Eccentric hamstring strength profile and limb asymmetry in sub-elite female taekwondo athletes: Implications for injury prevention

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ABSTRACT

Background: Taekwondo is a physical contact sport requiring quick reactions and explosive movements such as kicking, which depend heavily on hamstring muscle strength to maintain performance and reduce injury risk.

Objectives: This study aims to profile the eccentric hamstring strength and asymmetry in sub-elite female taekwondo athletes in East Java.

Methods: This was a quantitative descriptive study with a cross-sectional approach. A total of 22 female athletes with regional competition experience and no lower limb injuries were selected using purposive sampling. Data were collected using the NordBord by Vald Performance, a reliable tool for measuring eccentric hamstring strength and asymmetry. Descriptive statistics analyzed the mean, standard deviation, minimum, maximum, and strength percentage relative to normative values.

Results: The athletes had an average age of 18.86±2.05 years, body mass of 57.45±8.90 kg, height of 160.68±6.72 cm, and BMI of24.33 ±2.51. Eccentric hamstring strength was 89.6% in the left leg, 85% in the right leg, and 87.2% overall, indicating the need for improvement.

Conclusions: The eccentric hamstring strength of both legs needs to be increased by approximately 12.8% while maintaining the current low asymmetry level to support muscle balance. Targeted hamstring strengthening exercises are recommended to enhance performance and reduce injury risk. This study is limited to female athletes; further research should include broader populations and variables.

Keywords: eccentric, nordic hamstring, profiling, taekwondo.

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INTRODUCTION

Taekwondo is a dynamic physical contact martial arts sport that requires quick reactions, agility, and explosiveness due to pressure and repetitive lower extremity movements in training and competition (Naserpour et al., 2021; Shin & Kim, 2020). The demands of sports with specific positions can lead to differences in the limbs and lengths of the dominant limbs in kicking and punching, which allows for power (Fox et al., 2023; Guan et al., 2021). This factor can be caused by pressure or use on one part (either right or left) of the body excessively and continuously (Zein & Sudarko, 2020).

In the lower extremities, as much as 44.5% (Pieter et al., 2012) and the hamstring was the most commonly injured muscle group (48.4%) compared to the quadriceps (23.2%) and calf muscles (9.6%) (Rüther et al., 2021). Non-contact ankle ligament injuries were more common (83%), and there were biomechanical differences in the knee joint between male and female athletes that contributed to the risk of non-contact ACL injuries (Willauschus et al., 2021; Zheng et al., 2020). The causes of lower extremity injuries are low muscle strength, incorrect technique, lack of flexibility, and inadequate injury rehabilitation (Fredriksen et al., 2020).

Recent research by Uh et al. (2024) discussed the demands of muscle strength, including the important role of hamstring muscles in taekwondo competition, so that muscle endurance can improve the performance of fast and powerful kicks. Other studies have suggested that asymmetry in hamstring strength ratios between the dominant and non-dominant legs may influence the risk of non-contact injuries. The main findings of this study indicate that hamstring strength in the dominant leg is significantly greater than in the non-dominant leg, particularly during eccentric contractions (Cheon et al., 2024; Kotsifaki et al., 2022).

With the increased participation of women in sports comes an increase in injury rates and a high risk of ACL injury of 4 - 6 times greater than men (O'Sullivan & Tanaka, 2021). Physiologically, the Q-angle in women tends to be larger because they have wider pelvises and shorter femurs. A larger Q-angle increases the range of motion and load on the patella joint, potentially increasing the risk of injury (Febiolita Tambunan et al., 2021). Thus, injuries can end an athlete's career, and injury recovery takes at least two months before the athlete can return to sport (Cha & Park, 2021; Minghelli et al., 2020). So, in this case, there are strong body parts and vice versa.

Although various studies have evaluated the hamstring to quadriceps strength ratio (H/Q ratio) in taekwondo athletes, most emphasized isokinetic ratios at various angular velocities among male and female athletes in general (Jung et al., 2017), as well as measuring asymmetry in young athletes without focusing on unilateral eccentric contractions (Jung et al., 2024), however, these studies did not specifically examine iconic hamstring eccentric strength in female taekwondo athletes from the Indonesian region, as well as the asymmetry profile between dominant and non-dominant legs when using practical measurements such as the Nordic hamstring test. Significantly, few studies have utilized portable devices and directly examined hamstring eccentric asymmetry values in female taekwondo athletes, even though this condition is highly relevant for identifying injury risk and designing appropriate training interventions.

