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Hamstring Flexibility and Balance Impact on T Kick Speed in Pencak Silat Athletes in Madiun City: A Cross-Sectional Study

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ABSTRACT

Introduction: Pencak silat is a traditional Indonesian martial art that has been an integral part of Indonesian culture for centuries. Among its various techniques, the T kick is known for its higher effectiveness than other kicks. To achieve a fast T kick, biomotor components such as flexibility and balance are essential.
Methods: This observational analytic study employed a cross-sectional design. Subjects were selected through purposive sampling, consisting of male pencak silat athletes aged 15-18 years, with a total sample size of 116. The study included three variables: two independent variables (hamstring flexibility and balance) and one dependent variable (T kick speed). Data collection involved measuring hamstring flexibility, balance, and kick speed tests. The data were analyzed using the Spearman's rho correlation test. This study aimed to determine the relationship between hamstring flexibility and balance with T kick speed in pencak silat athletes in Madiun City.
Results: The non-parametric Spearman's rho analysis showed a significant relationship between hamstring flexibility and T kick speed, with p=0.000 (p<0.05) and a correlation coefficient of 0.348. Additionally, a significant relationship was found between balance and T kick speed, with p=0.000 (p<0.05) and a correlation coefficient of 0.508.
Conclusion: Based on these findings, it can be concluded that there is a relationship between hamstring flexibility and balance with T kick speed in pencak silat athletes in Madiun City.

Keywords: Hamstring Flexibility, Balance, Speed, Pencak Silat, T Kick, Madiun City

INTRODUCTION

Pencak silat is a traditional Indonesian martial art that has been an inseparable part of Indonesian culture for centuries. This martial art was originally developed by the ancestors of the Indonesian people as a means of self-defense and survival in nature. Great kingdoms such as Sriwijaya and Majapahit in ancient times had warriors and soldiers skilled in martial arts.[1] Historically, the development of pencak silat began to be documented in the 14th century, influenced by Islamic missionaries in the archipelago. Pencak silat became part of spiritual training in religious education at surau or pesantren.[2] As an ancestral heritage, pencak silat needs to be preserved, nurtured, and continuously developed.[3] Recognizing this, a national pencak silat organization was needed to unify the various schools of pencak silat across Indonesia, leading to the formation of the Indonesian Pencak Silat Association (IPSI).

The national governing body for pencak silat in Indonesia, commonly abbreviated as IPSI, did not come into existence immediately. It is mentioned that ten historical schools played a significant role in the establishment of IPSI. These include Persaudaraan Setia Hati, Persaudaraan Setia Hati Terate, Kelatnas Indonesia, Perisai Diri, PSN Perisai Putih, Tapak Suci Putera Muhammadiyah, Phasadja Mataram, Perpi Harimuti, Persatuan Pencak Silat Indonesia, PPS Putera Betawi, and KPS Nusantara.[4] These pencak silat schools have now spread throughout Indonesia. Persaudaraan Setia Hati Terate (PSHT), one of the historical schools involved in the founding of IPSI, is one of the oldest, established in 1922 in Madiun, East Java.

Over time, pencak silat in Indonesia has experienced significant development. As of 2018, the total number of pencak silat schools in Indonesia reached 850. These schools are now spread across 34 regions with over 99 branches and 400 sub-branches.[5] Pencak silat has also spread to 31 countries worldwide. The sport, particularly in Indonesia, continues to show positive growth, evidenced by numerous pencak silat competitions held at regional, national, and international levels across various age categories including children, adolescents, and adults.

Despite the positive development of pencak silat overall, Madiun City, known as the "City of Warriors," has recently experienced a decline in achievements. The city has not been able to achieve notable success in several provincial sporting events in recent years. According to a report from Memo Surabaya by Hardiansyah, Madiun City did not win any medals in pencak silat at the PORPROV VIII event in 2023.[6] This indicates the need for research to identify the contributing factors to this decline in performance.

