira, 2021; Ojeda-Aravena, 2023). Accordingly, the present findings suggest that evaluating multiple physical characteristics simultaneously may provide a more comprehensive understanding of crescent kick performance than examining either lower limb muscle strength or reaction time in isolation.

Importantly, the associations identified in the present study should not be interpreted as evidence that lower limb muscle strength and body reaction time are the sole determinants of crescent kick performance. When lower limb muscle strength was considered individually, approximately 53.9% of the variance in crescent kick performance was associated with differences in strength, leaving a substantial proportion of variance unaccounted for. Similarly, the combined model accounted for 56.8% of the variance, indicating that other characteristics may also contribute to performance. Previous research has emphasized the multidimensional nature of sport performance, with factors such as coordination, balance, flexibility, technical proficiency, and movement control potentially contributing to successful technical execution (Apollaro, 2024; Kusuma, 2023; Suwirman, 2021). Therefore, lower limb muscle strength and reaction time should be viewed as relevant correlates

within a broader performance framework rather than as isolated or causal determinants of crescent kick performance.

These findings have practical implications for physical conditioning and athlete monitoring in pencak silat. Because greater lower limb muscle strength and shorter reaction time were associated with better crescent kick performance, coaches may consider integrating strength development and reaction-oriented exercises with sport-specific technical training. Progressive resistance training may be combined with plyometric exercises, dynamic balance activities, reaction drills, and repeated crescent kick practice to facilitate the transfer of general physical capacities into sport-specific performance (Ojeda-Aravena, 2023). However, improvements in general physical qualities should not be assumed to translate automatically into better kicking performance. Consistent with the principle of training specificity, physical conditioning should be integrated with technical practice that reflects the movement characteristics and perceptual demands of pencak silat competition. Periodic assessment of lower limb muscle strength, reaction time, and kicking performance may also assist coaches in monitoring athlete development and identifying individual training priorities.

Limitations of the study

The present study has several limitations that should be considered when interpreting the findings. First, the correlational design does not permit causal inference; therefore, greater lower limb muscle strength or shorter reaction time cannot be concluded to cause better crescent kick performance. Second, the sample consisted of only 30 athletes from a single training center, which limits the generalizability of the findings to broader populations of pencak silat athletes. Third, crescent kick performance was assessed as the number of valid kicks completed within 10 seconds and did not directly measure biomechanical variables such as kick velocity, impact force, joint angular velocity, or movement kinetics. Fourth, body reaction time was measured using a general reaction timer rather than a sport-specific perceptual-response task involving an opponent or competitive stimulus. Finally, potentially relevant characteristics such as lower limb power, balance, flexibility, coordination, technical proficiency, training experience, and psychological factors were not included in the statistical model. Future research should therefore incorporate larger and more diverse samples, sport-specific reaction tasks, biomechanical assessment, and additional physical and technical characteristics to develop a more comprehensive understanding of crescent kick performance.

Overall, the present findings demonstrate that greater lower limb muscle strength and shorter body reaction time are strongly associated with better crescent kick performance among competitive pencak silat athletes. The combined association of these two characteristics further supports the multidimensional nature of technical performance in pencak silat. Rather than identifying strength or reaction time as isolated determinants, the findings indicate that both characteristics should be considered within a broader framework integrating physical conditioning, neuromuscular responsiveness, and sport-specific technical ability. This perspective may provide a more appropriate basis for athlete assessment and the development of integrated training strategies aimed at improving crescent kick performance.

CONCLUSION

This study demonstrated that greater lower limb muscle strength and shorter body reaction time were significantly associated with better crescent kick performance among competitive pencak silat athletes. Collectively, these variables accounted for 56.8% of the variance in crescent kick performance, indicating that both muscular and neuromuscular characteristics are relevant to sport-specific technical performance. These findings support the integration of lower limb strength development and reaction-oriented exercises with sport-specific technical training in athlete conditioning programs. However, the correlational design, relatively small sample from a single training center, and inclusion of only two physical variables limit causal interpretation and generalizability. Future studies should involve larger and more diverse athlete populations, incorporate additional physical, biomechanical, technical, and psychological characteristics, and use longitudinal or experimental designs to further clarify the factors associated with crescent kick performance.

ACKNOWLEDGMENTS

The author would like to express sincere gratitude to the athletes and coaches of Kuningan Terate Sport Center for their participation and cooperation throughout the study. The author also gratefully acknowledges the supervisors, lecturers, and Faculty of Sports Science, Universitas Negeri Semarang, for their valuable guidance, constructive feedback, and academic support during the research process.

AI DISCLOSURE STATEMENT

During the preparation of this manuscript, the authors used Claude AI and Grammarly to improve language clarity, readability, grammar, and overall linguistic quality. These tools were used solely for language refinement and did not contribute to the study design, data collection, data analysis, interpretation of the results, or formulation of the scientific conclusions. All AI-assisted revisions were carefully reviewed, edited, and verified by the authors. The authors take full responsibility for the accuracy, originality, integrity, and final content of the manuscript.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to participant privacy and confidentiality considerations.

FUNDING

This research does not receive external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

PUBLISHER'S NOTE

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors, and the reviewers. Any product that may be evaluated in this article, or a claim its manufacturer may make, is not guaranteed or endorsed by the publisher.

