Journal of Physical Education and Sport ® (JPES), Vol. 24 (issue 8), Art 219, pp. 1978 - 1983, August 2024
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Differences in eccentric hamstring force among young indonesian handball players based on injury history

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Published online: August 31, 2024
Accepted for publication : August 15, 2024
DOI:10.7752/jpes.2024.08219

Abstract:
Handball is characterized by frequent changes in direction, jumping, and intense physical contact, which contribute to a high incidence of injuries, especially in the lower extremities. These injuries often come with the risk of re-injury or new injuries, affecting athletic performance. Assessing hamstring muscle strength, vital for knee joint stability, is a crucial approach to preventing sports injuries. Weakness in eccentric hamstring strength can increase the risk of overuse injuries, hamstring strains, and ACL tears. Detecting muscle strength imbalances in athletes is an effective strategy for preventing future injuries. This study aimed to compare maximum eccentric hamstring force and assess asymmetry between the right and left legs in young male and female handball players with differing injury histories. Performed as an analytic observational study with a cross-sectional design, it involved a total sample of 82 young handball players (46 males and 36 females), grouped according to their injury history. Participants performed an eccentric hamstring strength test using the Nordic hamstring bilateral test, measured with the NordBord hamstring testing device (VALD Performance, Australia). This study found a significant difference in the percentage of asymmetry between players with a history of injury and those without ($p = 0.000$). However, the mean maximal hamstring eccentric strength did not differ significantly between injury history groups in each gender. The observed higher mean percentage of hamstring eccentric imbalance in players with a history of injury may be influenced by various factors, including player position, rehabilitation process, training level, body composition, and overall physical performance. The high percentage of imbalances in athletes requires careful attention to mitigate their negative effects on athletic performance and reduce the risk of injury.
Keywords: Hamstring force, NordBord, Handball, Injury prevention, Healthy lifestyle

Introduction

Handball, a popular sport played by two teams of seven players, involves rapid transitions between offensive and defensive roles through activities such as throwing, passing, jumping, blocking, pushing, running, and dribbling the ball into the opponent's goal to score points (Marczinka & Csáki, 2023). The mechanical stresses from frequent direction changes and high physical contact often lead to injuries, with a prevalence rate of 82.2% (Logerstedt et al., 2022; Martín-Guzón et al., 2021; Vila et al., 2022). Sports injuries encompass pain, discomfort, or loss of function that impair the ability to exercise, potentially leading to physical, mental, and financial challenges, all of which can impact both individual and team performance (Benson et al., 2024; Emery & Pasanen, 2019). These injuries arise from a complex interplay of risk factors and triggers (Bittencourt et al., 2016). Most injuries are attributed to player contact, resulting in traumatic injuries, while non-contact and overuse injuries commonly affect the knee, shoulder, and ankle (Raya-González et al., 2020; Vila et al., 2022).

In handball, lower extremity injuries, such as those affecting the knee, hip, and ankle, are more prevalent than upper extremity injuries (Martín-Guzón et al., 2021; Vila et al., 2022). A history of lower extremity injury increases the risk of re-injury or new injury and can lead to long-term negative effects on tissue function, including muscle atrophy and reduced muscle strength (Mardani-Kivi et al., 2020). Previous research suggests that a history of ACL injury in female may lead to diminished knee flexor function compared to knee extensors (Collings et al., 2021). Athletes who have recovered from previous injuries may develop biomechanical abnormalities owing to residual effects from the rehabilitation process, which can increase their susceptibility to injuries in other areas (Palermi et al., 2023). To reduce the frequency of injuries in handball

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players, it is essential to monitor their injury history and physical condition, including muscle strength. This proactive approach can help minimize the risk of future injuries (Bedo et al., 2019).

An effective injury prevention strategy highlighted in previous research involves addressing muscle strength asymmetries in the lower extremities, such as those in the hamstring muscles, which can impact athletic performance (Almeida et al., 2018; Fort-Vanmeerhaeghe et al., 2020). Hamstring muscle strength plays a multifaceted role for handball players. Its primary functions include knee flexion, hip extension, and stabilization of the knee joint, which collectively influence running, jumping, and agility maneuvers such as acceleration, deceleration, and changes in direction (Chang et al., 2020; Markovic et al., 2020). In addition to absolute levels of eccentric hamstring strength, significant asymmetry between the right and left legs (greater than 15%) can considerably increase the risk of injury and has been identified as a predictor of injury (Bishop et al., 2022; Claudino et al., 2021). The Nordic hamstring eccentric strength test has proven to be a valid and effective method for both preventing and reducing the incidence of injuries, particularly those involving the hamstring muscles (Almeida et al., 2018; Bishop et al., 2022).