According to Bompa and Buzzichelli, achieving performance is determined by 4 training factors: physical preparation, technical preparation, tactics, and mental preparation. Physical preparation serves as the foundational basis for building performance. The stronger one's physical condition, the greater their technical and tactical abilities will be, ultimately improving their mental condition as well. Components of physical condition can be divided into 9 aspects including speed, strength, endurance, balance, flexibility, agility, power, accuracy, and stamina. Each sport discipline requires different components of physical condition according to its specific needs. According to Chan et al., physical conditioning aims to enhance an athlete's potential and develop biomotor abilities in the athlete's body to a high level. Thus, good physical condition serves as a primary supporting factor for athletes to achieve peak performance. [7] Pencak silat also utilizes components of physical conditioning that are essential for technical movements.[8] Techniques in pencak silat can be enhanced with a good level of physical conditioning. The techniques in pencak silat broadly include striking techniques, kicking techniques, sweeps, evasions, locks, footwork patterns, and more.[9]

From the analysis of technical skill in attacks, kicking is the most dominant component. In pencak silat competitions, kicking techniques constitute a significant percentage of offensive maneuvers, reaching up to 47%.[10] Some examples of kicks in pencak silat include straight kick, hook kick, back kick, and T kick. Kusuma et al.,12 analyzed the effectiveness of kicks used in pencak silat competitions across 6 championships. They found that the effectiveness of the T kick in hitting the opponent's body target was higher compared to other kicking techniques, with a percentage of 38.94%.[11]

The T kick in its execution requires elements of both speed and strength because the combination of these elements can result in a powerful explosive kick.[12] Fast and powerful kicks make it difficult for opponents to defend against or evade, highlighting the importance of speed for scoring points in pencak silat competitions. The speed of kicks can be influenced by several factors such as flexibility, balance, leg power, explosive strength, and agility.

The quality of flexibility possessed by an athlete influences other biomotor components. Flexibility is a crucial requirement for executing movements that require a wide range of joint motion and quick, agile activities.14 Flexibility can be defined as the ability of joints, muscles, and ligaments to move comfortably and freely within their expected range of motion.[13] Many coaches overlook flexibility because they believe it has little impact on athlete performance. However, flexibility is crucial for athletes, especially in pencak silat, as it directly relates to the range of motion (ROM) needed to execute techniques effectively. Flexibility in pencak silat, in particular, is a dominant factor because quick kicks require flexible muscles that can quickly shorten and lengthen, enabling swift movements. Thus, good flexibility in athletes is expected to enhance kicking speed. The elasticity of muscles and their ability to transition from agonist to antagonist muscles are critical factors in achieving high-frequency movements and correct technique execution.[14]

The T kick technique not only requires physical conditioning components like flexibility but also demands good balance. Balance is the body's ability to react to changes in position while maintaining stability or control.[15] For a pencak silat athlete, balance is a critical physical component, especially concerning kicking ability. During a kick, maintaining proper body position is essential to avoid leaning too far forward or backward.

Research is needed to investigate the specific physical components that affect the T kick. This study aims to examine the relationship between hamstring flexibility and balance with T kick speed among athletes in Madiun City. Understanding this relationship could lead to methods for enhancing athletes' performance in Madiun City by improving relevant physical components.

METHODS

This study employed an analytical observational design with a cross-sectional approach. It was conducted at three pencak silat training centers in Madiun City: Manguharjo Training Center, Biru Muda Training Center, and Krida Satia Tama Training Center in June 2024. The target population consisted of male silat athletes aged 15-18 years in Madiun City.

Sampling technique utilized non-probability sampling, specifically purposive sampling method. Initially, 127 individuals participated in the measurements, which were then narrowed down to 116 after applying inclusion and exclusion criteria through purposive sampling. Inclusion criteria included male silat athletes aged 15-18 years with normal BMI, normal vital signs (HR: 60-100 beats/minute, RR: 12-20 breaths/minute, BP: 60-90/90-130 mmHg), capable of performing T kicks proficiently (minimum 1 year of practice), having participated in at least one pencak silat competition, and providing informed consent to participate throughout the study. Exclusion criteria involved a history of musculoskeletal injuries such as fractures or severe conditions in the lower extremities as determined by physiotherapy examination.

