Eccentric hamstring strength and asymmetry in female handball athletes: A descriptive study

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ABSTRACT

Background: Handball is a competitive sport that requires high physical strength and muscle endurance. The game requires a balance of muscle strength to support athletes in performing movements such as sprints, jumps, and fast movement maneuvers. Lack of flexibility and high hamstring muscle asymmetry values are risk factors for injury to handball athletes.

Objectives: This study aims to determine the eccentric strength and hamstring muscle asymmetry in female handball athletes in Surabaya City.

Methods: The study subjects were 13 female handball athletes from Surabaya aged 18-23 years with regional-level competition experience and no lower extremity injuries. The instrument in this study is Nordbord by Vald Performance; Nordbord is a portable rapid assessment tool that can analyze large groups, providing information about the exact functional strength parameters quickly and efficiently. This study used a quantitative descriptive method to analyze hamstring muscle strength and asymmetry data.

Results: Indicated the athletes had an average (body mass of 59.30 ± 10.94 kg and height of 164.80 ± 6.80 cm). The overall eccentric hamstring strength was 88.1% of the expected norm, with right and left maximum forces averaging 230.70 ± 48.80 N and 233.61 ± 50.15 N, respectively. The average asymmetry between legs was -1.44 ± 9.14%, suggesting relatively balanced muscle strength.

Conclusions: The study concluded that hamstring eccentric strength in both legs should be improved by approximately 11.9% while maintaining the current low asymmetry levels to support muscle balance. Targeted training interventions are recommended to increase hamstring strength and minimize asymmetry, enhancing performance and reducing injury risk in female handball athletes.

Keywords: asymmetry, eccentric, hamstring, handball, nordic hamstring.

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INTRODUCTION

Handball is a very popular competitive sport today and has been quite popular in Indonesia. It is played in several regional and international competitions (Muarif et al., 2024). Depending on their position, each player has different physical demands, including explosive movements such as jumps, sprints, and quick direction changes, all of which require excellent strength and endurance. Therefore, handball is categorized as a sport with a high potential for injury, especially in the lower extremities (Firmansyah et al., 2024). In handball athletes playing in the Iceland league, the majority of injuries were to the lower extremities, particularly the knee (26%) and ankle (19%) (Rafnsson et al., 2019). Knee injuries, particularly anterior cruciate ligament (ACL) ruptures, are the most common serious injuries in individuals aged 15–19 years. Girls are at higher risk for ACL injuries, especially during adolescence (Schmidt & Jaitner, 2023).

The causes of injuries to the lower extremities of handball athletes are rapid changes in direction, sudden landings from jumps, and frequent contact and collisions between players (Raya-González et al., 2022). In addition, risk factors for injury also include weak muscle strength, improper technique, limited muscle flexibility, and a suboptimal injury rehabilitation process (Fredriksen et al., 2020).

The hamstring muscle group is particularly crucial for activities such as acceleration, deceleration, and changing direction, where athletes often need to balance on one leg (Wing et al., 2020). Hamstring muscles play an important role in performance and injury prevention for handball athletes. Therefore, hamstring strength tests are important for athletes and coaches to understand hamstring muscle strength and its related normative data, and it is also important to design the right training program when evaluating rehabilitation progression and making return-to-play decisions (Firmansyah et al., 2024). In addition, normative data on hamstring muscle strength is essential for medical doctors and physical therapists to assess athletes' physical condition, determine their readiness, and ensure safety when they are ready to return to competition after injury. This data assists in evidence-based decision-making for rehabilitation and prevention (Owoeye et al., 2024).