Testing asymmetrical hamstring strength is essential for assessing maximum strength and potential imbalances, especially for athletes and individuals at risk of hamstring injuries (Claudino et al., 2021). Taekwondo athletes with hamstring muscle strength and a small imbalance value will produce techniques and movements that minimize injury. This study aimed to determine the profile of hamstring muscle eccentric strength in East Java female Taekwondo athletes. Therefore, the findings of this study are expected to contribute to the development of evidence-based training and rehabilitation programs by providing a specific profile of eccentric hamstring strength and asymmetry in sub-elite female taekwondo athletes. These insights can help coaches, trainers, and medical professionals identify muscle imbalances early and design targeted interventions that reduce the risk of lower extremity injuries and significantly enhance performance, instilling a sense of optimism and motivation in the athletes.

METHODS

Study Design and Participants

This study employed a quantitative descriptive design with a cross-sectional approach to analyze the eccentric hamstring strength and asymmetry in sub-elite female taekwondo athletes. The subjects in this study were 22 East Java female taekwondo athletes. Sample selection was conducted using non-random (non-probability) sampling methods with purposive sampling techniques. Subject selection was based on inclusion criteria: female taekwondo athletes with at least regional-level competition experience and were not currently experiencing lower extremity injuries. Meanwhile, exclusion criteria were athletes who did not have regional-level competition experience and athletes who were currently experiencing lower extremity injuries.

Ethical approval statement

This research has been approved by the Health Research Ethics Committee of the Universitas Airlangga with Number 434/HRECC.FODM/VIII/2024.

Research Instruments

This research instrument uses NordBord and is then tested using the Nordic Hamstring. The tool measures the eccentric force by the hamstring muscle as it extends under body weight. They were instructed to lean forward as slowly as possible while resisting the movement with the hamstring muscles. Before taking the measurements, all athletes had their height and weight measured and were then asked to warm up with more focus on the lower extremities. Each athlete was tested thrice with a rest time of 1 minute per repetition. Two bilateral Nordic hamstring assessments showed high to moderate reliability: Intraclass Correlation Coefficient (ICC) = 0.83–0.90 and Standard Error of Measurement (SEM) = 6–9%. However, in unilateral testing, reliability was found to be low (ICC = 0.56–0.73 and SEM = 10–11%). Moreover, the imbalance between limbs in the peak ratio averaged over six trials with reliability values (ICC = 0.85; 95% CI 0.71–0.93; SEM = 5%, 95% CI 4–6%).

Data Analysis

This type of research uses descriptive quantitative methods to present data to be analyzed and interpreted. Then, the design of this study uses a cross-sectional study. The approach uses statistical analysis to describe, explain, and test the relationship between variables. To test the frequency distribution by displaying the average results, standard deviation, and imbalance using SPSS, an Excel application to calculate percentages. Then, the test results will be analyzed by calculating the formula (N = 4 x body mass (kg) + 26) to determine the maximum percentage of the hamstring muscle.

RESULTS

Table 1 presents the study participants' demographic characteristics, consisting of 22 sub-elite female taekwondo athletes from East Java. The majority of athletes were in the age range of 17-19 years (45.4%), with the most weight distribution in the 46-52 kg category (41%) and the most height in the 160-164 cm range (40.9%). These age, weight, and height variations indicate the diversity of participants' physical characteristics that may influence their muscular strength profiles, including eccentric hamstring strength. This data is important as a basis for analyzing the match between muscle strength and anthropometric parameters of athletes.

Table 1. Characteristics of Participants

Variable	n = 22	
	n	%
Age (Years)		
14–16	3	13,6
17–19	10	45,4
20–22	8	36,3
Body Weight (Kg)		
46–52	9	41
53–59	6	27,2
60–66	2	9
67–73	4	18,1
74–80	1	4,5
Body Height (Cm)		
150–154	6	27,2
155–159	1	4,5
160–164	9	40,9
165–169	4	18,1
170–174	1	4,5

Table 2. Right and left Hamstring Strength

Variable	Min	Max	Mean	Std. Deviation
L Max *Force* (N)	152.5	364.75	227.72	51.88
R Max *Force* (N)	133.5	341.25	217.38	51.74
***Max Imbalance* %**	-19.9	11	-4.39	9.35

Note, L = *Left*; R = *Right*, N = *Newton*

Table 2 presents the left and right hamstring maximal strength data and the percentage of imbalance between limbs. The average hamstring eccentric strength of the left leg was 227.72 N, while the right leg was lower at 217.38 N. Inter-limb imbalance was recorded at an average of -4.39%, indicating a predominance of strength in the left leg. The relatively high standard deviation value (around 51 N) reflects the considerable variation in individual strength ability. Although the average imbalance value was within safe limits (<10%), some individuals showed significant imbalances and need special attention in preventive exercise planning.