The study incorporated three variables: independent variables comprising hamstring flexibility and balance, a dependent variable being T kick speed, and control variables including gender, age, BMI, and vital signs. Measurement procedures included assessing hamstring flexibility using the V-sit and reach test, with the highest result from three attempts recorded. Balance was evaluated using the standing stork test. T kick speed was measured by performing T kicks on a pacing target as frequently as possible within 15 seconds.

Data analysis involved both univariate and bivariate analyses. Univariate analysis aimed to describe the studied phenomena, analyzing variables such as gender, age, hamstring flexibility, balance, and T kick speed. Bivariate analysis aimed to explore the relationships between independent variables (hamstring flexibility and balance) and the dependent variable (T kick speed), testing hypotheses to understand the correlations.

Ethical approval for the study was obtained from the Research Ethics Commission of the Faculty of Medicine, Udayana University / Sanglah General Hospital, with Ethical Clearance Number 1598/UN14.2.2.VII.14/LT/2024. Informed consent was secured from all study participants before commencing the research.

RESULTS

This study targeted male martial artists aged 15-18 years. Initially, 127 participants underwent measurements, which were subsequently adjusted based on inclusion and exclusion criteria, resulting in a final sample size of 116 individuals. Diagram 1 below illustrates the flowchart depicting the sampling process.

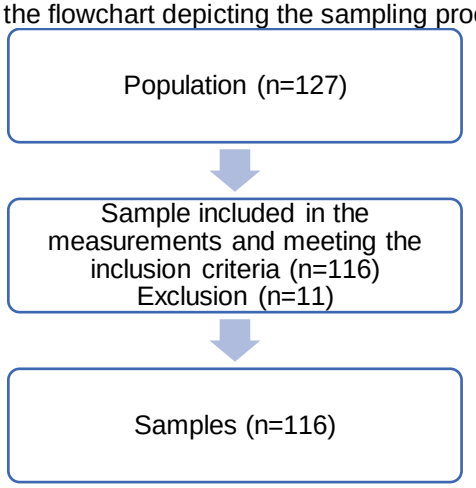

Figure 1. Sampling Process

Based on Figure 1, the total sample size for this study was 116 individuals, determined after adjustment for inclusion and exclusion criteria. Additionally, 11 individuals were excluded due to not meeting criteria such as abnormal BMI and vital signs outside normal limits. There were no missing values or data in the variables studied, and sensitivity analysis was not conducted to assess the study's stability. The sample characteristics by age and gender are detailed in Table 1.

Table 1. Sample Characteristics by Age and Gender

	Number (n)	Percentage (%)
Gender		
Male	116	100
Female	0	0
Age		
15	11	9,5
16	39	33,6
17	50	43,1
18	16	113,8

Based on Table 1 above, all subjects in this study were male, totaling 116 individuals (100%). In terms of age distribution, the study was predominantly represented by the 17-year-old group with 50 individuals (43.1%), followed by the 16-year-old group with 39 individuals (33.6%), the 18-year-old group with 16 individuals (13.8%), and the least represented was the 15-year-old group with 11 individuals (9.5%). Sample characteristics based on hamstring flexibility can be seen in Table 2.

Table 2. Sample Characteristics Based on Hamstring Flexibility

Age	Categories	Frequency	Percentage (%)
15	Very Good	0	0
	Good	9	7.8
	Fair	0	0
	Poor	2	1.7
	Very Poor	0	0
16	Very Good	7	6
	Good	26	22.4
	Fair	0	0
	Poor	6	5.2
	Very Poor	0	0
17	Very Good	6	5.2
	Good	5	4.3
	Fair	30	25.9
	Poor	5	4.3
	Very Poor	4	3.4
18	Very Good	3	2.6
	Good	13	11.2
	Fair	0	0
	Poor	0	0
	Very Poor	0	0

Based on Table 2, it is noted that among subjects aged 15 years, the majority demonstrated good flexibility, comprising 9 individuals (7.8%), while 2 individuals (1.7%) fell into the less flexible category. Moving to the 16-year-old age group, most subjects showed good flexibility with 26 individuals (22.4%), followed by very good flexibility with 7 individuals (6.0%), and 6 individuals (5.2%) in the less flexible category. In contrast, among those aged 17 years, subjects demonstrated a range of flexibility categories: sufficient flexibility was observed in 30 individuals (25.9%), very good flexibility in 6 individuals (5.2%), good and less flexible in 5 individuals each (4.3%), and the least number in the very poor flexibility category with 4 individuals (3.4%). For the 18-year-old age group, only good flexibility was observed in 13 individuals (11.2%) and very good flexibility in 3 individuals (2.6%). Sample characteristics based on balance can be found in Table 3.