Four assessments of eccentric hamstring muscle strength with knee flexors often used to determine imbalance are carried out using the Nordic hamstring test (Van Dyk et al., 2019). Testing eccentric hamstring strength is crucial for assessing maximum strength and potential imbalances, especially for athletes and individuals at risk for hamstring injuries (Claudino et al., 2021). Eccentric strength assessment is more appropriate than isokinetic testing (Chavarro-Nieto et al., 2022). Several instruments are available to assess hamstring muscle strength, and eccentric strength assessment is helpful as an indicator for predicting injury, one of which is using the Nordic hamstring test (Timmins, 2016; Opar., 2015; Barrera-dom et al., 2021). Handball athletes with balanced hamstring muscle strength, indicated by low asymmetry values, tend to be able to perform techniques and movements more effectively. Good hamstring muscle balance not only improves athlete performance but also contributes to reducing the risk of injury. With optimal hamstring muscle strength, athletes can maintain stability and flexibility, which are very important in carrying out various techniques in handball. This study aimed to determine the strength and asymmetry of the hamstring muscles in female handball athletes in Surabaya City.

Although many studies highlight the importance of hamstring muscle strength in preventing injury in handball athletes, data on the strength profile and asymmetry of hamstring muscles in female handball athletes is still limited. This study is important because it provides an empirical picture specific to the local population, which has not been widely explored in national and international literature. The results are expected to be a reference in developing evidence-based training programs and appropriate rehabilitation protocols while helping coaches and medical professionals identify and address muscle asymmetries at risk of increasing injury.

METHODS

Study Design and Participants

The subjects in this study were handball athletes from Surabaya City, consisting of 13 women aged 18-23 years. Subject selection was conducted using non-random (nonprobability) sampling with a purposive sampling technique. The selection of subjects was based on inclusion criteria, namely handball athletes with at least experience competing at the regional level and not currently experiencing lower extremity injuries. The exclusion criteria are athletes who do not have experience competing at the regional level and athletes who are 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 429/HRECC.FODM/VII/2024.

Research Instruments

The instrument in this study used Nordbord (Vald Performance), a portable rapid assessment tool that can analyze large groups, providing information on the same functional strength parameters quickly and efficiently (Timmins et al., 2016). The Nordbord tool in bilateral Nordic hamstring assessment showed high to moderate reliability, namely Intraclass Correlation Coefficient (ICC) = 0.83-0.90 and Standard Error of Measurement (SEM) = 6-9%. In addition, in assessing imbalance between limbs, the peak force ratio averaged over six trials was found to have acceptable reliability values (ICC = 0.85; 95% CI 0.71-0.93; SEM = 5%, 95% CI 4-6%). Before taking the measurements, all athletes had their height and weight measured, and they were then asked to warm up with more focus on the lower extremities. They were instructed to lean forward as slowly as possible while resisting the movement with the hamstring muscles. Each athlete was tested three times with a 1-minute rest period per repetition.

Data Analysis

This research is a descriptive study with quantitative methods. Quantitative descriptive statistical analysis involves using statistical techniques to describe, summarize, and analyze quantitative data. Quantitative data refers to data that can be measured or calculated using numerical values, such as weight, height, and others. The purpose of quantitative descriptive statistical analysis is to provide a comprehensive and accurate picture of the data collected to enable the interpretation and decision-making process by utilizing the available data. To test the frequency distribution by displaying the average, standard deviation, and asymmetry results and using Excel to calculate the percentage. Then, the strength and asymmetry of the

Nordic hamstring test results were analyzed to determine the strength and asymmetry values of the hamstring muscles of each athlete using the Nordic hamstring formula (N = 4 × body mass (kg) + 26). The existing norms are used in the Valdhub application for the asymmetry value, which is directly connected to the Nordbord tool.

RESULTS

The research results displayed through Table 1 to Table 7 and Figure 1 to Figure 3 provide a comprehensive picture of eccentric strength and hamstring muscle asymmetry in female handball athletes in Surabaya City. Table 1 presents descriptive statistics showing that the average right and left hamstring muscle strengths are 230.70 N and 233.61 N, respectively, with an average asymmetry value of -1.44%, indicating a relatively balanced muscle condition. Figure 1 reinforces this data by visualizing the variation in strength between individuals.