Analyzing individual player profiles is an important step in injury prevention because it helps identify hamstring eccentric strength values and potential underlying mechanisms. This information serves as a valuable reference for coaches and physiotherapists in designing targeted training programs that focus on injury prevention, performance enhancement, and improving the overall quality of life for handball players. Consequently, this study aims to compare hamstring muscle eccentric strength between young male and female handball players with and without lower extremity injuries to reduce the risk of re-injury or new injuries in the future.

Materials and Methods

Participants

This study is an analytic observational research design. Data were collected from hamstring eccentric strength examinations performed on 82 young handball players in Surabaya, Indonesia, from January to August 2023. Participants were required to have no acute injuries or history of lower extremity musculoskeletal surgery in the past 12 months. Before participation, both players and coaches were informed of the potential risks and provided informed consent. Injury history data were collected through interviews and physiotherapist examinations, which included details about the player's profile, injury location, and the side of the previously injured limb. This study received approval from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Airlangga, under approval number No. 48/EC/KEPK/FKUA/2024.

Procedure and protocol test

Hamstring eccentric strength was assessed using the Nordic bilateral hamstring test with the NordBord hamstring testing device (VALD Performance, Australia). This device has demonstrated moderate to high test–retest reliability, with an intraclass correlation coefficient (ICC) of 0.83–0.90 for eccentric knee flexor strength, and is commonly used in athlete populations (Almousa et al., 2023; Bishop et al., 2022). Before testing, participants performed a dynamic stretching warm-up for 5 min. During the test, players performed maximal Nordic hamstring movements in one set of three repetitions, with a 5–10 s rest between repetitions. Participants were instructed to kneel on the padding of the NordBord device, with a support hook positioned over the lateral malleolus. They were instructed to maintain hip and lumbar extension during the test while leaning forward as slowly as possible. This position was maintained maximally using both feet, with their hands ready to support their body as they approached the floor. After completing each repetition, participants were asked to return to the starting position before performing the next repetition. The maximum strength values for the right and left limbs, derived from the three repetitions, were measured in Newtons (N), which can be converted to the basic unit of kg/m^2. Muscle strength imbalance between the right and left limbs was calculated as the percentage difference in strength values between the stronger and weaker limbs (0% indicates no imbalance, while values greater than 0% indicate the dominance of strength on either the right or left side) (Benson et al., 2024; Bishop et al., 2022; Claudino et al., 2021).

Statistical analysis

The data were analyzed using SPSS software, which provided both descriptive statistics (mean ± standard deviation) and assessments of normality. For statistical analysis, the independent T-test was used for parametric data, while the Mann–Whitney test was employed for non-parametric data. Statistical significance was set at $p < 0.05$.

Results

A total of 82 young handball players (46 males and 36 females) were divided into gender-specific groups based on their injury history. Of these players, 65% (53 players) had experienced a lower extremity injury, including 31 males and 22 females. In the male group, the position with the highest number of injuries was the wink position (n = 14), while in the female group, the backcourt position had the most injuries (n = 9) (Figure 1). According to Table 1, there were no significant differences in anthropometric characteristics (age,

weight, height, and body mass index) between the injured and uninjured groups in both male and female categories.

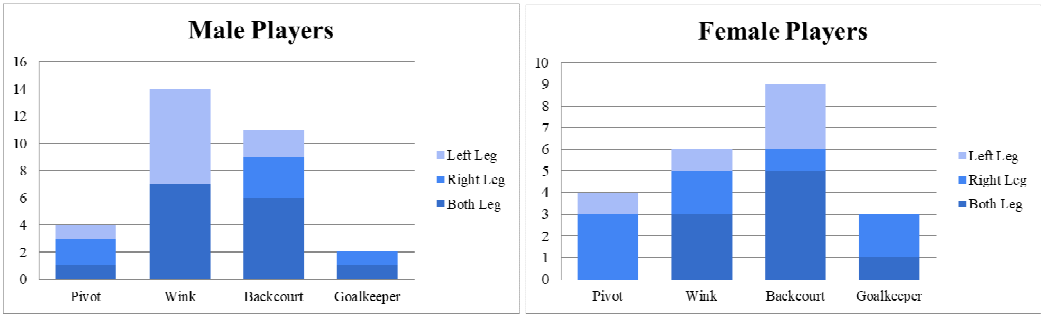

Figure 1. Distribution of previously injured limb by player position in male and female handball players