Table 3. Sample Characteristics Based on Balance

	Frequency	Percentage (%)
Very Good	57	49.1
Above Average	17	14.7
Average	29	25
Below Average	13	11.2
Bad	0	0

Based on Table 3, it is evident that the majority of subjects achieved excellent balance, totaling 57 individuals (49.1%). This was followed by the average category, with 29 individuals (25%), above-average with a frequency of 17 individuals (14.7%), and the fewest in the below-average category, totaling 13 individuals (11.2%). There were no subjects with poor balance. Sample characteristics based on T Kick Speed can be seen in Table 4.

Table 4. Sample Characteristics Based on T Kick Speed

	Frequency	Percentage (%)
Very Good	16	13,8
Good	53	45,7
Fair	30	25,9
Poor	13	11,2
Very Poor	4	3,4

Based on Table 4, the majority of subjects exhibited good T kick speed, totaling 53 individuals (45.7%). This was followed by the category of fair, with 30 individuals (25.9%), and thirdly, very good with 16 individuals (13.8%). There were also findings of subjects with T kick speed in the categories of poor and very poor, with 13 individuals each (11.2% and 3.4%, respectively). The analysis of the relationship between hamstring flexibility and T kick speed, as well as the relationship between balance and T kick speed, can be observed in Table 5.

Table 5. Relationship Between Hamstring Flexibility and T Kick Speed, and Relationship Between Balance and T Kick Speed

Variable Correlation	Correlation	p-value
Hamstring Flexibility with T Kick Speed	0.348	0.000
Balance with T Kick Speed	0.508	0.000

Table 5 shows a significant relationship between hamstring flexibility and T kick speed, as indicated by the significance value of $p = 0.000$ ($p < 0.05$). The correlation coefficient obtained was 0.348, which is positive and suggests a moderate correlation within the range of 0.26-0.50. Therefore, it can be inferred that higher hamstring flexibility correlates with better T kick speed.

Furthermore, the analysis also revealed a significant relationship between balance and T kick speed, with a significance value of $p = 0.000$ ($p < 0.05$). The correlation coefficient for this relationship was 0.508, indicating a positive correlation within the range of 0.26-0.50. This suggests that better balance correlates with improved T kick speed.

DISCUSSION

Sample Characteristics

This study was conducted over a period of 1 week at 3 pencak silat training centers in Madiun City: Manguharjo Training Center, Biru Muda Training Center, and Krida Satria Tama Training Center, targeting male martial artists aged 15-18 years. Based on the study findings, the subjects were predominantly 17 years old, totaling 50 individuals, accounting for 43.11%. According to the Ministry of Health, 17 years old falls within the adolescent category, a period crucial for self-identity exploration.[16] Pencak silat can serve as a means to build self-confidence, discipline, and camaraderie, while also strengthening cultural values and traditions.[17] This makes it possible to attract the interest of 17-year-old teenagers more than other age groups in the adolescent category to join the pencak silat community and develop themselves. The sampling in this study used purposive sampling techniques, resulting in a total of 116 subjects. The data were collected by the researcher after meeting the inclusion and exclusion criteria.

The hamstring flexibility values in this study exhibited varied results, with the lowest value recorded at 12 cm and the highest at 42 cm. Each category of flexibility value included at least one subject. The most frequent category was 'good,' appearing most prominently in the 15-year-old age group with 9 individuals (7.8%), in the 16-year-old age group with 26 individuals (22.4%), in the 17-year-old age group with 5 individuals (4.3%), and in the 18-year-old age group with 13 individuals (11.2%). The range of values varied across each age group.