Table 1. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Weight (Kg)	13	47.00	90.00	59.30	10.94
Height (Cm)	13	158.00	183.00	164.80	6.80
RMax Force (N)	13	143.00	320.00	230.70	48.80
LMax Force (N)	13	178.00	341.00	233.61	50.15
Max Asymmetry (%)	13	-19.40	13.38	-1.44	9.14

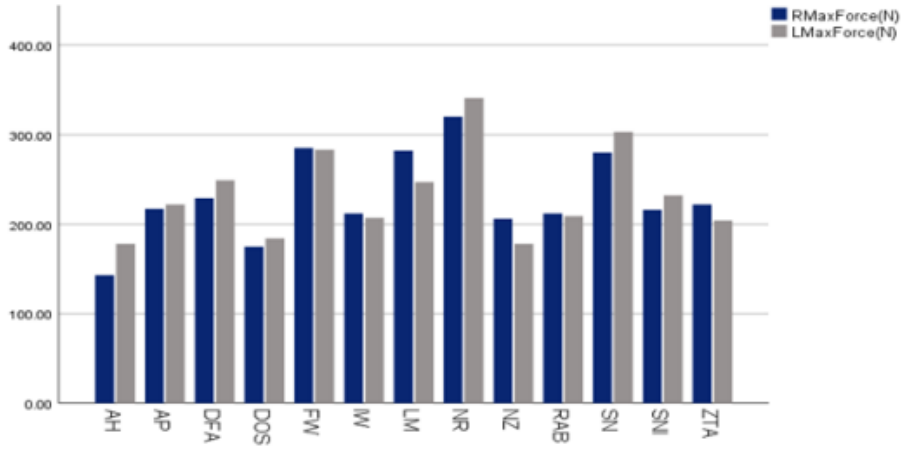

Figure 1. Power Chart Athlete's Hamstring

The frequency distribution of hamstring muscle strength is shown in Table 2 and Table 3, where the left muscle strength is more concentrated in the 178-221 N range, while the right strength is more spread out.

Table 2. Power Frequency Distribution Left Hamstring

No.	Max Left Force (N)	Frequency
1	178 - 221	6
2	212 - 245	2
3	246 - 279	2
4	280 - 313	2
5	314 - 347	1
	Total	13

Table 4 shows summary statistics of left and right hamstring strength compared to normative strength values based on body weight (N = 4 × body weight + 26). The average left hamstring strength was 233.73 N, the right was 230.48 N, and the mean

normative value was 263.23 N. This indicates that most athletes have not reached the ideal strength according to the standard, and an improvement of about 11.9% is needed.

Table 3. Power Frequency Distribution Right Hamstring

No.	Max Right Force (N)	Frequency
1	143 - 178	2
2	179 - 214	3
3	215 - 250	3
4	251 - 286	2
5	287 - 322	1
	Total	13

Table 4. Power Category Athlete's Hamstring

Variable	Min	Max	Mean	Std. Deviation
Weight (Kg)	47	90	59.31	10.95
L Force (N)	177.75	340.75	233.73	50.10
R Force (N)	143.25	319.75	230.48	48.77
Eccentric Strength (N=weight x 4 + 26)	214	386	263.23	43.80

Table 5 shows the percentage of left and right hamstring strength against normative values. The average left hamstring strength reached 88.6%, and the right, 87.6%, with a combined value of 88.1%. This suggests that although some athletes are approaching the expected strength standards, additional strengthening programs are needed to keep all athletes in the optimal strength range that can support performance and prevent injury.