Table 1. Participant characteristics

Variable	Male			Female		
	Previously injured (n = 31)	Uninjured (n = 15)	*p-value*	Previously injured (n = 22)	Uninjured (n = 14)	*p-value*
Age (year)	18.42 ± 2.13	18.73 ± 2.55	0.662	18.95 ± 2.15	17.79 ± 1.48	0.084
Weight (kg)	66.47 ± 13.78	64.19 ± 14.64	0.981	58.63 ± 10.74	60.25 ± 9.29	0.573
Height (cm)	172.68 ± 5.75	172.27 ± 5.69	0.367	163.00 ± 7.14	161.50 ± 6.44	0.528
BMI (kg/m^2)	22.20 ± 3.74	21.62 ± 4.71	0.379	21.95 ± 2.57	23.11 ± 3.38	0.249

Data are presented as mean ± SD; BMI: Body mass index; p-values were calculated using the independent t-test and Mann–Whitney test.

Maximum eccentric hamstring force

Table 2 details the differences in hamstring eccentric force between females and males based on injury history. The analysis revealed no significant differences in maximum eccentric hamstring force in each gender based on injury history. However, it was noted that both male and female handball players with previous injuries exhibited higher hamstring eccentric strength values compared to those without injuries. Additionally, male players demonstrated a higher mean value of maximum eccentric hamstring force compared to female players.

Table 2. Eccentric hamstring force by gender and injury history

	n	Maximum hamstring eccentric force (MHF)			
		Right MHF (N)	Left MHF (N)	Δ MHF (N)	Imbalance MHF (%)
Male					
Previously injured	31	284.27 ± 64.99	269.06 ± 62.43	30.24 ± 18.86	10.72 ± 7.01
Uninjured	15	264.42 ± 53.70	264.67 ± 54.26	7.58 ± 7.34	2.95 ± 2.90
p-value		0.311	0.817	0.000*	0.000*
Female					
Previously injured	22	205.66 ± 61.08	203.36 ± 56.67	20.02 ± 13.70	9.49 ± 6.81
Uninjured	14	191.80 ± 44.53	193.16 ± 45.93	5.25 ± 6.37	2.51 ± 2.59
p-value		0.469	0.576	0.000*	0.000*

Data are presented as mean ± SD. MHF: Maximum hamstring force. N: Newton; Δ: Delta. (*) Indicates a significant difference from the Previously injured group ($p \leq 0.05$).

Imbalance in asymmetrical eccentric hamstring strength

During the eccentric hamstring test, limb asymmetry was measured by comparing the force generated between the right and left limbs. Table 2 indicates that the delta data and the percentage of maximum eccentric hamstring force imbalance significantly differed between groups with and without previously injured individuals. Specifically, in males, the imbalance was 10.72 ± 7.01% in those with previous injuries compared to 2.95 ± 2.90% in those without ($p = 0.000$). In females, the imbalance was 9.49 ± 6.81% for those with previous injuries versus 2.51 ± 2.59% for those without ($p = 0.000$).

Discussion

The high rate of injury among handball players is an important issue that requires efforts to improve the quality of life by reducing injury incidence during competition or training. Extensive research on injury prevention has highlighted the importance of hamstring muscle eccentric strength parameters (Almeida et al., 2018; Bishop et al., 2022; Hu et al., 2023). This handball study yielded several key findings. First, male handball players demonstrated higher maximum hamstring eccentric force values compared to females. Second, players with a history of injury had higher maximum hamstring eccentric force values than those without injuries. Third, there was no significant difference in maximum hamstring eccentric force between the male and female groups. Fourth, the percentage of hamstring eccentric force imbalance in each group significantly differed from that of the uninjured group.