The age of 16 marks a phase where many adolescents experience the peak of puberty growth, often accompanied by rapid increases in muscle strength and flexibility. This period is also commonly referred to as the growth spurt. A growth spurt involves a rapid increase in the body's rate of growth, initiating an accelerated period of development.[18] During this period, the body develops rapidly, and muscles become more elastic. According to research by Moran et al., during the growth spurt, there is a significant improvement in overall physical performance, including flexibility. By the age of 17, although physical growth continues, some adolescents begin to experience stabilization in physical and hormonal changes. [19] This may lead to a slight decrease or stagnation in flexibility as the body adjusts to the growth that has occurred. This aligns with the statements of Kohl and Cook, where flexibility tends to decline after the age of 17 in both males and females, partly due to reduced physical activity and normal aging processes. At this age, other factors such as increased training intensity, fatigue, and a lack of focus on specific flexibility exercises can also contribute to reduced flexibility.[20]

Balance in this study, measured by the standing stork test, also showed diverse results. The lowest recorded time was 22 seconds, while the highest was 50 seconds. Nearly every category displayed had at least one subject, except for the "poor" category. The most frequent category was "excellent," with 57 subjects able to maintain balance for up to 50 seconds. This categorization reflects excellent balance if a subject can maintain it for the full duration.

Regarding the T kick speed results, the majority fell into the "good" category (45.7%), with 53 individuals scoring between 20-24 kicks. This was followed by the "fair" category with 30 individuals (25.9%), "very good" with 16 individuals (13.8%), "poor" with 13 individuals (11.2%), and the fewest in the "very poor" category with 4 individuals (3.4%).

Relationship Between Hamstring Flexibility and T Kick Speed

Based on the data analysis using Spearman's rho non-parametric analysis (Table 5), a significance value of $p = 0.000$ ($p < 0.05$) was obtained, indicating a significant relationship between hamstring flexibility and T kick speed among martial artists in Madiun City. Furthermore, the analysis revealed a correlation coefficient of 0.348, which is positive. A positive value indicates a direct relationship between the two variables, suggesting that higher hamstring flexibility correlates with better T kick speed. The correlation coefficient falls within the moderate range of 0.26-0.50, indicating a moderately strong correlation.[21]

In martial artists, hamstring flexibility is crucial for supporting kicking movements. Without adequate flexibility, kicks may appear stiff, resulting in slower execution and making them easier for opponents to anticipate.[21] In performing the T kick, there are several phases: the initial phase, body position and trajectory phase, balance phase, impact phase, and final phase.[22] The hamstring muscles themselves, when contracting, produce knee flexion and hip extension movements. In the context of the T kick phases, the hamstring muscles act as primary movers during the initial phase and then transition to stabilizers at the peak of the kick. The hamstrings attach to two joints: the hip and knee joints. Optimal hamstring flexibility enhances the range of motion at these joints throughout each phase of the T kick movement. Flexibility is essential for achieving rapid contraction and extension. With good flexibility, a martial artist can generate wider and stronger leg swings, enabling them to execute multiple kicks quickly. Therefore, it can be said that the more flexible a martial artist is, the more kicks they can deliver.[23]

Biomechanically, flexibility in antagonistic muscles allows agonistic muscles to contract and produce movements without resistance, thereby enhancing the speed of agonistic muscle contractions to execute a full cycle of movement.[23] In this context, the hamstring muscles, as antagonistic muscles, when they have good flexibility, allow their agonistic muscles to contract and produce movements without resistance. This capability enhances the speed of kicks.

It seems like the study by Andito et al., which examined the relationship between leg length, flexibility, and side kick speed (T) among 30 male martial artists from the INSEBA (Indonesia Seni Bela Diri) school in Brebes Regency, found a significant relationship between flexibility and T kick speed, with a significance value of $p = 0.002$ (sig. $0.002 < 0.05$). This supports your findings on the importance of flexibility in martial arts performance.[24]

The Relationship Between Balance and T Kick Speed

Based on the data analysis using Spearman's rho non-parametric analysis (Table 5), a significance value of $p = 0.000$ ($p < 0.05$) was obtained, indicating a significant relationship between balance and T kick speed among martial artists in Madiun City. Furthermore, the analysis revealed a positive correlation coefficient of 0.508. A positive value indicates a direct relationship between the two variables, suggesting that higher balance correlates with better T kick speed. The correlation coefficient falls within the moderately strong range of 0.26-0.50, indicating a significant correlation.