Table 5. Muscle Strength Percentage Right and Left Leg Hamstrings

Variable	Min	Max	Mean	Std. Deviation
L Force (N)	71.1	106.4	88.6	11.48
R Force (N)	57.3	106.9	87.6	12.84
(% L + % R) / 2	64.2	106.6	88.1	11.48

Table 6. Asymmetry Category Right and Left Hamstring

Variable	Min	Max	Mean	Std. Deviation
Max Asymmetry (%)	-19.4	13.3	-1.44	9.10

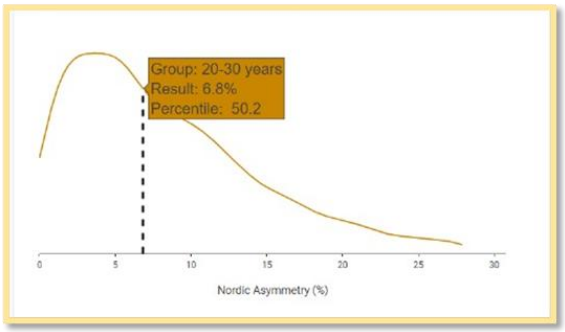

Figure 1. Vald Normative Nordic Asymmetry

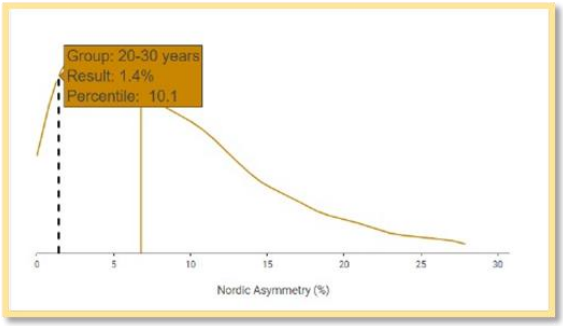

Figure 2. Results Average Asymmetry Nordic Hamstring Athletes

Table 6 shows the hamstring muscle asymmetry values between limbs. The mean asymmetry value was -1.44%, with a standard deviation of 9.10% and a range of -19.4% to 13.3%. Although some athletes had a relatively high level of asymmetry (above 10%), overall, the group showed a relatively low muscle imbalance and was still within safe limits based on the international normative reference of 6.8%. Maintaining this condition through unilateral training that targets weaker limbs is important. Figure 2 displays the international standard limit for asymmetry (around 6.8%), while Figure 3 shows the athletes' actual average asymmetry (1.4%) within safe limits. Finally, Table 7 presents the recommended bilateral and unilateral exercises to increase strength and decrease muscle imbalance, such as the Nordic Hamstring Curl and Single Leg Hip Thrust.

DISCUSSION

The results showed a significant variation in hamstring muscle strength in female handball athletes in Surabaya City. The average hamstring strength of the left leg reached 233.6 N, with the highest value of 340.75 N and the lowest 177.75 N, while the right leg had an average of 230 N, with the highest value of 319.75 N and the lowest 143.25 N. This difference indicates an imbalance of strength between athletes, even between limbs in one athlete. The proportion of athletes with strength below the average value is quite large, indicating that some athletes have not reached the optimal strength standard required to support performance and prevent injury. This underscores the importance of a training program focused on improving hamstring strength, especially for athletes with low strength values, to reduce the risk of injury and improve knee joint stability during competitive activities. The hamstring muscles are crucial in controlling daily body movements, playing a role in basic activities such as walking and running, as well as complex activities such as jumping and maintaining posture when sitting or standing (Paramita, Rahmanto, & Rahim, 2024).

In addition to hamstring muscle strength values, muscle asymmetry is an important factor affecting injury risk. The results showed that the lowest asymmetry value was -2.5% in the left leg and 0.4% in the right leg, while the highest asymmetry reached -19.4% in the left leg and 13.3% in the right leg. This significant difference in asymmetry indicates a muscle imbalance that can potentially increase the risk of injury, given that Silvers-Granelli et al. (2021) stated that the risk of injury increases if the strength deficit between sides exceeds 10-15%. However, on average, the asymmetry in Surabaya City female handball athletes is only 1.4%, far below the international normative limit of 6.8% for ages 20-30 years (Vald Performance), which indicates a relatively balanced muscle condition and supports optimal performance (Hammi, 2018).