Table 3 presents the hamstring muscle strength categories based on athletes' body mass using the Nordic hamstring formula (4 x body mass + 26). The results show that the average actual eccentric strength (87.29%) is still below the target value calculated based on body weight. This indicates a shortfall of approximately 12.71% from the ideal target of eccentric hamstring strength. Specifically, the left leg strength needs to be increased by about 10.4% and the right leg by 15% to reach the optimal strength standard. These results underscore the importance of bilateral and unilateral hamstring strengthening training interventions to reduce injury risk and improve overall athlete performance.

Table 3. Hamstring Muscle Strength Category

Variable (n=22)	Min	Max	Mean	Std. Deviation
Body Mass (Kg)	46	77	57.45	8.91
L Max *Force* (N)	152.5	364.75	227.72	51.88
R Max *Force* (N)	133.5	341.25	217.38	51.74
***Eccentric Strength* (N=*body mass* x 4 + 26)**	210	334	255.82	35.62
% L Max + % R Max / 2	52.2	113.6	87.29	16.75

Note, L = *Left*; R = *Right*, N = *Newton*

Table 4. Percentage of Left and Right Leg Eccentric Strength against Nordic Hamstring Strength Target Value

Variable (n=22)	Min	Max	Mean	Std. Deviation
% L Max *Force*	49.10	125.6	89.60	18.46
% R Max *Force*	55.30	111.5	85	16.10
% L Max + % R Max / 2	52.20	113.60	87.29	16.75

Note, L = *Left*; R = *Right*, N = *Newton*

The results in Table 4 show that the average percentage of left leg hamstring eccentric strength was 89.61%, while the right leg was 85%, with a combined average of both (%L Max + %R Max/2) of 87.29%. This value is still below the target hamstring eccentric strength set standard based on the Nordic Hamstring formula (4 × body weight + 26). Thus, a shortfall of 12.71% from the ideal value (100%) indicates the need for an overall improvement in hamstring muscle strength. In addition, the difference in strength between limbs also showed a tendency for left leg dominance, which could impact muscle balance and injury risk. Therefore, training interventions to increase eccentric strength and reduce muscle asymmetry are highly recommended for athletes. Figure 1 shows 87.29% overall eccentric strength in the hamstring muscles of East Java taekwondo female athletes.

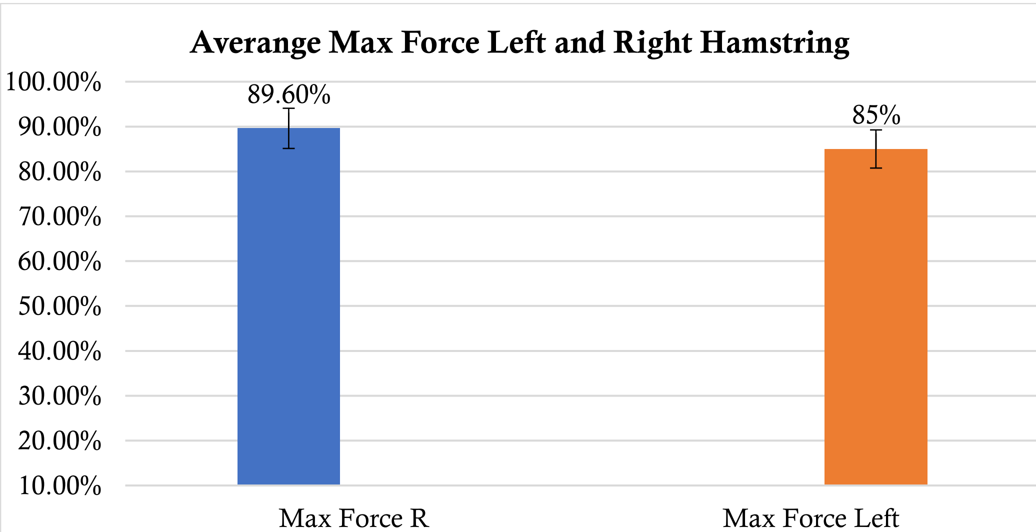

Figure 1. Averange Max Force Left and Right Hamstring

DISCUSSION

The research results on average left leg hamstring muscle strength in East Java female taekwondo athletes were 227.59 N of hamstring muscle strength in the left leg, with the highest strength of 364.75 N and the lowest value of 152.5 N. Meanwhile, the average right leg muscle was 271.31 N, with the highest strength of 341.25 N and the lowest strength value of 133.5 N. Hamstring muscles have an important role in supporting performance in daily activities such as walking and jumping (Ragia et al., 2021).