In pencak silat, balance is essential for martial artists to execute attacks and defenses with proper body positioning, providing a stable foundation to prevent injuries. It is also a crucial component for enhancing basic techniques in pencak silat.[25] During kicking, the body must be in motion to generate optimal kicks that score points. It's crucial to maintain good balance for this. The speed of kicks is influenced by a martial artist's ability to quickly shift their body weight from one position to another without losing balance. Good core stability allows for more efficient movements and effective energy transfer from the upper body to the legs, ultimately enhancing kicking speed.[26] In other words, good stability in the proximal area (core of the body) allows martial artists to maximize mobility and speed in the distal segments (legs), enabling them to execute kicks faster and more powerfully. This concept aligns with the theory of "proximal stability for distal mobility," which states that to achieve good mobility in the distal segments, strong stability in the proximal area is essential.[27]

In the T kick, the body shifts weight from one leg to another. Good balance allows martial artists to maintain a stable base of support (BOS) with the supporting leg while swinging the kicking leg. This is crucial for accuracy and power in kicks. Martial artists must lift and launch their leg quickly towards the target while maintaining body balance. If balance is disrupted, kick speed can decrease because the martial artist must expend more energy to stabilize their

body. Without balance, kicks become unstable and uncontrolled.[28] This can cause martial artists to step too far, lose balance, or miss the target, affecting the quantity of kicks they can deliver within a specific timeframe.

The study by Firmanto et al., which examined the relationship between balance, leg muscle strength, and T kick speed among martial artists at the Sumpah Pemuda unit in Bandar Lampung, supports the findings of your research.[29] From Firmanto et al.'s study at the Sumpah Pemuda unit in Bandar Lampung, a significant relationship between balance and T kick speed was found. The calculated t-value of 12.63 exceeded the critical t-value of 2.144, indicating statistical significance. Data analysis revealed that this relationship falls into the category of very strong correlation, with a correlation coefficient (r) of 0.956. This implies that better balance in an athlete correlates with faster T kick speed, whereas suboptimal balance can lead to slower kicking speeds. Balance was found to influence 91.4% of T kick speed, with the remaining 8.6% attributed to other factors.

Several limitations of this study include the use of purposive sampling, which may restrict the generalizability of findings. Purposive sampling selects samples based on specific criteria rather than randomly, potentially resulting in samples with unique characteristics that may not reflect a broader population. In this study, only male martial artists were included, limiting the applicability of results to female martial artists. Additionally, the short duration of the study, one week, may not encompass variations in performance that could occur over a longer period.

Several recommendations can be made for future researchers. It is suggested that they consider additional variables that could influence T kick speed outcomes, such as the strength of agonist muscles associated with hamstring contraction, the kicking technique from initiation to completion phases, and the psychological factors of athletes related to confidence in executing kicks, which ultimately affect the quantity of kicks produced within a specific timeframe. Furthermore, martial artists are advised to enhance and maintain hamstring flexibility through exercises like static, dynamic, and ballistic stretching, including specific hamstring stretches. Additionally, it is important to maintain balance by engaging in specific exercises that enhance both static and dynamic balance.

CONCLUSION

Based on the data analysis conducted, significant results were obtained with a significance value of $p=0.000$ ($p<0.05$) and a correlation coefficient of 0.348, indicating a positive correlation. This suggests a significant relationship between hamstring flexibility and T kick speed among martial artists in Kota Madiun. The positive correlation indicates that higher hamstring flexibility correlates with better T kick speed.

Furthermore, the analysis showed significant results for the relationship between balance and T kick speed, with a significance value of $p=0.000$ ($p<0.05$) and a correlation coefficient of 0.508, also indicating a positive correlation. This underscores a significant relationship between balance and T kick speed among martial artists in Kota Madiun. Similarly, the positive correlation indicates that higher balance correlates with better T kick speed.

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