The asymmetry imbalance found in some athletes is likely due to the dominance of certain limbs, where athletes tend to use one leg more often as a fulcrum or dominant leg in movements such as kicking, jumping, or changing direction. In addition, uneven training loads or a lack of unilateral strengthening exercises may exacerbate this imbalance (Kang, Yu, & Kwon, 2017; Mrzygłód et al., 2021). Therefore, coaches need to identify athletes with high asymmetry and design training programs that target the strengthening of weaker limbs to reduce the risk of injury and improve athletes' stability and overall performance.

The results showed that most female handball athletes in Surabaya City had not reached the ideal hamstring muscle strength category based on the Nordic Hamstring formula (N = 4 x body mass (kg) + 26). The average percentage of hamstring strength of all athletes only reached 88.1%, with details of 88.7% on the left leg and 87.6% on the right leg. This indicates an overall need for improvement in hamstring muscle strength of approximately 11.9%, with a slightly greater improvement in the right leg (12.4%) than the left leg (11.3%).

Longitudinal studies are also highly recommended to monitor the development of muscle strength and injury risk over time, especially the training program implemented. With such an approach, training interventions can be better targeted to improve hamstring muscle strength and flexibility, which in turn can reduce injury risk and improve overall athlete performance; some exercise models that can be used to increase hamstring muscle strength and flexibility include:

Table 7. Bilateral and Unilateral Exercise Recommendations for Improving Hamstring Muscle Strength and Balance

Bilateral Exercise	Unilateral Exercise
Nordic Hamstring Curl	Single Leg Hamstring Bridge
Hip Thrust Exercise	Single Leg Hip Thrust
Swiss Ball Hip Extension and Leg Curl	Single Leg Kettlebell Deadlift

Table 7 presents different bilateral and unilateral exercises recommended for improving hamstring muscle eccentric strength and correcting limb imbalances. Bilateral exercises such as the Nordic Hamstring Curl, Hip Thrust Exercise, Swiss Ball Hip Extension, and Leg Curl strengthen both limbs simultaneously and build fundamental strength. Meanwhile, unilateral exercises such as Single Leg Hamstring Bridge, Single Leg Hip Thrust, and Single Leg Kettlebell Deadlift aim to address muscle asymmetry by targeting the weaker limb. Combining these two types of training is important to improve hamstring stability, flexibility, and strength in a balanced way and reduce the risk of injury, especially in athletes who exhibit asymmetry values above the normative limit.

Limitations of the study

Although the results of this study provide important insights into hamstring muscle strength and balance, some limitations need to be noted. Firstly, the limited number of subjects (13 athletes) may reduce the generalizability of the findings to a broader population. Secondly, muscle strength measurements were made using the Nordic Hamstring test, which is susceptible to variations in execution techniques and athletes' motivation levels during testing, which may affect the accuracy of the data. In addition, this study only included athletes from the Surabaya area, so the results may not represent the characteristics of athletes from other regions. For this reason, future research should use a larger and geographically diverse sample and consider

additional variables such as biomechanical factors, injury history, and differences in athlete ability levels.

CONCLUSIONS

This study confirms that most Surabaya City female handball athletes have not achieved ideal hamstring muscle eccentric strength based on the Nordic Hamstring formula (N = 4 x body mass (Kg) + 26), with an average overall strength of only 88.1%. The average strength of the left and right limbs was 88.7% and 87.6%, respectively, indicating the need for increased strength on both sides—the asymmetry assessment of female handball athletes in Surabaya City with an overall average of 1.4%. Ten female handball athletes in Surabaya City have an asymmetry value below 10%; these results make it perfect for athletes towards peak performance. A small number of athletes with asymmetries above 10% signal the need for unilateral specialized training interventions to address these imbalances. These findings provide important input for coaches and athletes to focus on training programs that target improvements in hamstring muscle strength and balance to optimize performance and prevent injury risk.

Future research is recommended to develop variables that have not been explored, such as biomechanical factors or injury history. Expansion of subjects and data collection to make the sample more representative is also important. In addition, future research should consider gender differences by including male athletes and comparing athletes with different skill levels (e.g., elite athletes) for a more comprehensive understanding.

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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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This research does not receive external funding.

CONFLICT OF INTEREST

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

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