In addition to hamstring muscle strength, muscle imbalance is one of the risks of muscle injury. The study obtained an average imbalance of -4.5%, with the worst imbalance value of -19.9% on the left leg and an imbalance value of 10.3% on the right leg. At the same time, the best imbalance value is -2% on the left leg and 0.1% on the right leg. Muscle strength imbalance can adversely affect athlete performance and is a relevant factor in determining playing conditions that significantly limit player performance (Śliwowski et al., 2024). Muscle imbalance can be said to be good if the percentage of imbalance deficits in a person is less than 10%-15% (Silvers-Granelli et al., 2021), and currently, lower extremity strength asymmetry involving contact sports is a significant subject in several studies (Ryu & Lee, 2021).

The results of this study obtained several categories of hamstring strength using the Nordic hamstring formula. Table 3 shows the test results of East Java female taekwondo athletes. The analysis based on the Nordic hamstring formula shows differences in strength between the left and right limbs. Based on the analysis results in Table 4, the average hamstring eccentric strength of East Java taekwondo female athletes is 87% of the ideal target calculated based on the Nordic Hamstring formula. This value is still below the optimal threshold, so an overall increase in hamstring muscle strength of about 13% is needed. Specifically, the left leg requires an increase of about 10%, and the right leg about 15% to reach the ideal eccentric strength standard. In addition, the data also showed a tendency for strength dominance in the left leg, which could lead to muscle imbalances and increase the risk of injury. Therefore, bilaterally and unilaterally focused exercise interventions are recommended to improve overall muscle strength and balance.

This research aligns with previous research, which reported significantly higher strength levels on the dominant and non-dominant sides (Cheon et al., 2024). In that study, the dominant hamstring strength of young Korean taekwondo athletes was significantly higher than the non-dominant strength, especially during eccentric contraction.

Although this study focused on hamstring muscle eccentric strength and asymmetry between limbs, several other factors could influence the results but have not been analyzed in depth. Age is one variable that can affect muscle contraction capacity, as muscle mass and strength typically increase into early adulthood and then gradually decline (Shur et al., 2021). In this study, the age range of athletes was quite wide (14-22 years), potentially leading to physiological differences and muscle performance between age subgroups. In addition, training level or training experience also affects neuromuscular adaptation to eccentric loading, where athletes who train more intensely or longer tend to have higher and more stable muscle strength (Edouard et al., 2018). The technique of performing the Nordic hamstring test can also affect the accuracy of the results, especially if the athlete is unfamiliar with the testing procedure or does not perform the contraction to its full potential (van Dyk et al., 2019). Therefore, differences in results between individuals in this study may also be influenced by variations in age, training experience, and consistency of technique during testing, which should be considered in data interpretation and subsequent intervention design.

Limitations of the study

The limitation of this study is that the sample used in the study consisted of female taekwondo athletes from East Java who had at least regional championship experience and had not suffered injuries to their lower extremities. Furthermore, this assessment only considered the maximum force of the hamstring muscles and muscle imbalance in the hamstrings. In addition, other factors may influence the results of this study, such as age, gender, injury history, and so on.

Therefore, specific hamstring strength training intervention is needed for female taekwondo athletes. Unilateral training is recommended to reduce muscle imbalance between the right and left legs. In contrast, bilateral training is recommended for the right and left legs that have not yet achieved maximum hamstring strength in both legs. Proper training is needed to form balanced and maximum muscle strength in taekwondo athletes.

CONCLUSIONS

The findings indicate a notable imbalance in eccentric hamstring strength between limbs among sub-elite female taekwondo athletes, who tend to rely more on one leg. This asymmetry underscores the importance of targeted interventions to enhance muscular balance, particularly in the hamstring group, which is critical in maintaining postural stability and reducing injury risk. Implementing structured training strategies that focus on bilateral strength development is essential to support athletic performance and prevent potential injuries. Coaches and physiotherapists are vital in designing and supervising these programs, ensuring athletes achieve optimal physical condition while minimizing the likelihood of hamstring-related injuries.

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DATA AVAILABILITY

All data supporting the findings in this study are available and accessible upon reasonable request to the corresponding authors. Data were collected and analyzed by ethical research standards and stored securely by the research team to ensure the confidentiality and integrity of the information.

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CONFLICT OF INTEREST

The author declares that this research is free from conflicts of interest with any party.

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