REFERENCES

Apollaro, G., Panascì, M., Ouergui, I., Falcó, C., Franchini, E., Ruggeri, P., & Faelli, E. (2024). Influence of body composition and muscle power performance on multiple frequency speed of kick test in taekwondo athletes. *Sports, 12*(12), 322. https://doi.org/10.3390/sports12120322

Cano, L. A., Gerez, G. D., García, M. S., Albarracín, A. L., Farfán, F. D., & Fernández-Jover, E. (2024). Decision-making time analysis for assessing processing speed in athletes during motor reaction tasks. *Sports, 12*(6), 151. https://doi.org/10.3390/sports12060151

Ervilha, U. F., Fernandes, F. D. M., Souza, C. C. D., & Hamill, J. (2020). Reaction time and muscle activation patterns in elite and novice athletes performing a taekwondo kick. *Sports biomechanics, 19*(5), 665-677. https://doi.org/10.1080/14763141.2018.1515244

Faro, H., Lima, L. A. D., Silva, R. D. M., Mortatti, A. L., & Machado, D. G. S. (2025). Development and reliability of test to measure perceptual-motor performance in combat sports: The Striking Reaction Time Task (SRTT). *Revista de Artes Marciales Asiáticas, 20*(1), 77–92. https://doi.org/10.18002/rama.v20i1.2505

Ihsan, N., Hidayat, R., Damrah, Neldi, H., Sepriadi, & Muslimin. (2022). The contribution of leg muscle explosive power, agility, and self-confidence on sickle kick performance. *International Journal of Human Movement and Sports Sciences, 10*(4), 683–688. https://doi.org/10.13189/saj.2022.100408

Ilahi, B. R., Okilanda, A., Raibowo, S., Yarmani, Sugihartono, T., Syafrial, Nopiyanto, Y. E., Hiasa, F., Ihsan, N., & Putra, J. (2023). The effect of resistance bands rubber spring exercise on the front kick speed of adolescent pencak silat women. *International Journal of Human Movement and Sports Sciences, 11*(2), 418–423. https://doi.org/10.13189/saj.2023.110219

Kabadayı, M., Karadeniz, S., Yılmaz, A. K., Karaduman, E., Bostancı, Ö., Akyildiz, Z., Clemente, F. M., & Silva, A. F. (2022). Effects of Core Training in Physical Fitness of Youth Karate Athletes: A Controlled Study Design. *International Journal of Environmental Research and Public Health, 19*(10), 5816. https://doi.org/10.3390/ijerph19105816

Karo-Karo, A. A. P., Rahayu, T., Setyawati, H., Mukarromah, S. B., & Syaifullah, R. (2023). Analysis of Pencak Silat Techniques Using a Biomechanical Approach: Systematic Literature Review. *Physical Education Theory and Methodology, 23*(6), 947-953. https://doi.org/10.17309/tmfv.2023.6.18

Kusuma, M. N. H. (2023). Investigating The Causative Factor Of Musculoskeletal. Physical Education Theory and Methodology, 7989, 185–191. https://doi.org/10.17309/tmfv.2023.2.05

Lubis, J., Haqiyah, A., Robianto, A., Ihsanti, S. I., Wardoyo, H., Ginanjar, S., Irawan, A. A., Sumartiningsih, S., Setiawan, I., Lubis, R. A., Sanjaya, K. H.,

& Kusumandari, D. E. (2024). The effect of six-week plyometric, functional, and interval trainings on body composition, power, and kicking speed in male Pencak Silat university athletes. *International Journal of Disabilities Sports and Health Sciences, 7(Special Issue 1)*, 46–53. https://doi.org/10.33438/ijdshs.1371605

Lubis, J., Thongdaeng, N., Haqiyah, A., Sukur, A., Abidin, D., Ayu Irawan, A., Sumartiningsih, S., & Hanief, Y. N. (2022). The Effect of Five-Week Aerobic Interval Training on The Body Composition of Pencak Silat Elite Athletes. *International Journal of Kinesiology and Sports Science, 10*(2), 16-24. https://doi.org/10.7575/aiac.ijkss.v.10n.2p.16

Moreira, P. V. S., Falco, C., Menegaldo, L. L., Goethel, M. F., De Paula, L. V., & Gonçalves, M. (2021). Are isokinetic leg torques and kick velocity reliable predictors of competitive level in taekwondo athletes?. *PloS one, 16*(6), e0235582. https://doi.org/10.1371/journal.pone.0235582

Nugroho, G. (2017). The effect of repetition training method on PPLP Dispora Riau Pencak Silat athletes' crescent kick speed. *IOP Conference Series: Materials Science and Engineering, 180*, 012163. https://doi.org/10.1088/1757-899X/180/1/012163

Ojeda-Aravena, A., Herrera-Valenzuela, T., Valdés-Badilla, P., Báez-San Martín, E., Thapa, R. K., & Ramirez-Campillo, R. (2023). A systematic review with meta-analysis on the effects of plyometric-jump training on the physical fitness of combat sport athletes. *Sports, 11*(2), 33. https://doi.org/10.3390/sports11020033

Subekti, N., Hidayatullah, M. F., Syaifullah, R., Setiyadi, N. A., & Warthadi, A. N. (2025). The effect of four-week high-intensity interval training on increasing physical fitness and specific speed in young Pencak Silat athletes. *SPORT TK-EuroAmerican Journal of Sport Sciences, 14*, 37. https://doi.org/10.6018/sportk.574961

Subekti, N., Sistiasih, V. S., Syaukani, A. A., & Fatoni, M. (2020). Kicking ability in pencak silat, reviewed from eye-foot coordination, speed, and ratio of limb length-body height. *Journal of Human Sport and Exercise, 15*(Proc2), S453–S461. https://doi.org/10.14198/jhse.2020.15.Proc2.36

Suwirman. (2021). Instrument speed endurance test of pencak silat athletes. International Journal of Human Movement and Sports Sciences, 9(6), 1447–1452. https://doi.org/10.13189/saj.2021.090641