Eccentric hamstring strength in male athletes can be influenced by various factors, including training modifications, techniques, and injury history (Alt et al., 2023). The results of this study are consistent with previous research, which indicates that male handball players typically exhibit higher maximum eccentric strength compared to females (Opar et al., 2015; Timmins et al., 2016). This disparity in hamstring muscle strength between genders is attributed to differences in body composition, hormonal levels, muscle fiber types, and individual factors such as training history and physical activity levels (Nuzzo, 2023). Muscle strength results from training adaptations that impact the body's physiological systems, including the action of testosterone, the primary anabolic hormone that stimulates protein synthesis and inhibits protein degradation in muscles through androgen receptors (Gharahdaghi et al., 2020; Xu et al., 2021). Athletes who regularly engage in strength training and possess extensive sports experience are typically better equipped to optimize their training to enhance muscle strength. These athletes often demonstrate improved muscle strength owing to adaptations in both the muscular and neurological systems (Benson et al., 2024). Other studies have indicated that absolute hamstring eccentric strength can be influenced by factors such as age, body mass, and body composition balance, contributing to higher maximum hamstring muscle strength values in male handball players (Buchheit et al., 2016; Jeanguyot et al., 2023).

Previous research has found that athletes with hamstring injuries lasting more than three weeks often exhibit weakness in the injured limb compared to the uninjured limb (Palermi et al., 2023; Vicens-Bordas et al., 2020). However, this study found different results, showing no significant differences in maximum eccentric hamstring force between genders based on injury history. This contrasts with earlier studies, which reported a reduction in hamstring eccentric strength in athletes with previous injuries compared to those without such injuries. These findings may be associated with the prevalence of wing and backcourt players in the injury group. Previous research has indicated that wing players in handball, who frequently engage in rapid direction changes and high-intensity running, typically exhibit higher lower limb muscle strength (Fort-Vanmeerhaeghe et al., 2020; Gaamouri et al., 2023). Similarly, backcourt players also demonstrate greater lower limb strength, which is crucial for jumping movements used to defend and block opponents' shots effectively (Gaamouri et al., 2023). This optimal lower limb strength may have led to the injured group displaying higher muscle strength values compared to the uninjured group.

Muscle imbalances in athletes with a history of injuries are a common issue that can increase the risk of re-injury or new injuries. Athletes who have experienced hamstring injuries may be particularly vulnerable to strength imbalances owing to changes in muscle activation patterns after the injury. These changes can negatively impact movement biomechanics and strength performance (Kwak & Oh, 2023; Palermi et al., 2023). A study of young female handball athletes found that muscle imbalances, particularly hamstring weakness, are more prevalent than quadriceps imbalances and can increase the risk of musculoskeletal injuries (Almousa et al., 2023; Collings et al., 2021; Wiprich et al., 2022). This finding aligns with previous research, which indicates that the percentage of eccentric hamstring force imbalance is significantly higher in both male and female athletes with a history of injuries compared to those without such injuries (Benson et al., 2024; Bishop et al., 2022; Opar et al., 2015). Long-term hamstring strength imbalances can lead to compensatory mechanisms, chronic pain, and fatigue, which can worsen the issue and increase the risk of injury (Benson et al., 2024; Kwak & Oh, 2023; Palermi et al., 2023). This underscores the need for handball teams to carefully assess and address muscle imbalances, particularly after injuries, to reduce the risk of re-injury or new injuries. Such measures are crucial for preventing negative impacts on both individual players and the team as a whole.

Conclusions

In this study, differences in maximal hamstring eccentric strength based on injury history were primarily observed in the values of limb-side comparisons and bilateral asymmetry. The mean maximum hamstring eccentric strength values for both the right and left sides were higher in the injured group. This can be attributed to factors such as player position, the rehabilitation process, training factors, body composition, the level of handball training, and an understanding of the importance of hamstring muscle strength. The high percentage of imbalance in some athletes highlights the need for targeted muscle strength training to reduce its negative impact on performance. When assessing physical performance, it is crucial to account for specific

characteristics such as coaching background, length of experience, and history of training programs for each handball player. Further research is needed to explore the factors influencing physical performance in handball players, particularly those with a history of injury. Additionally, establishing normative data and standardizing maximum hamstring muscle strength measurements will be important for providing accurate references and benchmarks for handball athletes.

Acknowledgments

We would like to thank the Indonesia Handball Association and KineticX Sport Science & Body Performance for their collaboration in obtaining the data. The authors would like to thank Falcon Scientific Editing (https://falconediting.com) for proofreading the English language in this paper.

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